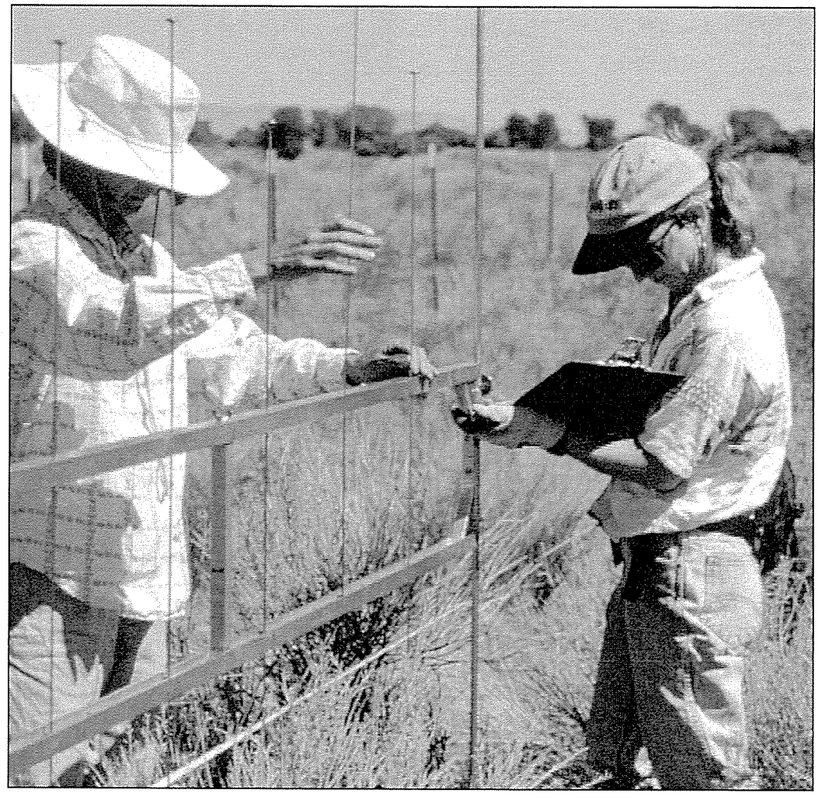

INYO COUNTY WATER DEPARTMENT
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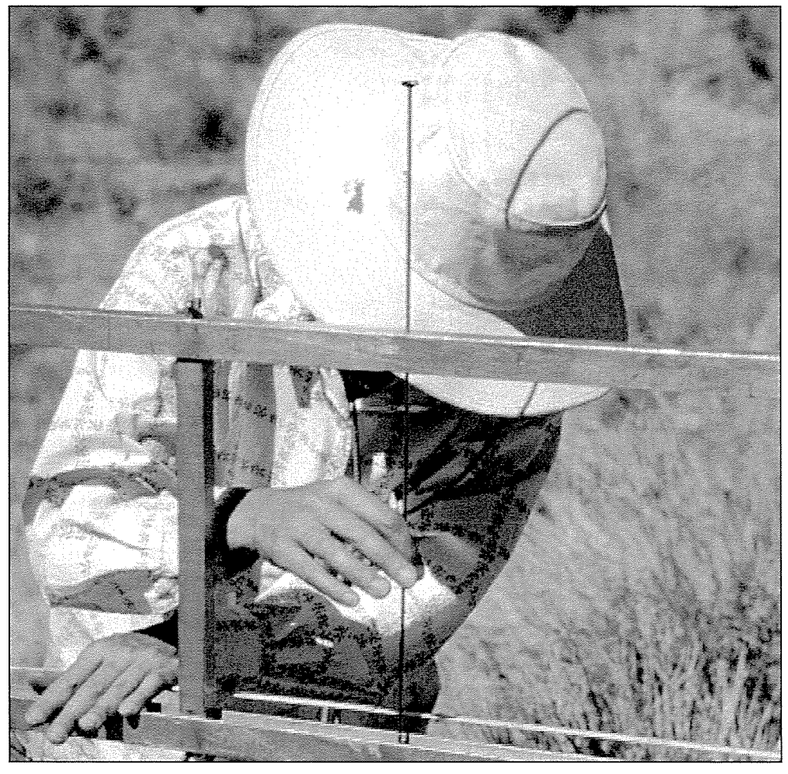
THE OWENS VALLEY

MONITOR



INYO COUNTY WATER DEPARTMENT'S ANNUAL REPORT
ON ACTIVITIES AND CONDITIONS IN THE OWENS VALLEY

1999-2000

The Owens Valley Monitor, Inyo County Water Department's (ICWD) annual report, is an account of monitoring and other work performed by ICWD and the Los Angeles Department of Water and Power (LADWP). In accordance with the Inyo/Los Angeles Water Agreement, ICWD and LADWP monitor water-related activities in the valley and their effects on groundwater levels and vegetation. The two agencies also conduct scientific research to improve water management methods.

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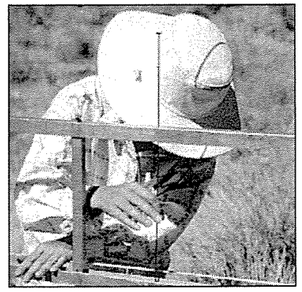

THE OWENS VALLEY MONITOR

This annual report was produced by the Inyo County Water Department in Bishop, California.

ICWD also produces a newsletter called the Owens Valley Water Reporter. The newsletter covers the activities of ICWD and water issues in the Owens Valley and the Eastern Sierra. If you would like to receive the newsletter and the annual report, let us know:

Phone: (760) 872-1168
FAX: (760) 873-5695
E-mail: inyowaterdept@telis.org
Web: http://www.inyowater.org
Write: Inyo County Water Department
163 May Street
Bishop, CA 93514

Front Cover:
Irene Yamashita uses point-frame to measure vegetation at one of 33 Owens Valley monitoring sites. Photo by Leah Kirk

Facing page:
An autumnal perspective of the Owens Valley. Photo by Greg James

Back cover:
ICWD's Sally Manning and Irene Yamashita run a 100 meter point-frame transect at one of 33 permanent monitoring sites where Owens Valley vegetation is monitored. Photo by Leah Kirk

Edited by Leah Kirk
Map production by Chris Howard

This report is published on recycled paper.

THE INYO COUNTY WATER DEPARTMENT

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Yerba mansa (*Anemopsis californica)* Photo by Leah Kirk

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1999 BUDGET

Inyo County Water Department's general operations budget for fiscal year 1999-2000 was $1,072,273. General operations included ongoing monitoring and management of LADWP water gathering activities and department administration. Funding for the $1,072,273, LADWP provided $971,604, the county's geothermal trust fund provided $23,245, and funds remaining from previous years provided $52,424.

The 1999-2000 budget for the Inyo County Saltcedar Control Program was $217,446. The program was funded by LADWP as provided in the Inyo/Los Angeles Water Agreement.

REPORTS & PUBLICATIONS

Vegetation

1998 Revegetation Progress Report for Impacts Described in the LADWP/Inyo County EIR for Groundwater Management. Irene Yamashita. November 1998.

Condition of selected vegetation parcels and assessment according to the Drought Recovery Policy. Inyo County Water Dept. Staff. March 1999.

The effects of water table decline on groundwater-dependent Great Basin plant communities in the Owens Valley, California. pp. 231-237 In: McArthur, E. Durant; Ostler, W. Kent; Wambolt, Carl L. comps. 1999. Proceedings: Shrubland Ecotones. 1998 August 12-14, Ephraim, UT. Proceedings RMRS-P-11. Ogden, UT: U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. September 1999.

Summary of 1998 perennial cover and life form changes in parcels inventoried with line-point transects. Sally Manning. April 14, 1999.

Quantifying vegetation change in Owens Valley, CA using Spectral Mixture Analysis and the Normalized Difference Vegetation Index. Submitted to: Remote Sensing of Environment. Andrew J. Elmore, John F. Mustard, Sara J. Manning and David B. Lobell. (ms accepted for publication). November 1999.

The status of Owens Valley vegetation parcels according to the Drought Recovery Policy. Sally Manning. March 13, 2000.

Summary of 1999 perennial cover and life form changes in parcels inventoried with line-point transects. Sally Manning. April 2000.

Semi-Arid Plant Community Response to Drought and Land Use at the Regional Scale. Ecological Society of America. Snowmass UT (abstract submitted for August 2000 meeting). Andrew J. Elmore, John F. Mustard, and Sara J. Manning. January 2000.

American Geophysical Union. Dec. 1999. San Francisco, CA. Effects of water table fluctuations on phreatophytic plant communities in the Owens Valley, California. Sara J. Manning and Robert F. Harrington. Supplement to EOS, Transactions, AGU 80:46, November 16, 1999. Oral presentation Dec. 17, 1999.

Hydrology

Bishop Cone Audit Report 1998-1999 Runoff Year. Randy Jackson.

Mounding Effects Estimates From Streams And Canals, Owens Valley, Inyo County, California. ICWD Technical Note 2000-1. Randy Jackson.

Updated Regression Models for Forecasting Pumping-Induced Water Table Fluctuations. June 23, 1999. Robert Harrington

Soils

Transpiration Coefficients for Three Great Basin Shrubs. Aaron Steinwand. May 12, 1999.

Transpiration Coefficients for Two Great Basin Phreatophytic Grasses. Aaron Steinwand. November 24, 1999. (Amended January 19, 2000)

Assessment of Uncertainty in Kc Transpiration Estimates for Five Phreatophytic Shrubs and Grasses. Aaron Steinwand. November 24, 1999. (Amended January 19, 2000).

Comparison of Green Book and Kc Calculations to Estimate Vegetation Water Requirements. Aaron Steinwand. February 3, 1999.

The Effects of Kc and Green Book Models for Vegetation Water Requirements on Permanent Monitoring Site On/Off Status. Aaron Steinwand. April 24, 2000.

ACTIVITIES

Conferences

California Exotic Pest Plant Council (CalEPPC), October 15-17, 1999, Sacramento, California. Brian Cashore.

Soil Science Society of America Annual Meetings, Oct. 31-Nov.4, 1999. Salt Lake City, UT, poster presented by Aaron Steinwand: Transpiration coefficients for three Great Basin shrubs.

Devil's Hole 2000 Workshop. May 2-4, 2000. Bob Harrington and Randy Jackson.

DWR Bulletin 118 Workshop. Randy Jackson.

Estimating Natural Recharge Workshop, Desert Research Institute, Reno, Nevada, March 22. Bob Harrington

American Geophysical Union Fall Meeting, December 13-17, 1999. Bob Harrington presented a poster titled "Regression Modeling of Water Table Fluctuations for Management of Groundwater Pumping in Phreatophytic Vegetation."

Ecological Society of America. Aug 1999. Spokane, WA. Patterns of vegetation response to groundwater pumping detected with field monitoring and Landsat TM data. Poster presentation by Sara J. Manning, John F. Mustard and Andrew J. Elmore.

Ecological Society of America. Aug 1999. Spokane, WA. Precision and accuracy of remotely sensed data for quantitative analysis of vegetation change in a semi-arid region. Oral presentation by Andrew J. Elmore, John F. Mustard, Sara Manning, and David Lobell.

Nevada State GIS Conference. April 1999, Reno, NV. Poster co-presented by Chris Howard. Case studies in collaboration: Establishment of the GIS facility and Eastern Sierra node of the National Geospatial Data Clearinghouse at UC White Mountain Research Station.

Education

University of California Environmental Biology "Supercourse." Invited instructor, field trip leader, and student research project advisor. Sally Manning.

Eastern Sierra Institute (through Inyo County Office of Education), field and classroom presentations to elementary and high school students from Los Angeles. Sally Manning.

Brown University Undergraduate Thesis Advisor: Telling a Story from the Ground Up: Land-use History and Vegetation Change in Owens Valley, California. By Virali Gokaldas. Sally Manning. July 1999.

Home Street School Inventor's Fair judge. Sally Manning.

Round Valley School Science Fair judge. Irene Yamashita and Sally Manning.

Inyo County science fair judge. Aaron Steinwand.

Presentation for Friends of White Mountain Research Station lecture series. Owens Valley Soils: The Earth Beneath Your Feet. Aaron Steinwand. April 13, 2000.

Assisted with field trips conducted by North Dakota State University Geosciences Department, March 15-16, 2000, and University of California, Riverside Department of Soil and Environmental Sciences. Aaron Steinwand. May 4-5, 2000.

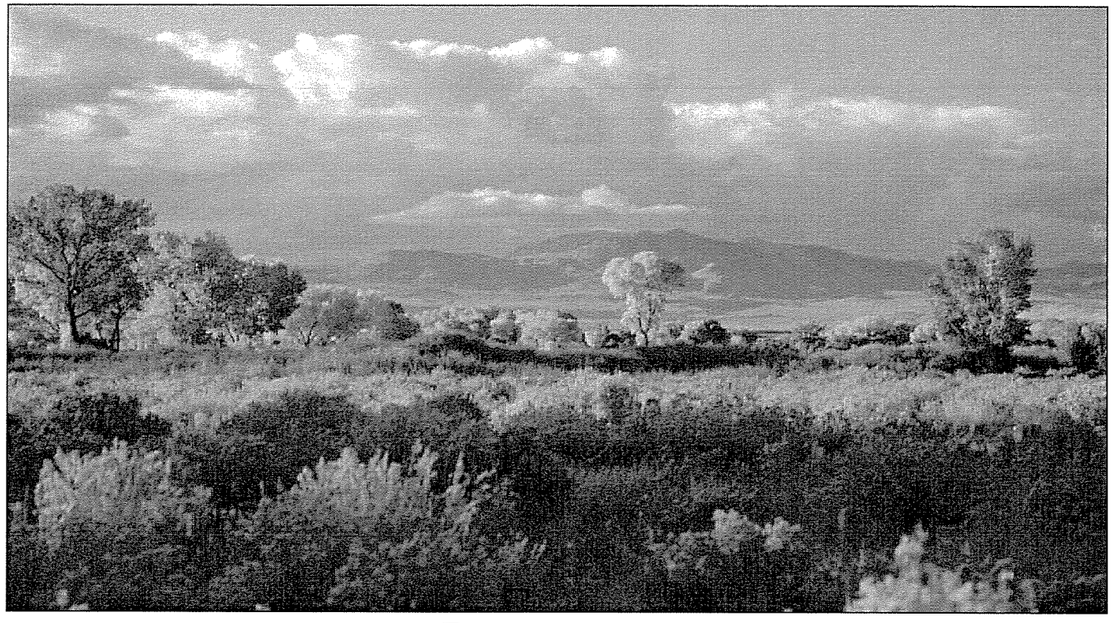
Eastern Sierra Weed Management Area information booth at Inyo County Fairgrounds. Brian Cashore and Rick Puskar.

Contributor, Eastern Sierra Weed Management Area Noxious Weed Identification Handbook. Brian Cashore, Chris Howard.

Accomplishments

Eastern Sierra Weed Management Area was awarded a $45,000 grant from the National Fish and Wildlife Foundation for cooperative interagency weed control work in the Owens Valley. The Inyo County Saltcedar Control Program is a member of ESWMA.

Vice-Chairman, Eastern Sierra Land Information System Network. Chris Howard.



PERSPECTIVE

Greg James, Director

The past few years have seen some big changes in the Inyo County Water Commission. Three long-time members of the Water Commission stepped down, and one of the original commission members returned to the commission after a hiatus of several years. Harry Holgate, the last of the Water Commissioners who had continuously served since the creation of the commission in 1980, decided to step down at the end of 1999. Prior to Harry's departure, Scott Kemp, who had served longer than anyone other than Harry, stepped down. Ray Gray, a Commission member since the mid-1980s, also decided to retire.

It is indeed difficult to lose the services of three dedicated commissioners who had volunteered so much of their time to improve the Owens Valley. All three could be counted on to candidly express their views and to diligently work to protect and enhance the valley. Each of them contributed much to the attainment and success of the Inyo/Los Angeles Water Agreement. All three will be sorely missed.

Fortunately, a previous Water Commissioner, Paul Lamos, who had served on the Commission for a decade before stepping down, expressed interest in filling one of the vacancies. The Board of Supervisors promptly appointed Paul. He joined Commissioners Teri Cawelti and David Miller. The two remaining seats were filled by Anna Zacher and Judy Fowler. Anna is from Sage Flat (near Olancha) and is retired from the U.S. Bureau of Reclamation. Judy is from Lone Pine and has an impressive background in agricultural issues. We welcome all three and have already enjoyed working with each of them.

For several years, the Water Department has been striving to obtain agreement with the City of Los Angeles to conduct several cooperative studies that would improve our ability to manage the valley's water resources to attain the goals of the Water Agreement. Last year, there was a breakthrough, and the Standing Committee conditionally approved the first of eight studies proposed by the county. Since then, agreement has been reached to conduct seven of the studies, and we expect the eighth study to be approved this fall.

California's, and Nevada's, ever-expanding populations and water woes continue to affect Inyo County. In the Olancha area, at the request of the project proponent, a proposed water export project has been on hold for several months. However, proposed groundwater pumping by Inyo's neighbors in Nevada could affect the water resources on the east side of the county.

In Olancha, several years ago, a groundwater export project was proposed by a company called Samda. The project was purchased from Samda by Western Water, who proposed pumping up to 6,000 acre-feet of water annually for sale to the City of Los Angeles. Now it appears that Western Water is attempting to market the project.

Continued on next page

Table 1. Precipitation measured in ICWD rain gauges by water year (October 1 of the previous year through September 30 of the year noted).

Rain Gauge	Precipitation (inches)						
	1993	1994	1995	1996	1997	1998	1999
RG-1, east of Fish Slough	5.94	3.40	7.60	4.51	4.66	6.09	1.82
RG-2, Laws Museum	6.29	3.62	7.80	4.55	4.91	7.34	2.50
RG-3, southeast of Bishop	7.21	4.34	8.87	4.29	6.85	9.98	2.39
RG-4, south of Big Pine	8.29	4.24	9.76	6.85	8.33	8.99	1.83
RG-5, Goose Lake	6.83	2.15	7.07	5.64	7.02	7.47	1.98
RG-6, near Blackrock	9.00	2.95	8.67	7.07	8.68	10.01	1.88
RG-1, east of Union Wash	5.00	1.61	4.88	2.14	4.35	5.06	1.61
Water Year AVG	**6.94**	**3.19**	**7.81**	**5.01**	**6.40**	**7.85**	**2.00**
Pre-Growing Season Avg (Oct 1- Apr 15)	**6.85**	**1.81**	**6.76**	**4.45**	**4.67**	**5.81**	**1.48**

Owens Valley Precipitation

Sally Manning, Vegetation Scientist

Precipitation data have been collected at seven ICWD rain gauges since 1993. Precipitation totals for ICWD rain gauges appear in Table 1. For the water year beginning October 1, 1998, and ending September 30, 1999, precipitation measured at the gauges averaged 2 inches. This was the lowest average during the period of ICWD record. During the pre-growing season period, October 1 through April 15, an average of 1.48 inches was measured. In contrast, the previous (1997-98) water year exhibited the highest valley floor precipitation on ICWD record, 7.85 inches, and 5.81 inches fell prior to the growing season.

Acronyms

This issue of the Owens Valley Monitor contains several acronyms, shortcuts for long titles.

Here are a few acronyms used frequently in these pages.

EIR: Environmental Impact Report, specifically the 1991 EIR covering the Inyo/Los Angeles Water Agreement and LADWP's groundwater pumping from 1970 to 1990.

ICWD: Inyo County Water Department.

LADWP: Los Angeles Department of Water and Power.

MOU: the Memorandum of Understanding between the California Department of Fish and Game, the State Lands Commission, the Sierra Club, the Owens Valley Committee, the Los Angeles Department of Water and Power, and Inyo County.

The MOU resolved the concerns of these organizations and state agencies over the Lower Owens River Project and other provisions of the 1991 EIR.

Perspective continued from page 3

Some interest in purchasing the project was expressed by the Indian Wells Valley Water District (a public agency that provides water in the Ridgecrest area). However, after investigating Inyo County's permit requirements, the district may no longer be interested. If an entity ever does seek a permit for the project from the county, the Water Department and Water Commission will serve as the county's hydrological consultants in evaluating the proposed project.

In Nevada, the application filed by Las Vegas in the late 1980s to appropriate groundwater from a 20,000 square mile area of central and southern Nevada remains active. During the past year, the three affected rural Nevada counties (Nye, White Pine, and Lincoln), together with Inyo County, were able to reach an agreement with Las Vegas that gives the rural counties the right to some of the water (subject to the appropriation applications) and a voice in their water futures. Moreover, last year, Nevada's water law was amended at the behest of the rural counties (working with Inyo) to require the Nevada State Engineer to consider the long-term and environmental consequences of interbasin transfers of groundwater.

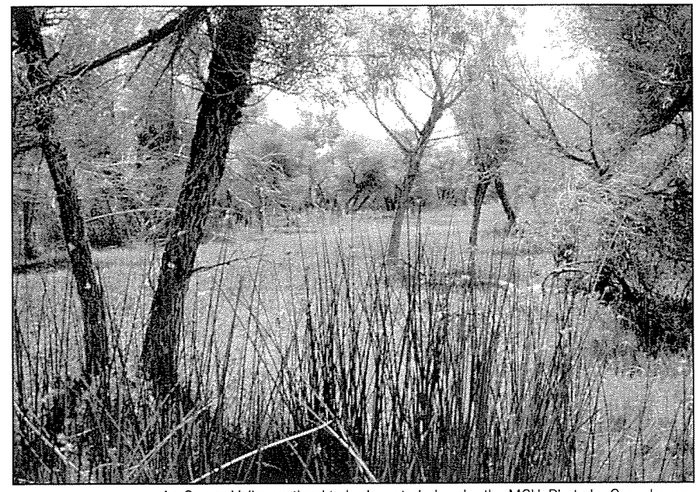
Also, the unincorporated town of Pahrump, Inyo's neighbor in Nye County, Nevada, is seeking the right to annually appropriate up to about 34,000 acre-feet of groundwater to meet the needs of its burgeoning population. Inyo Supervisors and Nye County Commissioners are attempting to set up a joint meeting to discuss the potential impacts of the proposed pumping on the water resources of the eastern portion of Inyo County.

Finally, a two-year evaluation of a proposal by LADWP to pump groundwater from under Owens Lake for use in implementing dust abatement measures on the lake has concluded with the recommendation that there be at least three more years of study. LADWP has said that due to its commitments to implement dust abatement measures on the lake by next year, it will not consider proceeding with the recommended studies for at least a year or two. In the meantime, water for the dust abatement measures will be diverted from the Los Angeles Aqueduct.

Yellow-Billed Cuckoo Habitat Evaluation

Under the direction of LADWP and the county, Ecosystem Sciences, Inc. (ESI), will evaluate Yellow-billed Cuckoo habitat in woodland areas of Hogback and Baker creeks. ESI will develop habitat enhancement plans for these areas in consultation with LADWP, the lessees for the areas, and the parties to the MOU. The MOU requires that the evaluations be completed by June 2000. Habitat enhancement plans will be implemented as expeditiously as possible.

Status: ESI is preparing draft habitat enhancement plans.



An Owens Valley wetland to be inventoried under the MOU. Photo by Greg James.

Inventories of Plants and Animals at Springs and Seeps

LADWP and the county must complete an inventory of plants and animals at springs and seeps on Los Angeles land in the Owens Valley.

Status: The MOU signatories agreed to extend the deadline for completing this project from June 13, 2000, to December 31, 2000. ESI has nearly completed the fieldwork for the inventory; the reports should be completed by the deadline for this work.

Additional Mitigation

Under the direction of LADWP and the county, ESI will recommend on-site and/or off-site mitigation measures, including mitigation at Hines Spring, to supplement mitigation measures identified in the 1991 EIR for impacts to Owens Valley springs. LADWP is to provide 1,600 acre-feet of water per year to supply the recommended measures. The mitigation measures will be implemented by LADWP and maintained by LADWP and/or the county. Plans for the measures must be completed by June 2000.

Status: ESI has initiated its evaluation of potential mitigation sites.

Owens Valley Management Plans

LADWP, in consultation with the parties to the MOU and others, is to develop management plans for their Owens Valley land. Priority will be given to riparian areas, irrigated meadows, and sensitive plant and animal habitats. The plans will provide for the continuation of sustainable uses, including recreation, livestock grazing, agriculture, and other activities and will consider the enhancement of threatened and endangered species habitats. The planning effort is to begin by 2002, and plans are to be completed no later than 2007. Each plan will contain an implementation schedule and will be implemented in compliance with CEQA.

Status: ESI has completed draft land management plans for Los Angeles land within the LORP area. Planning for LADWP outside the LORP is expected to be completed well ahead of schedule in 2001.

Type E Vegetation Inventory

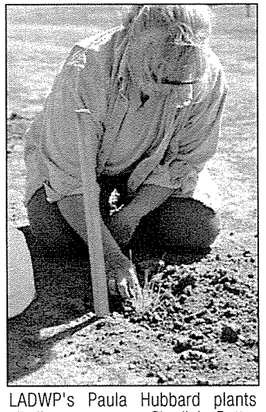
By December 1999, LADWP and the county are to inventory vegetation identified in the Inyo/Los Angeles Water Agreement as "Type E," or irrigated. The data from the inventory will be used as the baseline conditions for management of vegetation under the Water Agreement.

Status: The inventory was completed in 1999.

Aerial Photo Analysis

This element of the MOU is described in "Aerial Photo Study" on page 16 of this issue of the Monitor. The MOU signatories extended the deadline for completing the analysis from June 13, 2000, to December 31, 2000.

Mitigation Plans for Impacts Identified in the EIR



LADWP's Paula Hubbard plants alkali sacaton near Charlie's Butte. Photo by Irene Yamashita.

The EIR identifies approximately 1,300 acres of land in the Owens Valley that were adversely affected by LADWP water gathering. The EIR provides that these lands will be revegetated with plant species native to the valley. By June 1998, the Technical Group was to complete mitigation plans for the areas.

Status: See "Owens Valley Revegetation Program" on page 18 of the Monitor for an update on this MOU project.

Update on Memorandum of Understanding

Leah Kirk, Environmental Project Coordinator

The Memorandum of Understanding (MOU) is an agreement between the California Department of Fish and Game, the State Lands Commission, the Sierra Club, the Owens Valley Committee, the Los Angeles Department of Water and Power and Inyo County. The MOU resolved the concerns of the organizations and state agencies over the Lower Owens River Project and other provisions of the 1991 environmental impact report (EIR) for groundwater management in the Owens Valley.

The MOU requires LADWP and Inyo County to implement numerous environmental projects and studies. Here is a summary of MOU projects and accomplishments during 1999.

Lower Owens River Project

This project was originally a provision of the Inyo/Los Angeles Water Agreement; it was later identified in the EIR as compensatory mitigation for impacts from LADWP's water exports. The MOU augments the Water Agreement and the EIR. As augmented, the LORP consists of:

The Lower Owens River. A 60-mile stretch of the river channel will be rewatered from the point where the river is diverted to the Los Angeles Aqueduct to Owens Lake. Flows in the river will be approximately 40 cubic feet per second (cfs), with higher "seasonal habitat flows" up to 200 cfs.

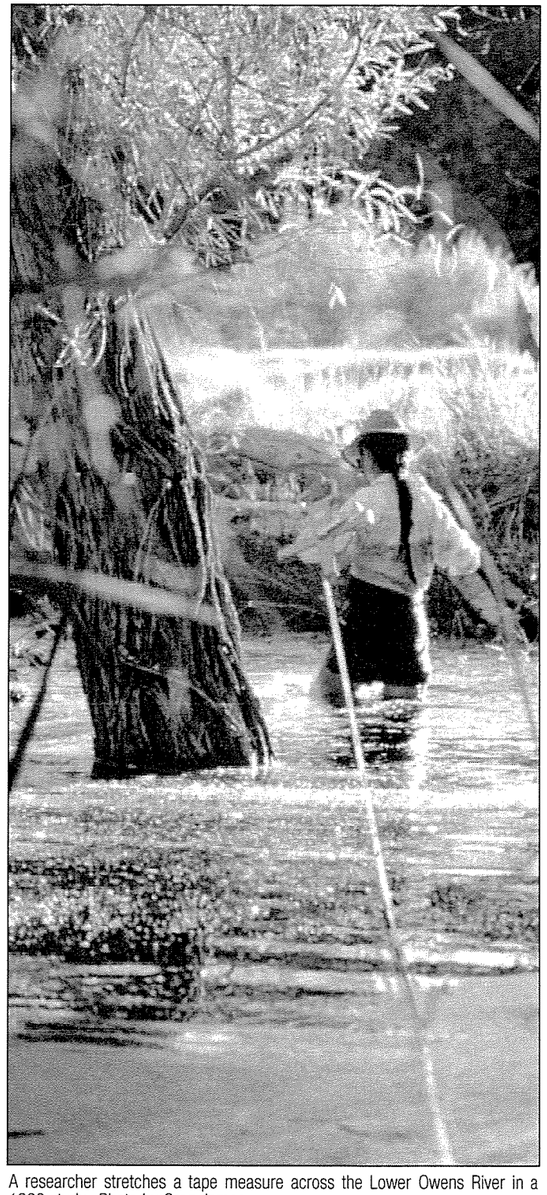
The Owens River Delta Habitat Area. 6-9 cfs will be supplied to an area of wetlands at the north end of Owens Lake to provide habitat for shorebirds, waterfowl, and other animals.

Off-River Lakes and Ponds. Existing off-river lakes and ponds in the LORP area will be maintained for fisheries, waterfowl, shorebirds, and other animals.

The 1,500-Acre Blackrock Waterfowl Habitat Area. In average and above runoff years, approximately 500 acres within an overall project area of 1,500 acres will be flooded to provide habitat for resident and migratory waterfowl and other native species. In drier years, a smaller area will be flooded.

Status: In March 2000, the parties to the MOU agreed to extend the deadline for completing the draft EIR/EIS for the project from June 13, 2000 to September 30, 2000. The draft document is scheduled to be released in late summer 2000 for a 60-day public review. Construction of a pump system to be located near Owens Lake to carry water from the river to the Los Angeles Aqueduct or to Owens Lake for dust abatement should be completed in 2002. Under the MOU, 40 cfs flows must be achieved in the river channel by June 2003.

With the assistance of Congressman Jerry Lewis, Inyo County has obtained about $4.5 million from the federal government to offset the costs of implementing the project. The county is seeking additional federal funds to assist it in meeting its share of the substantial long-term operation costs for the project.



A researcher stretches a tape measure across the Lower Owens River in a 1988 study. Photo by Greg James.

1999-2000 LADWP Groundwater Pumping

Inyo County and LADWP agreed to a maximum groundwater pumping limit of 67,500 acre-feet for the 1999-2000 runoff year (April 1, 1999-March 30, 2000). Actual pumping was 63,699. Table 2 shows planned and actual pumping for 1999-2000 by wellfield (see Figure 1 on page 6, which shows the Owens Valley wellfields).

Table 2. Owens Valley planned and actual groundwater pumping for runoff year 1999-2000

Wellfield	Planned (acre-feet)	Actual (acre-feet)
Lone Pine	1,200	1,238
Bairs-Georges	0	1
Symmes-Shepherd	1,500	1,167
Independence-Oak	7,000	6,981
Thibaut-Sawmill	13,000	12,549
Taboose-Aberdeen	9,500	9,813
Big Pine	22,600	19,512
Bishop	12,000	10,764
Laws	700	1,674
Total	**67,500**	**63,699**

Owens Valley Water Uses

Water uses on LADWP's Owens Valley lands for the 1999-2000 runoff year were 95,676 acre-feet. These uses included irrigation, stockwater, LADWP recreation and wildlife, and enhancement/mitigation. Irrigation refers to water used to irrigate LADWP lands, such as pasture or alfalfa, leased to ranchers. Stockwater is water released in ditches and canals for livestock on LADWP lands in the valley. Recreation and wildlife refers to LADWP water releases, initiated between 1970 and 1984, to areas such as Buckley and Rawson ponds west of Bishop, Farmers' Pond north of Bishop, and Thibaut Ponds near Indepepndence. Enhancement/mitigation (E/M) refers to projects developed by Inyo County and LADWP to improve the value or attractiveness of an area or to moderate or eliminate effects of former LADWP pumping practices. The projects include Klondike Lake, Lone Pine Riparian Park, treelots in Independence and Lone Pine, several pastures and alfalfa fields, and the water releases since 1986 to the Lower Owens River. Table 3 shows Owens Valley water uses by area.

Table 3. Owens Valley water uses for runoff year 1999-2000

Area	Irrigation	Stockwater	E/M	Recreation & Wildlife	Totals
Round Valley	10,619	1,016	0	955	**12,590**
Bishop	19,539	3,368	0	3,838	**26,745**
Laws	410	1,272	1,494	0	**3,176**
Big Pine	12,750	1,427	1,482	656	**16,315**
Tinnemaha to Haiwee Reservoir	5,990	7,363	21,476	2,021	**36,850**
Totals	**49,308**	**14,446**	**24,452**	**7,470**	**95,676**

LADWP Pumping and Uses on the Bishop Cone

Each year, ICWD and LADWP conduct an audit of LADWP's groundwater extraction and water uses on Los Angeles land in the area surrounding Bishop commonly referred to as the "Bishop Cone." The Inyo/Los Angeles Water Agreement requires that, in any runoff year, LADWP's groundwater extraction may not exceed the amount of water used on its Bishop Cone lands. (A 1998 court decision may affect LADWP's pumping on the Cone.)

The Water Agreement defines water uses as the amount of water supplied to Los Angeles land on the Bishop Cone less any return flow to the Los Angeles Aqueduct system. Uses include irrigation, stockwater, and recreation, as well as conveyance losses (i.e. water seepage from canals and ditches). Groundwater extraction is defined as the sum of all groundwater pumped by LADWP on the Bishop Cone plus the amount of artesian water that flowed out of uncapped wells on Los Angeles land on the Cone during the runoff year.

Table 4. Summary of Bishop Cone audits performed to date.

Runoff Year (April 1-March 31)	Uses (acre-feet)	Groundwater Extractions (acre-feet)
1995-1996	31,073	9,006
1996-1997	25,098	14,421
1997-1998	22,750	15,541
1998-1999	21,825	10,073

LADWP collects the pumping and surface water information at mutually agreed upon measuring stations and provides that data to the county. ICWD performs the audit and reports on the water uses and groundwater extractions on the Bishop Cone. Table 4 shows the results of Bishop Cone audits performed to date.

Owens Valley Wellfields and LADWP Pumping 1972-1999

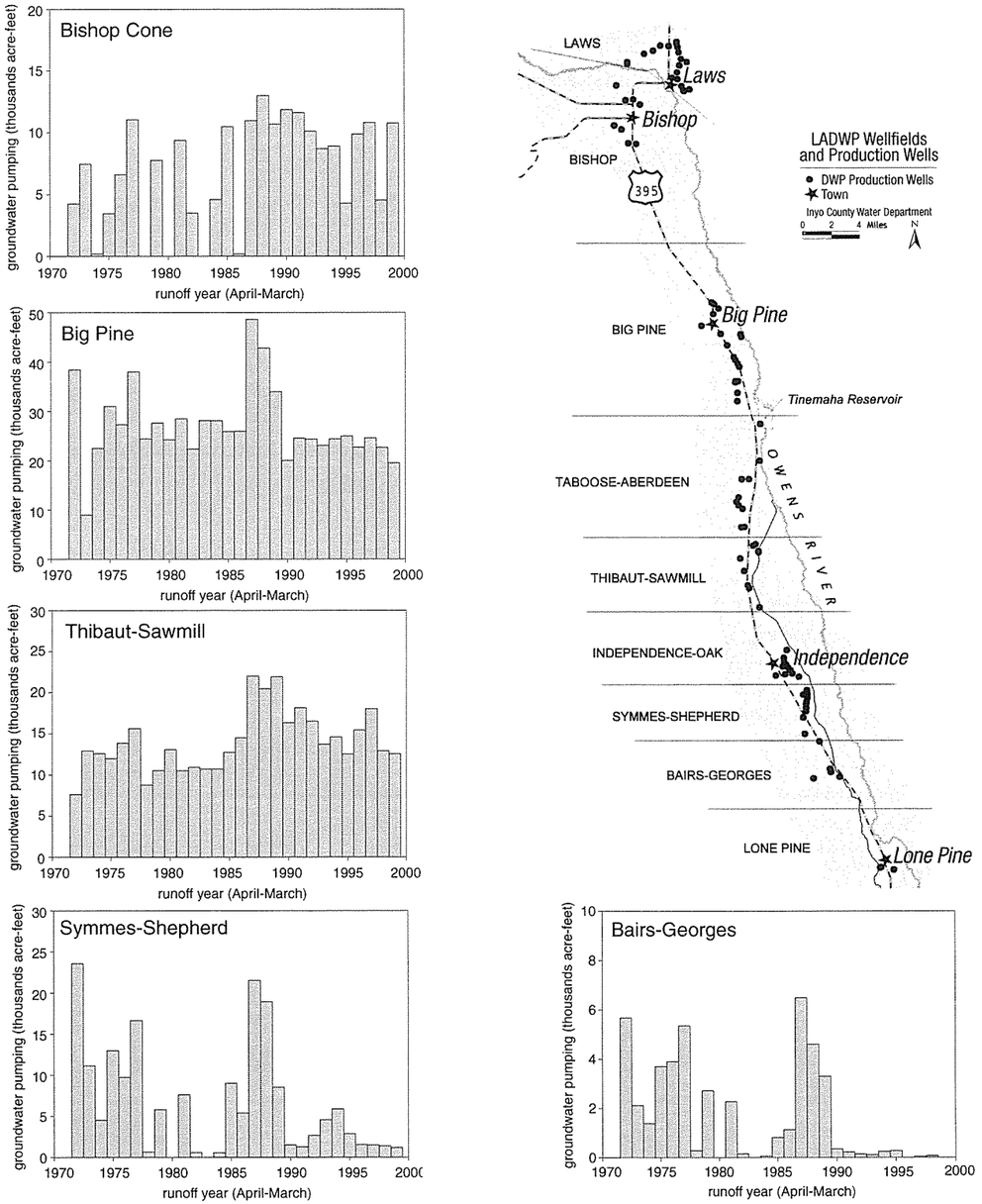


Figure 1. General north/south boundaries of LADWP wellfields, and LADWP pumping by wellfield from 1972 to 1999. (Note that the scale for pumping varies by wellfield).

Saltcedar Control Program

Brian Cashore, Saltcedar Control Project Coordinator

The effects of agriculture, dam construction, groundwater pumping, livestock grazing, urbanization, and other human activities have led to the decline of many southwestern riparian vegetation communities. Invasive weed establishment is often a by-product of such disturbance. The dry Lower Owens River channel exemplifies some of these processes in action.

1999 saltcedar control crew: from left to right, Brian Cashore, Jerry Zatorski, Bill Howe, Chuck Spresser, Rick Puskar, Nathan Reade, and Jason Denio. Lori Gillem, also a crew member is not in the photo.

If you had visited this stretch of the river between October 1999 and March 2000 you would have seen the Inyo County Saltcedar Control Program crew clearing the channel of a virtual monoculture of approximately thirty-year-old saltcedar, or tamarisk, trees. The saltcedar control work was focused in this area this year to prepare the channel for the impending water releases to the river channel as part of the Lower Owens River Project. Though we exceeded our goals for the season, there is still much work yet to be done. We have witnessed firsthand that a century of human disturbance to a riparian ecosystem cannot be reversed within a few seasons.

This year's work was accomplished with our largest crew yet, including Jason Denio, Lori Gillem, Bill Howe, Rick Puskar, Nathan Reade, Chuck Spresser, Jerry Zatorski, and myself. We alternated jobs throughout the day between cutting with chainsaws and brushcutters, spraying cut stumps, and "swamping," or clearing limbs and logs. Each day found us either working our way south along the banks of the dry Lower Owens River channel or cutting for days at a time on the adjacent flood plain benches, where dense thickets of thirty-year-old trees grew. These populations were established when runoff water released to the river during wet years deposited saltcedar seeds at the high-water points. It was always satisfying to look north and see the channel cleared of saltcedar, with an occasional willow tree, now free from competition, ready to re-colonize. The view to the south required philosophical thinking or a great sense of humor.

While the crew cleared an impressive 9 river miles of tamarisk this season the old-fashioned way, we sometimes wondered about our own competition. The newest tool in controlling saltcedar in the Owens Valley may be aliens. Legal ones from China. *Diorhabda elongata* is a tamarisk leaf-eating beetle that has been tested in quarantine in the U.S. for over ten years. The Saltcedar Control Program and LADWP are participating in a small-scale test of the effectiveness of these aliens in the valley. The study is being conducted by scientists from the U.S. Department of Agriculture. Eli Asarian, an ICWD college intern last summer, was invaluable in his assistance with this project as well as with other saltcedar work.

As new arrivals, the beetles seemed a little disoriented at first, but they eventually began feeding and reproducing on the contained test plants. The insects are extremely species-specific and have not demonstrated the ability to feed on any plant family other than that of the tamarisks. If successful, these beetles could eradicate up to 80% of the local saltcedar plants without herbicides, chainsaws, or harm to the native vegetation. If the USDA and the California Department of Food and Agriculture ultimately approve the use in California of biological control agents, such as the Chinese beetle, the Saltcedar Control Program will consider their use in the Owens Valley. This decision would be subject to a public environmental review process.

A landscape, such as the Owens Valley floor, that has experienced multiple disturbances over many years will reflect those changes in a variety of ways. The saltcedar in the valley and along the river is one such reflection. To restore a portion of the Owens Valley environment to a former or more natural state will require a tremendous amount of energy and expense. The Inyo County Saltcedar Control Program is attempting to reverse processes that began long ago, while getting the "biggest bang for the buck" out of available funding. Right now, that means cutting the plants down and treating the stumps. Biocontrol and other new techniques may offer promise, and we will always be open to options.

Someone looking ahead at the work yet to be done may question whether it is all worth it. What is the value of a monoculture of saltcedar versus a native riparian system? The answer involves taking responsibility for past disturbances and then deciding whether we should attempt to repair them or accept these altered lands as they are.

Owens Valley Revegetation Program

Irene Yamashita, Revegetation Project Coordinator

The EIR for the Inyo/Los Angeles Water Agreement, which describes the impacts of LADWP's groundwater pumping from 1970 to 1990, identifies more than 1,000 acres that were adversely affected by pumping. The EIR commits LADWP to implement mitigation measures for these impacts. LADWP and ICWD have developed mitigation plans for these lands. The plans are being implemented through the Owens Valley Revegetation Program.

As part of the implementation of this program, LADWP completed the fencing for nine of the 10 mitigation sites (see Figure 6). This measure alone could help stimulate recruitment of native species by reducing surface disturbances that can leave the sites susceptible to wind erosion.

No revegetation work is planned for the site near Hines Spring until ICWD and LADWP can evaluate the influence a mitigation project at the spring that is currently in the planning stage will have on the surrounding area.

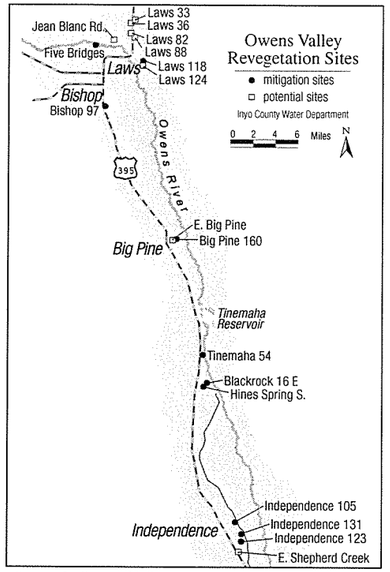


Figure 6: Owens Valley revegetation sites.

Mitigation site monitoring began this year. At six of the fenced sites, permanent transect posts were installed by LADWP, and ICWD and LADWP established long-term photo points. These transects and photos will be used to monitor changes in plant cover and composition over time. Two sites are behind schedule for installation of transect posts and another site, Five Bridges, was established as a mitigation site in 1988 and has vegetation transect data collected annually. All transect post and photo point locations are being stored in ICWD's Geographic Information System for future reference.

The baseline vegetation data collected in 1999 at six of the sites showed native perennial cover varying between 0.6% and 8.4%. Weed cover composed 90% to 95% of the vegetation cover at the three abandoned agricultural (ABAG) sites, Laws 118, Bishop 97, and Big Pine 160. In comparing the 1999 total vegetation cover (weeds and natives) to final cover goals, we found that the ABAG sites, although weedy, had greater cover than their respective final cover goals. This indicates that the cover goals for the ABAG sites are reasonable. These sites are capable of supporting their cover goals during a year with less than normal precipitation.

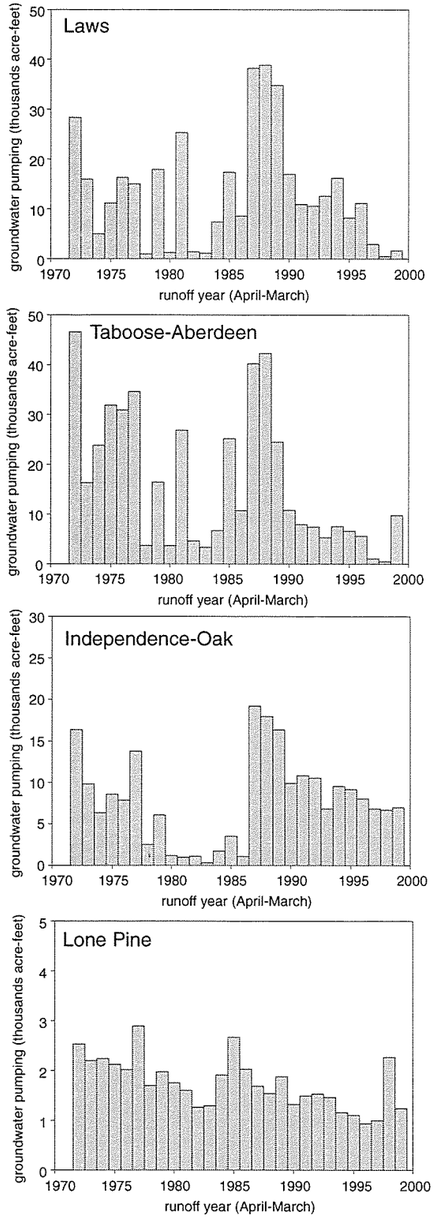
In contrast, the three groundwater-impacted sites that were monitored in 1999, Tinemaha 54, Blackrock 16E, and Independence 105, had lower total cover than their respective goals. The cover goals for these sites apparently can not be maintained by precipitation alone and will probably require a period of soil moisture recovery to attain and sustain their cover goals.

Due to time constraints and the low seed production year, only scant quantities of seeds were collected in 1999. However, two new species were added, inkweed (*Sueada moquinii*) and desert prince's plume (*Stanleya pinnata*), to the program's seed bank. These additions bring the number of native plant species in the seed bank to twenty-two.

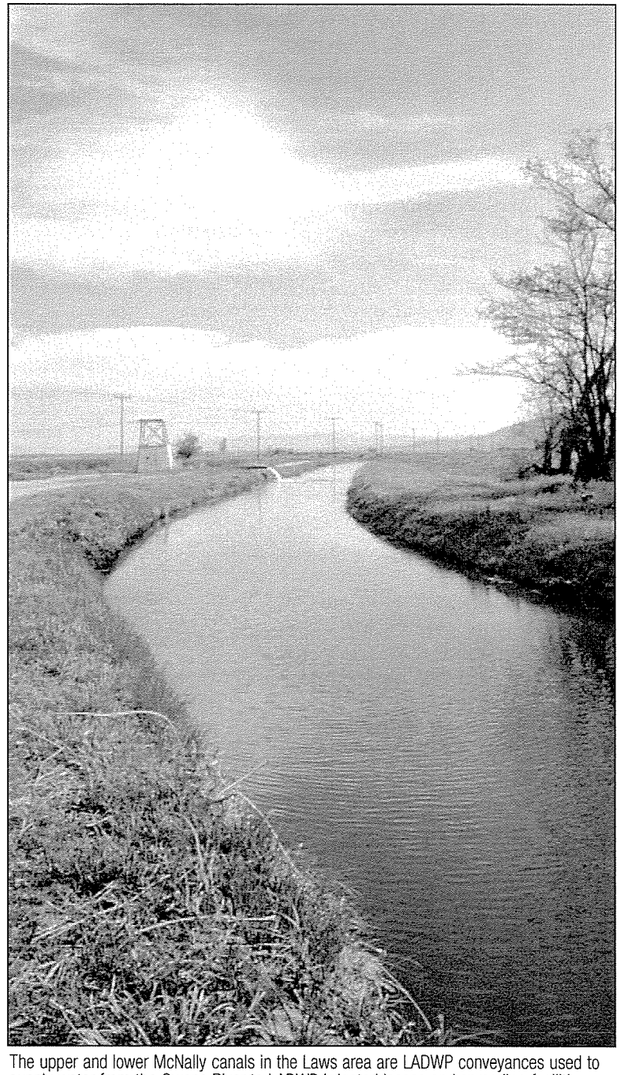
Weed control in 1999 was performed for Russian thistle (*Salsola tragus*), perennial pepperweed (*Lepidium latifolium*), and saltcedar (*Tamarix ramosissima*). Three hundred leaf-mining moths were released at the Big Pine 160 revegetation site, and near Jean Blanc Road north of Laws. These moths specialize in eating Russian thistle. The USDA and the Inyo County Agriculture Commissioner first introduced this moth into the valley in 1988 with little success. However, it is hoped that their presence may reduce the competitive ability of Russian thistle at these sites. LADWP continued its annual application of broadleaf-specific herbicide on perennial pepperweed near the Five Bridges area north of Bishop. And the ICWD saltcedar crew removed saltcedar from Independence 131. This site will require a minimal amount of follow-up treatment.

In 1999, alkali sacaton (*Sporobolus airoides*) plants were grown at the Deepest Valley Native Plant Propagation Center at the White Mountain Research Station. Staff from ICWD and LADWP planted 108 alkali sacaton plants at Tinemaha 54 (near Charlie's Butte) in the autumn. These plants were watered during planting and were provided monthly supplemental water during the very dry winter. We plan to continue irrigating during the growing season for two to three years.

Along with LADWP, ICWD developed a request for proposals to solicit proposals for irrigation systems and revegetation studies at two sites, Laws 118 and Independence 131. Early in 2000, we selected the consulting company SAIC, of Las Vegas. The work should begin in summer 2000.



McNally Canal



The upper and lower McNally canals in the Laws area are LADWP conveyances used to supply water from the Owens River to LADWP irrigated leases and spreading facilities. These canals are the primary source of recharge to the Laws area. LADWP also uses the canals to convey groundwater pumped from the Laws wellfield to the river for export to Los Angeles.

GROUNDWATER CONDITIONS

When LADWP inventoried Owens Valley vegetation between 1984 and 1987, water tables were generally high throughout the valley because of a series of wet years (1982-86) and relatively low groundwater pumping. The vegetation mapped during that period, which became the baseline for management under the Inyo/Los Angeles Water Agreement, reflected these conditions.

Following the inventory, during the first three years of the six-year drought, LADWP pumped approximately 210,000 acre-feet (1987), 200,000 acre-feet (1988), and 155,000 acre-feet (1989). Water tables declined in most wellfields to substantially below the plant root zones, and as a result, the vegetation declined.

In 1990, in recognition of the decline in water tables and vegetation and the experimental nature of the management techniques of the Water Agreement, the Inyo/Los Angeles Standing Committee adopted the "Drought Recovery Policy." The policy required that groundwater pumping be managed in a conservative manner to allow substantial recovery of water tables, soil moisture, and vegetation. Since then, LADWP's pumping has been lower than the pumping of the late 1980s (see Figure 1 on page 6). In response to both lower pumping and several high runoff years, water tables rose during the 1990s.

Figure 2a shows the magnitude of drawdown that occurred at 192 shallow monitoring wells between the baseline period for hydrology (1985 to 1987) and 1992, the last of six consecutive dry years. Figure 2b shows the difference between baseline water levels and April 1999 levels at 176 monitoring wells. The circles in this figure are shaded according to different criteria to show how close the test wells are to baseline levels. Baseline groundwater levels are the average April water levels from 1985 to 1987. The gray background shows the area within 1.5 miles of LADWP pumping wells.

Areas of greatest water table decline in Figure 2a (white circles) coincide with the locations of highest groundwater extraction. In Figure 2b, many of the monitoring wells that are the furthest from recovery to baseline (white circles) are also near areas where the greatest amount of pumping has occurred. Comparison of Figures 2a and 2b shows that some monitoring wells have recovered in response to the high recharge and pumping managed under the Drought Recovery Policy; however, many wells remain below baseline levels (white circles).

In the Laws area, north of Bishop, water tables were drawn down well below four feet between the baseline period and 1992 (Figure 2a). However, in 1999, several monitoring wells in the area were at baseline or above (Figure 2b). These high water table levels were the result of recharge induced by LADWP's operation of the McNally canals and water spreading in the Laws area during the summer of 1998. Water levels in some monitoring wells rose over 10 feet in that year. Water levels in the Laws area declined in 1999 in response to pumping and low recharge.

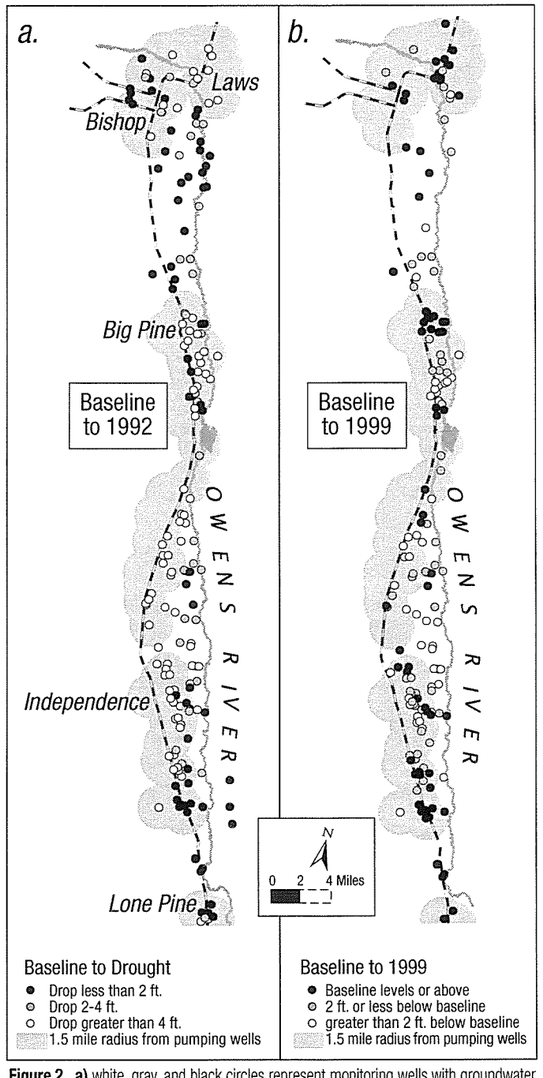
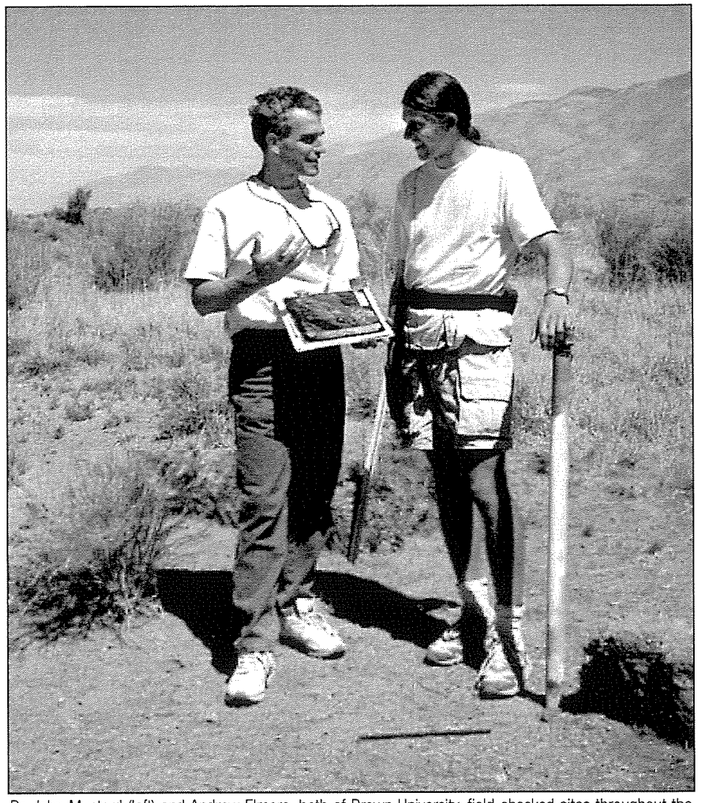


Figure 2. a) white, gray, and black circles represent monitoring wells with groundwater declines from baseline to 1992 of greater than four feet, from two to four feet, and less than two feet respectively; and **b)** white, gray, and black circles represent the deviation below baseline water levels, as of April 1999, of greater than two feet, two feet or less, and at or above baseline respectively.

natural climate variability should not adversely affect natural vegetation. This theory is based in part on the known drought tolerance of these plant communities. The long-term record of precipitation in the Owens Valley reports several droughts equal to or greater than the six-year drought that occurred in the last decade. Had these droughts led to effects as large as what we saw in the decade, it is unlikely that vegetation conditions recorded by LADWP prior to the drought would have been the same. Therefore, we needed to include human activities in our analyses of potential causes. Based on our fieldwork and a comparison of groundwater levels and vegetation changes, we attributed groundwater pumping by LADWP, which caused a drop in water tables across the valley, to the large decreases in live cover.

The Landsat TM satellite imagery allows us to extend ICWD's field measurements to a regional scale. Therefore, our results broaden the scope to the entire valley, instead of limited point measurements. Our results are as follows: Some meadow and shrub-meadow communities affected by pumping and insufficient recharge showed a greater than 50% decrease in live cover in more than 5%, or 12,500 acres, of the study area. An additional 15%, or 37,500 acres, of the groundwater dependent shrub and meadow communities were affected to a lesser extent by the same drivers. In many of these areas, the imposed stresses have resulted in a shift towards communities dominated by non-native annuals, rather than native perennial grasses and shrubs. Communities which were already dominated by annuals were least likely to be affected by pumping, but showed a strong dependence on annual rainfall. This response was observed over 22%, or 55,000 acres, of the study area. Modest increases in live cover were found in 3%, or 7,500 acres, of the study area, much of this attributable to irrigation practices. Within the limits of our observations, the remaining 55%, or 137,500 acres, of the study area was left largely unchanged despite low annual precipitation, primarily because these communities are either not dependent on groundwater or lie in



Dr. John Mustard (left) and Andrew Elmore, both of Brown University, field-checked sites throughout the valley to see how vegetation conditions compared to remotely sensed data. Photo by Sally Manning, ICWD.

regions of the valley where there was little change in the depth to groundwater over the 16-year study period.

In this study, we have found that intense land use coupled with natural climate variability can have far reaching effects on a semi-arid ecosystem such as the Owens Valley. Most significantly, these forces can result in a shift toward communities dominated by non-native annuals (weeds). We saw this shift go to completion (100% weeds) in 1%, or 2,500 acres, of the study area, and while our analyses are still underway, we consider this to be a significant change. Over 10%, or 25,000 acres, of the study area showed some increase in weed live cover. Land use history studies have shown that areas that experienced pumping- and drought-induced shifts towards weed-dominated systems during the past 100 years often remained in this unnatural state for several decades. The consequences of this type of non-elastic change are understudied, however, likely will include issues of loss in biodiversity (both plant and animal) and changes in water, carbon, and nitrogen budgets.

The remote sensing study will continue for at least another year. Results of the study may be used to develop a tool to predict on a regional scale the effects of drought and groundwater pumping on Owens Valley vegetation.

AIR PHOTO STUDY

Sally Manning, Vegetation Specialist & Leah Kirk, Environmental Project Coordinator

As part of the EIR for the Inyo/Los Angeles Water Agreement, and the MOU that resolved concerns over the adequacy of the EIR, the county and LADWP agreed to conduct an evaluation of existing air photos of the Owens Valley and to consider how to use air photos or other forms of remote sensing in future management. In December 1998, Ecosat Geobotanical Surveys, Inc., was hired to carry out the first phase of this important Inyo/Los Angeles cooperative study. Ecosat's tasks are to:

- evaluate the merits of using air photos to monitor vegetation conditions and changes in the valley,
- determine whether the photos can be used to describe vegetation changes that have occurred in the valley,
- determine the feasibility of using air photos to analyze and refine the Owens Valley vegetation map data base.

The study is to be conducted in two phases. The first phase involves testing air photo interpretation techniques by evaluating existing air photos of certain areas of the valley. The second phase will be the expansion of the evaluation to other areas of the valley.

Ecosat's first tasks were to request, locate, then acquire all the materials, data, and reports necessary to accomplish the study. This entailed examining existing aerial photo sets from 1944, 1968, 1981, and 1996 and satellite imagery from 1973. In the course of the examination, they determined that the 1981 photos should be re-printed from negatives, so this was done. They also reported that the 1968 photographs were of poor quality, but the negatives could not be found for re-printing. Unfortunately, Ecosat will not be able to analyze these photos to the same level as the photo sets for the other years.

Ecosat worked with ICWD and LADWP to define the "Phase 1" study areas. During Phase 1 of the aerial photo study, efforts were to be focused on key areas that include a broad range of vegetation types present in the valley. Five areas around Laws, Big Pine, Hines Spring, Blackrock Fish Hatchery, and Independence were identified, totaling approximately 15,000 acres.

Ecosat then delineated polygons, or units, of relatively homogenous vegetation and traced these polygons onto scanned images of the 1981 aerial photos. The result was a more detailed baseline vegetation map than is currently used by ICWD and LADWP. Next, using existing ICWD vegetation data and data collected during Ecosat's field visits to the valley, Ecosat developed a classification scheme for Owens Valley's vegetation. The plant community types that resulted from this analysis will serve as the legend for attributing the new map of baseline vegetation conditions.

Currently, Ecosat has turned its attention to attempting to identify vegetation changes from the aerial photographs from 1944 through 1996. For this task, Ecosat needs information on land use and hydrology, such as fire, water spreading, wildlife and livestock usage areas. ICWD and LADWP are working to assemble those data. Ecosat is also preparing for its accuracy analysis of the interpretations of the aerial photo sets. This necessary step estimates the accuracy level of the features the interpreters identify.

The first phase of the aerial photography study will be completed during 2000. After reviewing the results of the study, Inyo County and Los Angeles will decide whether to proceed to phase two of the study. In Phase 2, the aerial photo study tasks would be performed for the entire Owens Valley.

REMOTE SENSING STUDY

Andrew Elmore, Brown University

Since 1997, a team of researchers from Brown University has worked with ICWD scientists on a remote sensing study of Owens Valley vegetation. The study integrates ICWD's groundwater, vegetation, and other field data with Landsat TM satellite data to analyze changes in vegetation cover. The purpose of the study is to understand how Owens Valley's vegetation responds over time to climatic and anthropogenic forces. The area under study covers approximately 250,000 acres of Los Angeles land from the Inyo County line in the north to Lone Pine. The east and west boundaries are the lower alluvial slopes of the Sierra and Inyo/White ranges. Andrew Elmore, of Brown University, submitted the following report on recent progress.

In the past year, we analyzed a 16-year (1984-1999) database of vegetation live cover in the study area to identify areas that have changed significantly during this period. Changes identified included large and small decreases and increases in live cover; however, much of the study area has not shown any significant change. In addition to identifying areas of change, we attempted to attribute these changes to the corresponding driving forces.

Large-scale changes in semi-arid vegetation, such as that found in the Owens Valley, are not considered natural phenomena. Past studies and common sense suggest that

VEGETATION CONDITIONS

Sally Manning, Vegetation Scientist

High runoff coupled with low pumping amounts during 1998 helped raise water tables at most locations throughout the Owens Valley. Therefore, when monitoring wells were read during spring 1999, water tables had come up from the previous year's levels, perpetuating the mostly upward trend since the end of the 1987-92 drought. Although water table conditions improved, there was extremely low precipitation both prior to, and continuing into, the 1999 vegetation growing season (see "Owens Valley Precipitation" on page 4).

METHODS

During summer 1999, ICWD's vegetation research assistants ran 1,457 transects in 90 vegetation parcels. The parcels visited were from south of Lone Pine to north of Bishop and were located in both wellfield areas (within the range of influence of LADWP groundwater pumps) and in areas not affected by pumping (control areas). ICWD's program of annually inventorying a subset of LADWP vegetation parcels began in 1991. The purpose of the program is to assess the current year's conditions and compare them with the Inyo/Los Angeles Water Agreement's "baseline" conditions as defined by LADWP's 1984-87 vegetation map.

The 1999 vegetation data were analyzed in conjunction with an ICWD-derived depth-to-water table (DTW) model prepared using the spring season water level data. The DTW estimates yielded by the model allow us to identify which Owens Valley areas experienced water table recovery to the level where it had been during the baseline years, 1985–1987 for hydrology. The average April DTW during the baseline years was used as the target for water table recovery. After reviewing all the data for 1998 (which followed a wet year on the valley floor) and 1999 (which followed a dry year) it appeared that, when the modeled water table for a given parcel reached average baseline depth or rose above that depth, there was a high probability that the cover of perennial species within the parcel reached or exceeded the measured baseline perennial cover amount. However, when water tables failed to rise to baseline, full perennial recovery rarely occurred.

VEGETATION PARCEL CATEGORIES

Of the 90 parcels monitored during 1999, 32 of them were determined to be controls (not directly or measurably affected by pumping). The remaining 58 were believed to have been affected by pumping since the baseline vegetation mapping period. Using water table and vegetation data, it was concluded that 30 of these parcels had yet to experience both water table and perennial vegetation recovery to baseline levels. Because of this, it was recommended that groundwater pumping within the area of these parcels continue to be subject to the provisions of the Drought Recovery Policy (DRP). The DRP calls for pumping to be managed in an environmentally conservative manner until there has been substantial recovery in soil moisture and water table conditions in areas of groundwater dependent vegetation that have been affected by pumping. The 30 DRP parcels occurred in all but the Lone Pine wellfield.

Twenty-two parcels had experienced water table and perennial cover levels equal to or exceeding baseline conditions. Thus, these parcels were determined to be free from the DRP (DRPfree). For these, it was recommended that management proceed according to conservative management guidelines being discussed by Inyo County and Los Angeles. These parcels occurred in all but the Bairs-Georges wellfield.

For six parcels, located in the Taboose Aberdeen, Laws, and Independence wellfields, a determination regarding status according to the Drought Recovery Policy could not be made due to limits in available information, such as water table depth.

RESULTS

Each year, I calculate the percent change in perennial cover relative to baseline. The calculated values are then averaged for the Control, DRP, and DRPfree parcel groups. Results for 1999 were used to update a graph of vegetation change maintained since 1991 (see Figure 3). I also look at the average percent cover of species by life form. A comparison of the percent cover of grasses, shrubs, weeds, and "others" (generally forbs) between baseline and 1999 is presented in Figure 4.

General trends measured in the 1999 vegetation data were as follows:

Control Areas: Perennial cover exceeded baseline levels, despite low 1999 precipitation (Figure 3). The higher cover was the result of increases in grasses and/or shrubs, but neither species growth form showed universally higher cover in 1999 than baseline (Figure 4).

Parcels Still Subject to the DRP: Perennial cover was significantly below baseline levels (Figure 3). The low cover was primarily the result of significantly lower grass cover in 1999 compared with baseline (Figure 4).

Parcels Free from the DRP: Like the control parcels, perennial cover exceeded baseline (Figure 3). Increased shrub cover relative to baseline appears to have significantly contributed to the higher perennial cover than measured during the baseline period (Figure 4).

VEGETATION CONDITIONS BY WELLFIELD

Below, water table trends and vegetation conditions are presented for each of the nine Owens Valley wellfields. The various wellfields are roughly defined, usually by the creeks that feed them (see Figure 1 on page 6). They also vary in size and in the number and capacity of pumps within them. Previous studies

have indicated that the effective rooting depth of Owens Valley groundwater dependent shrubs is 4 meters; therefore, in the following discussion, I note when water tables averaged below 4 meters. (Owens Valley grasses, however, typically root to about 2 meters.) The following discussion proceeds up the valley from south to north. The number following the wellfield name is the total acre-feet (AF) of water pumped from that wellfield during 1984-1998. (See Figure 1 on page 6).

Lone Pine (25,229 AF): Beginning in 1987, water tables dropped below baseline levels in this relatively small wellfield, apparently due to pumping and/or drought. Although they declined, average water tables did not drop beneath 4 meters for the four parcels that we monitor in the Lone Pine area. Water tables began to rise in 1993 and have been in the baseline range since about 1996. It appeared that pumping only affected one of the four parcels. Perennial cover in the affected parcel has generally increased since the end of the drought, and in 1999 it equaled baseline conditions. This parcel was categorized as DRPfree.

Bairs-Georges (17,826 AF): Pumping reached an all-time high in 1987, but since 1990 pumping has been greatly reduced. Pumping and the drought led to water tables falling below 4 me-ters in the one large parcel containing groundwater dependent Nevada saltbush scrub that we monitor in this wellfield. By 1991, perennial cover in this parcel was less than two-tenths of what it had been during baseline. However, when pumping was decreased in 1990, water tables began to climb. Although the water table rose above the baseline average in 1996 and has remained above baseline since then, recovery of perennial species has been slow. Perennial cover peaked in 1998 at about seven-tenths of baseline, but declined again in 1999 to less than half of baseline; therefore, in 1999 it was still categorized as DRP.

Symmes-Shepherd (82,683 AF): Although pumping has been significantly reduced in this wellfield since the high amounts pumped in the late 1980s, water tables have risen very slowly. By 1999, water tables under five of the six parcels monitored in this wellfield had not recovered to baseline levels; similarly, perennial cover was also below baseline for these five parcels. All five are located east of Highway 395 and were categorized as DRP. Both water table and perennial cover exceeded baseline in one parcel in this wellfield located west of Highway 395.

Independence (145,303 AF): Pumping in this wellfield peaked in 1987 and has been reduced somewhat since then. Pumping occurs in this wellfield to supply the Independence Springfield Enhancement/Mitigation and other irrigation projects near Independence. We monitor five wellfield parcels near Independence. The two located closest to town, one to the north of town and one to the east, are still considered DRP. Neither parcel has experienced water table recovery to the baseline level. Perennial cover in both parcels exceeded baseline in the wet year, 1998, but cover declined in both parcels in 1999,

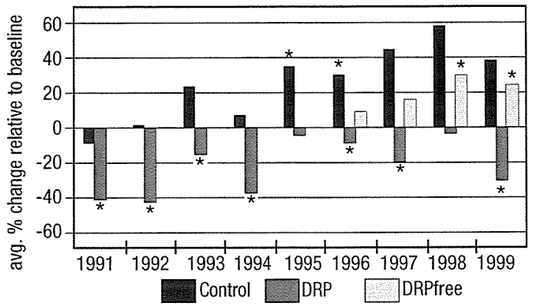


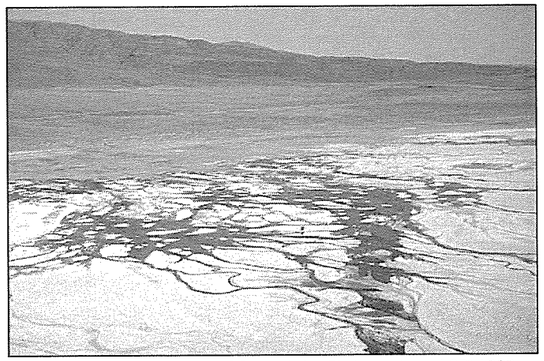
Figure 3. Changes in perennial plant cover relative to baseline for parcels monitored 1991-99. Control parcels are those presumed to have not been affected by pumping since 1985. There were 32 parcels in this group in 1999. Cover for the Control group has significantly exceeded baseline cover since 1995 (statistical significance is indicated by asterisks). Parcels in the DRP group are those in which either water tables or perennial plant cover or both have failed to recover to baseline levels. There were 30 parcels in this group in 1999. Average perennial cover for the DRP group has been significantly below baseline in all but the wettest years (1995 and 1998). Beginning in 1996, some parcels began to show water table and perennial cover improvement, so the DRPfree group was created for parcels in which both water tables and cover returned to or exceeded baseline. In 1999, there were 22 parcels in this group, and their perennial cover averaged significantly above baseline in 1998 and 1999.

with cover in the northern parcel falling below baseline levels. Baseline perennial cover recorded for the eastern parcel was unusually low and original field data cannot be located; therefore, it is hoped that the aerial photo study will help better describe baseline conditions for this particular parcel and a few others like it (see "Aerial Photo Study" on page 15). Two of the DRPfree parcels are located near Fort Independence, and although the area is hydrologically complex, they appear to have experienced both water table and perennial recovery to baseline level. The other DRPfree parcel straddles the aqueduct east of town, and it has also shown water table and perennial cover levels comparable to baseline.

Thibaut-Sawmill (253,293 AF): Approximately 13,000 AF per year are routinely pumped from this wellfield to supply the Blackrock Fish Hatchery. Each year during 1987-89, over 20,000 AF were pumped. The constant pumping seems to have lowered the water tables to the east of the Los Angeles Aqueduct (east of the pumps), but water tables beneath the two eastern parcels that we monitor were never below 4 meters. Perennial cover in these parcels typically hovers near baseline level or exceeds it. In the remainder of this wellfield, four meadow parcels are monitored. The water table had dropped well below baseline in three of these by 1989, and has not shown obvious recovery since then. 1999 perennial cover in these three DRP parcels was below baseline. The other parcel is categorized as DRPfree because its perennial cover never declined significantly below baseline, in recent years its cover has exceeded baseline and, although its water table showed decline since 1986, it never fell below 3 meters. (The water table in the latter parcel is probably buffered by ditches that flow through and around it.)

OWENS LAKE GROUNDWATER EVALUATION

Under an agreement with the Great Basin Unified Air Pollution Control District (GBUAPCD), LADWP must control dust from 10 square miles of Owens Lake by 2001. By 2006, LADWP must have implemented sufficient dust control on the lake so that federal air quality standards are met. Water necessary to implement these measures will be supplied from diversions from Los Angeles Aqueduct.



"Mill Site" seeps on east shore of Owens Lake. Photo courtesy of GBUAPCD

In the summer of 1998, LADWP proposed pumping groundwater from Owens Lake to obtain some of the water that will be needed to supply its dust control measures. The county became involved with the proposal because groundwater pumping by LADWP in Inyo County is subject to the Inyo/Los Angeles Water Agreement.

The county and LADWP jointly selected the firm of Camp Dresser & McKee to assist in an evaluation of the proposed pumping. CDM was given three tasks: (1) solicit input from the public regarding the environmental criteria by which groundwater pumping should be managed, (2) evaluate a proposal by LADWP for short-term pumping to supply a pilot dust abatement project at the lake, and (3) prepare a work plan for an evaluation of LADWP's proposal for long-term pumping from the lake. The consultants' work was conducted under a program called the Owens Lake Groundwater Evaluation (OLGE). The conclusions of the OLGE will be presented to the Inyo/Los Angeles Standing Committee and to the public in June.

During the course of the OLGE, CDM conducted a series of public workshops and interviews with interested citizens to hear their views. CDM reported that, in general, they wanted no change in water quantity or quality at non-LADWP wells, no damage to structures through land subsidence, no adverse changes to vegetation, and no loss of wildlife habitat. The result was a set of recommended standards and objectives for pumping at Owens Lake.

To evaluate the LADWP proposal for groundwater pumping in the short term, from 1999 to 2001, to supply the pilot project, CDM modified a groundwater model developed by the Desert Research Institute of Reno, Nevada, for GBUAPCD. The model was used to predict impacts to seep and spring flows and reductions of vegetation around the perimeter of the lake. However, the model tended to under-predict the amount of water table drawdown when the model results were compared with the actual drawdown that occurred during an aquifer test conducted by GBUAPCD near the Owens River Delta last year.

In September 1999, LADWP announced that it would not pursue short-term groundwater pumping to supply the pilot dust control project. LADWP said the OLGE had shown additional studies were needed to determine the amount of pumping, if any, that could take place without causing undesirable environmental impacts at the lake.

With regard to its final task of developing recommended studies to evaluate the feasibility of conducting long-term pumping from the lake, CDM developed a draft work plan that outlines recommended future studies and monitoring at Owens Lake. CDM's plan includes studies to address (1) the physical characteristics that affect the flow, storage, and quality of groundwater; (2) the lake's water budget (or the quantities of water that enter and leave the lake basin); and (3) the relationship between the groundwater basin and other environmental factors, such as native vegetation, wetlands, and private wells.

In June 2000, CDM presented its recommendations at its final workshop in Lone Pine. LADWP has said that, because of the amount of work involved in implementing dust control measures on the lake, it does not plan to decide whether to move ahead with the evaluation of its proposed long-term pumping from the lake for at least the next year or two.

If LADWP proposes pumping at Owens Lake in the future, in consideration of CDM's recommendations, Inyo County and LADWP would conduct a program of studies and monitoring at the lake. A public process would once again take place to inform the public of the pumping proposal and its potential impacts. Any pumping will be governed by the Inyo/Los Angeles Water Agreement. Based on the outcome of the studies and the public's views on the pumping, the Standing Committee will establish the standards and objectives to govern the pumping.

pumping decisions, this type of model is needed by the Technical Group to evaluate the environmental effects of proposed pumping scenarios and to provide reliable forecasts of expected pumping yields. An expert on soil water modeling will be selected to assist the principal investigators with this study.

Evapotranspiration from Groundwater-Dependent Plant Communities: Comparison of Micrometeorological Measurements and Vegetation-based Measurements

Robert Harrington, Aaron Steinwand, ICWD;
Paula Hubbard, David Martin, LADWP
Approved by Standing Committee, March 23, 2000.

The objective of this study is to provide direct measurements of evapotranspiration (ET), the combination of evaporation from the ground surface and plant water use, using micrometeorological methods to corroborate current estimates of vegetation transpiration. If the method is accurate, estimating ET from simple vegetation measurements offers important advantages for groundwater management. ET estimates are essential to the Green Book methods for managing pumping and may remain an important component of groundwater management strategies in the future. Results from this study will be applied to improve the ET component of numerical groundwater models (study #1) and soil water models (study #2).

Characterization of Confining Layer Hydrologic Conductivity and Storage Properties in the Owens Valley

Randy Jackson, ICWD; Saeed Jorat, LADWP
Approved by Standing Committee March 23, 2000.

The purpose of this study is to determine confining layer hydrologic properties to assist groundwater modeling efforts (study #1) and to improve the management of wells sealed to the deep aquifer. Pumping from deep aquifers potentially could be managed differently than the Green Book methods. Without information to be developed by this study, however, the magnitude and timing of the water table drawdown from pumping deep aquifers are difficult to predict, complicating any assessment of the effects of different pumping scenarios. A stepwise approach is proposed, starting with analysis of existing data and progressing to low and high intensity field projects, if necessary.

Shallow and Deep Groundwater Geochemistry and the Source of Spring and Seep Water in the Owens Valley

Aaron Steinwand, Randy Jackson, ICWD;
Saeed Jorat, Paula Hubbard, LADWP
Approved by the Standing Committee June 16, 2000

Springs and seeps are valuable and sensitive habitats in the Owens Valley. This study has two objectives. First, basic water quality indices will be monitored seasonally for one year to develop a database to be used to assist restoration of spring waters should any impacts occur. Secondly, the geochemical signatures of water from selected springs and seeps will be examined and compared to shallow and deep groundwater samples to identify the source of the water. These results will be used to link spring and seep flows to particular aquifers to improve groundwater models (study #1) used to assess potential effects of pumping on these areas. An expert in geochemical modeling will be selected by the fall of 2000 to assist the principal investigators with this study.

Application of Canonical Community Ordination (CANOCO) to Assess Owens Valley Vegetation Change

Sally Manning, ICWD; David Martin, LADWP
Approved by Standing Committee March 23, 2000.

To manage groundwater pumping to avoid adverse changes in vegetation, it is imperative to quantify the extent that water table fluctuations and other environmental factors affect vegetation over the long term. This study will apply complex statistical techniques to an extensive dataset of vegetation measurements collected by ICWD vegetation staff to quantify the importance of several environmental factors influencing vegetation changes observed in the last decade.

Inventory and Classification of Riparian Vegetation in the Owens Valley for Use in Future Monitoring

To understand and measure the effects of groundwater pumping and surface water flows on vegetation requires quantitative data on what vegetation is present and appropriate techniques to monitor it. The objective of this study is to inventory, map, and classify riparian (Type D) vegetation on Los Angeles-owned land in the Owens Valley to improve monitoring and management of these areas. This study was suggested in the Green Book but has not been completed. The Standing Committee agreed at its March 23, 2000 meeting that this work will be conducted by a consultant selected jointly by ICWD and LADWP, and that the contract will be managed by LADWP. The consultant will be selected this year to allow fieldwork to begin by March 2001.

Development of a Demographic Model for Nevada saltbush (Atriplex torreyi)

Sally Manning, ICWD; David Martin, LADWP
Approved by Standing Committee March 23, 2000.

The purpose of this study is to use existing data for Nevada saltbush collected by ICWD vegetation staff to develop a model that could allow researchers and managers to make predictions about future population trends of Nevada saltbush based on present conditions. Nevada saltbush is a native shrub that commonly invades meadows subjected to pumping. It has the potential to out-compete grass species and change the character of the plant community in a way not allowed under the Water Agreement. In some areas, this conversion may have already occurred before the baseline vegetation inventory of 1984-1987. It is unclear whether, once begun, saltbush invasion can be halted and whether existing saltbush-dominated communities are sustainable.

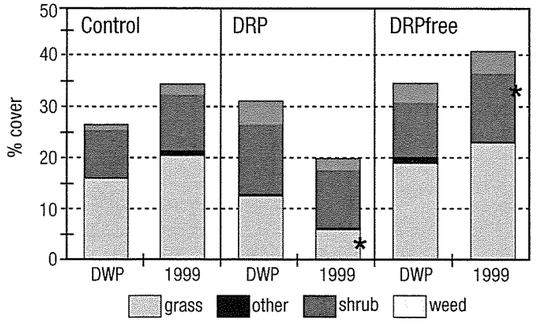


Figure 4. Average percent cover by life form (grass, other, shrub, weed) in parcels monitored in 1999 as compared with LADWP baseline conditions (1984-87). Statistically significant changes in 1999, denoted by asterisks, consisted of either a decrease in grass cover relative to baseline in DRP parcels or an increase in shrub cover in the DRPfree parcels.

Taboose-Aberdeen (212,562 AF): This wellfield experienced high amounts of pumping in the early 1970s, then a high amount again (>40,000 AF) in both 1986 and 1987. In each year since 1990, pumping has been below 10,000 AF. In recent years, the bulk of pumping has been shifted from the pumps located west of Highway 395 to one large pump (Well 349) located in the northern part of the wellfield near Charlie's Butte. Water tables were lowered throughout this region by the drought and pumping. In the southernmost part of this wellfield, water tables reached baseline levels in 1998 in the three parcels that we monitor. All showed perennial cover above baseline in 1998 (the wet year) and were therefore categorized as DRPfree, but in 1999, perennial cover in one of the parcels dropped significantly below baseline. Throughout the central part of this wellfield, water tables have been rising, but have reached baseline level in only one of the four parcels monitored. That parcel was the only parcel with 1999 perennial cover equal to baseline (therefore categorized as DRPfree), the other three had perennial cover below baseline and remained categorized as DRP. In the northern part of the wellfield, vegetation monitoring efforts were increased in 1999, but not hydrological monitoring. This area is hydrologically complex, and there are not enough monitoring wells to sufficiently monitor the effects of Well 349. In 1999, data showed perennial cover approximately equal to baseline in three parcels and below baseline in two.

Big Pine (436,415 AF): Largely because of pumping to supply the Fish Springs Fish Hatchery, annual pumping in this wellfield has hovered around 25,000 AF. In 1987, pumping was almost 50,000 AF, and it remained high through 1989. We monitor four parcels south and east of town. All four were categorized as DRP because they showed water table declines below baseline and below 4 meters, and none experienced water table or perennial cover increases to baseline level as of 1999. Faring somewhat better are the two parcels we monitor north of town. One showed water table and perennial cover recovery to baseline by 1997 and no adverse trends have been observed since that time. It has been categorized as DRPfree. The other has been on the verge of water table and perennial cover recovery, but as of 1999 was still categorized as DRP.

Bishop (141,743 AF): Since 1987, pumping has averaged about 10,000 AF per year. Because of the many irrigated parcels in the Bishop area, there are only a limited number of parcels in the wellfield that were dominated by native groundwater dependent species. Some lowering of the water table occurred in areas southeast of town since 1987, but they were gradual. In 1999, the two southeastern groundwater dependent shrub-dominated parcels that we monitor had water tables very close to baseline, but in both perennial cover was below baseline level. Two meadow parcels monitored northeast of town showed water table declines during the 1987-92 drought. In one parcel the water table has recovered to baseline, in the other it is below baseline but still well within the grass root zone. 1999 perennial cover in both parcels exceeded baseline; therefore both were categorized as DRPfree.

Laws (237,078 AF): High amounts of pumping (35,000-40,000 AF) occurred in 1987-89, moderate amounts (9,000-18,000 AF) occurred in 1990-96, and relatively small amounts (<3,000 AF) occurred in 1997-99. Water tables dropped, usually below 4 meters, in all but one of the 15 parcels monitored in this wellfield; therefore, that one parcel, which is located adjacent to the Owens River south of the town of Laws, is classified as a Control. Although water tables were still depressed under most of these parcels in April 1998, by spring 1999, water tables rose abruptly, causing a return to baseline levels under 11 of the 14 parcels. The rise in water table was most likely due to a combination of 1998 surface spreading from the McNally canals which was part of an effort to recharge the Laws aquifer with Owens River water, reduced pumping amounts, and, to a lesser extent, high natural recharge. Perennial cover in six parcels reached baseline in 1999 even though it was a dry year in terms of precipitation. Cover in the other eight parcels did not return to baseline levels in 1999 and are, therefore, still categorized as DRP. It is unknown how long water tables will remain at baseline levels in the Laws wellfield in the absence of flows through the McNally canals.

Soil Water Conditions

Aaron Steinwand, Soil Scientist/Science Coordinator

Under the Inyo/Los Angeles Water Agreement, groundwater pumping and subsequent water table decline and recovery is managed by monitoring the soil-plant water balance. Each month, ICWD visits 33 monitoring sites (including eight control sites located away from groundwater pumps) to measure depth to groundwater and soil water content to determine the on/off status of LADWP pumping wells. If the available soil water on July 1 or October 1 is less than the predicted amount of water required by the vegetation, pumping wells linked to the monitoring site must be turned off. The linked wells can be turned on when soil water exceeds the expected plant water requirement at the time wells were turned off.

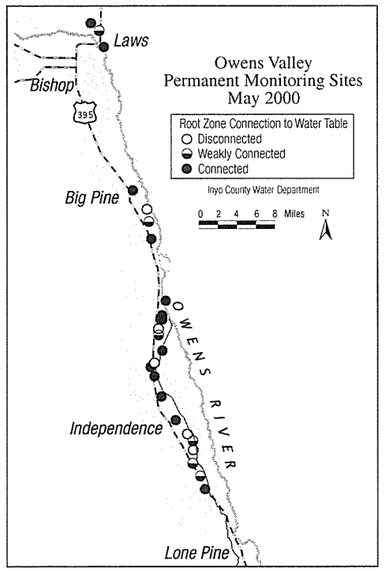


Figure 5. Soil water/root zone connection at permanent monitoring sites.

The on/off determination is affected by several factors, including predicted plant water requirements, estimated drought tolerance of the plant species, soil properties, depth of the root zone monitored, and the amount of precipitation and groundwater added to the soil. Because the relative importance of these factors on the soil-plant water balance can vary greatly, wells may be in "on" status even though no groundwater is reaching the root zone. Conversely, a site may be in "off" status if the water table occurs just below the root zone.

The plant communities that we monitor require periodic connection to the groundwater for long-term survival and recovery from drought. Unfortunately, the on/off status often is not an accurate indicator of whether groundwater is reaching the plant root zone, but the rise of water above the water table due to capillarity is detected easily by the monitoring. Using the soil water and groundwater data, we determine which monitoring sites are connected with the water table and which still need water table recovery. From these observations, possible reasons for the vegetation conditions at a particular site can be identified and the ICWD can then suggest appropriate pumping management under the Drought Recovery Policy, which calls for conservative management of pumping to promote recovery of soil water, water tables, and vegetation.

For simplicity, the 33 monitoring sites are grouped into three categories to summarize the root zone and groundwater connection. The water table depth necessary to provide water to the root zone is not only related to depth-to-water, but it also depends on the rooting depth and soil characteristics. For example, in similar soils, a shallower water table is necessary to supply groundwater to grass-dominated sites than shrub-dominated sites because of the shallower roots of the grasses. Similarly, the capillary rise above the water table in a silty soil is much greater than in a sandy soil thereby allowing plants access to groundwater from greater depths. Brief descriptions of the three categories are given below. For management purposes, grass-dominated sites are assigned a root zone of 2 meters; shrub sites are assigned a 4-meter root zone. The three categories are:

1. Disconnected: No groundwater is reaching the root zone. Five sites occur in this category.

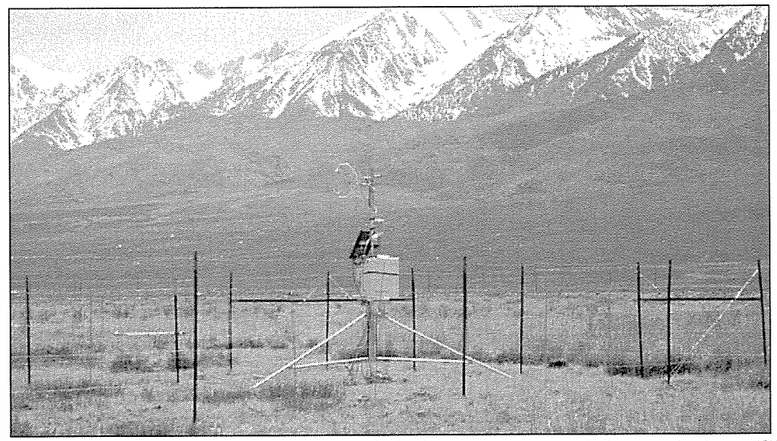
2. Weakly connected: Groundwater reaches the bottom 0.5 meters of the root zone. Six sites occur in this category.

3. Connected: Groundwater extends to the middle of the root zone, or retained soil water from earlier groundwater recovery is present in the middle of the root zone. Fourteen wellfield sites and all eight control sites occur in this category.

Reduced pumping and recent high runoff years have promoted substantial water table and soil water recovery from the decline induced by high pumping from 1987-1989 at the onset of the six-year drought. During 1999, however, water table recovery slowed or the water table declined slightly because runoff was less than in previous years and because water tables at several sites approached shallow depths reminiscent of pre-drought levels. As a result, the number and locations of sites in each category remained similar to 1998. As of April 1, 2000, the water table was supplying water to the root zone at 20 of the 25 monitoring sites located in wellfields (Figure 5). This compares to about six sites with groundwater in the root zone near the end of the drought in 1992. The five sites still not connected with groundwater are located in the Taboose-Aberdeen wellfield (1), the Thibaut-Sawmill wellfield (1), southeast of Big Pine (1), and south of Independence (2). Water tables in areas outside the wellfields were little affected by pumping and drought, and the root zones at monitoring sites in these areas remained connected to the water table during the drought.

Inyo/Los Angeles Cooperative Studies

Aaron Steinwand, Soil Scientist/Science Coordinator



Meterological instruments used to measure evapotranspiration from an akali meadow. Photo by Bob Harrington, ICWD.

It has been a decade since the techniques for groundwater and vegetation management were developed and incorporated into the Inyo/Los Angeles Water Agreement and its technical appendix, the Green Book. At the time these techniques were adopted, it was recognized that there would be a need for continuing research and cooperative studies to achieve the goals of the Water Agreement. Consequently, the Water Agreement was designed to be flexible to allow adoption of improved techniques to ensure the environmental protection and water supply goals are met.

At its June 1998 meeting, the Inyo/Los Angeles Standing Committee directed the Inyo/Los Angeles Technical Group to prepare cooperative study proposals for consideration. Eight draft proposals were prepared by ICWD scientists and forwarded to LADWP in June 1999. The proposed studies were directed specifically at improving the scientific models used to predict the effect of pumping on the water table and soil water and at quantifying how Owens Valley plant communities respond when several environmental factors change simultaneously (including water level fluctuations caused by pumping). Discussions between LADWP and Inyo County continued throughout 1999 to work through questions raised by LADWP regarding the purposes and eventual use of results from the proposed studies. Eventually, the scope of work, staffing, time lines, and budgets for the study proposals were agreed upon and five were approved by the Standing Committee. Three more proposals are in the final stages of preparation.

The following is the list of cooperative studies, including the principal investigators, the study objectives, and an update on the status of each study. Copies of the proposals are available at ICWD and can also be found on the ICWD website at: www.inyowater.org.

Development of Hydrological Modeling Tools

Robert Harrington, ICWD; Saeed Jorat, LADWP

Approved by the Standing Committee, May 11, 2000.

The purpose of this study is to improve hydrological models developed by previous cooperative studies to evaluate the impact of groundwater pumping, weather variations, surface water management, and other hydrologic changes on groundwater levels. Because groundwater modeling is the only method for consistent interpretation of groundwater data and evaluation of management options, this task is a prerequisite to fulfill the monitoring and technical goals of the Water Agreement. Inyo County and LADWP want to jointly develop a common set of modeling tools so that methods and analyses are understood and accessible to each agency.

Development of a Model for Predicting Phreatophyte Water Use and Soil Water Replenishment

Aaron Steinwand, Robert Harrington, ICWD; Saeed Jorat, Paula Hubbard, LADWP

Proposal is in final stages of preparation.

The purpose of this study is to combine information from vegetation, groundwater, precipitation, and soil water monitoring into a model to predict depletion and replenishment of stored soil water above a fluctuating water table. This capability will help protect Owens Valley vegetation by predicting how long soil water will support the vegetation after pumping commences. If soil water information will continue to be used to trigger