Draft Environmental Impact Report for the Review of Mono Basin Water Rights of the City of Los Angeles

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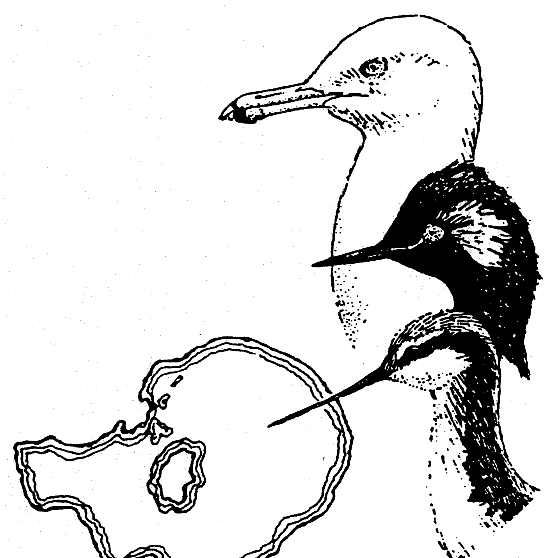
Summary



Summary

PROPOSED PROJECT

The California State Water Resources Control Board (SWRCB) has prepared a draft environmental impact report (EIR) for the review and modification of certain Mono Basin water rights held by the City of Los Angeles. The draft EIR was prepared in accordance with the provisions of the California Environmental Quality Act (CEQA). The project evaluated in the draft EIR consists of:

- the establishment and maintenance of instream flow requirements in the Mono Lake tributaries from which the City of Los Angeles diverts water; the instream flow requirements will be established in compliance with California Fish and Game Code Sections 5937 and 5946 and a court mandate to release sufficient water to reestablish and maintain fisheries that existed in these streams prior to the city's diversions; and
- the establishment and maintenance of water elevation requirements in Mono Lake to provide appropriate protection for public trust resources and beneficial uses of Mono Lake.

The SWRCB will incorporate the appropriate instream flow requirements, lake level requirements, and mitigation measures into the City of Los Angeles' water right licenses for diversion from Mono Basin.

BACKGROUND

In 1940, the city was granted permits by the State of California allowing the appropriation of flows from four major tributary streams to Mono Lake, which lies in an interior-drained basin east of the Sierra Nevada in Mono County. The lake, because of its great geologic age, is hypersaline and supports a unique and very productive invertebrate population (alkali fly and brine shrimp), which supports annual migration and nesting of millions of birds.

For more than 50 years, the city has been diverting an increasing portion of the flows of Lee Vining Creek and Rush Creek, including two of its tributaries, Parker and Walker Creeks, which flow from the snowy east side of the Sierra Nevada. By 1970, stream diversions were nearly total. Exported through the Mono Craters tunnel, about 83,000 acre-feet (af) of water per year since the mid-1970s have augmented threefold the flows of the Upper Owens River.

The Owens River has provided a major source of water to the city since 1913, when the Los Angles Aqueduct was constructed with an intake south of Bishop near Big Pine. The Upper Owens River, regulated at Lake Crowley reservoir near Mammoth Lakes, is joined by many other streams and exports from groundwater pumping in Inyo County near Bishop before reaching the aqueduct intake. Power is generated from the Middle Owens River where it passes through the Owens River gorge. In recent decades, exports from Mono Basin made up about one-fifth of the waters taken by the aqueduct.

In 1974, the SWRCB granted licenses to the city confirming the city's right to Mono Basin waters. The city's exports have caused a decline in lake surface elevation of 40 feet and in lake surface area by 25%. Salinity and alkalinity of the lake waters have increased, bird-nesting islands have lost their security from mainland predators, riparian and freshwater habitats along the tributary streams have been irreversibly lost through erosion, and occasional massive dust storms have been induced from salt efflorescence on exposed lakebeds. Yet the lake's fascinating complex of tufa formations, formed underwater during higher lake levels, has been increasingly exposed for the enjoyment of the curious explorer.

In 1983, in response to a suit filed by the National Audubon Society, the California Supreme Court held that the public trust mandated reconsideration of the City of Los Angeles' water rights in Mono Basin. The court noted that Mono Lake is a scenic and ecological treasure of national significance and that the lake's value as a recreational and ecological resource was diminished by recession of the water level.

The court found that the city's water rights were granted without consideration of impacts on these resources and therefore the SWRCB or the court should reconsider the city's water rights. The court noted that before continued stream diversions could be approved, the effect of such diversion on interests protected by the public trust should be considered and that harm to those interests should be minimized or avoided if feasible.

In 1990, the California Court of Appeal ruled that the city's water rights licenses must be conditioned to require bypass streamflow around the diversions sufficient to reestablish and maintain the fisheries that existed before its diversion of water. The court noted that this requirement of state law must be met regardless of the city's need for water.

Subsequently, the Superior Court for El Dorado County entered preliminary injunction requiring the city to modify or cease exports as needed to maintain the surface elevation of Mono Lake at or above 6,377 feet and to provide a specified minimum flow regime in all four diverted tributary streams. These restrictions are to remain in effect until amended by the court or until the SWRCB amends the city's water rights licenses. The SWRCB decision amending the city's water rights is subject to judicial review.

DECISION PROCESS

The EIR is being circulated for 90 days to interested parties for review and submission of written comments. Following this period, public hearings will be held in Sacramento to receive evidence related to the amendment of the City of Los Angeles' water rights licenses. Based on submitted comments, modifications to this draft report may be made before any SWRCB decisions.

PROJECT ALTERNATIVES

This EIR evaluates the full range of water rights alternatives, each of which represents a lake level target and projected volume of water export based on assumed stream diversion rules. The alternatives range from imposing no new restrictions on diversion to ending all diversions. The definition of alternatives is based primarily on differing lake levels rather than on the quantity of water needed to provide instream fishery flows. Whatever fishery flows are eventually determined by the SWRCB to be appropriate will be associated with some net quantity of inflow to Mono Lake and a corresponding lake level. The range of alternatives defined in this report is sufficiently broad to cover any potential level of inflow that would result from those fishery flows.

Seven alternatives have been defined. The No-Restriction and No-Diversion Alternatives define the full range of possibilities, but the No-Restriction Alternative cannot meet the project objectives. Five intermediate alternatives have been formulated that can meet project objectives to varying degrees; they entail minimum required streamflows supplemented as needed through additional streamflow releases intended to keep the lake surface above selected target elevations whenever possible (Figure S-1).

The alternative development process included constructing several numerical models for simulation purposes and formulating appropriate diversion management rules as assumptions on which to base the simulations. Relationships between streamflows and lake volume and surface elevation were identified through the development of a monthly Mono Lake water balance model. Relationships between available water exports from Mono Basin and the city's water demand, other supplies available to the aqueduct from Owens Valley streams and the groundwater basin, and water conveyance and storage constraints throughout the aqueduct system were simulated with a numerical monthly model of the system.

The aqueduct model was used to perform simulations of specific project alternatives that embody consistent water release requirements and target lake levels. The alternatives entail minimum specified streamflows, accounting for in-basin irrigation, triggering supplemental lake releases when needed, respecting aqueduct-operating constraints, and meeting water supply targets whenever possible. The diversion management rules would specify minimum streamflows and annual supplemental releases to Mono Lake based on the April 1 runoff forecast of each year. They also include actions to manage reservoir levels within specified ranges and to export surplus water from the basin subject to streamflow limits for the Upper Owens River.

For all simulations of the alternatives, the historical 1940-1989 hydrologic record was used to represent the normal range of climatic variation that could be expected to occur in the future. The simulations revealed that the assumed diversion rules would generally, but not always, prevent the lake surface from falling below the target lake level of the alternative. Estimates of minimum lake elevations under each alternative for prolonged droughts also were estimated based on data from the current drought and other dry years of record.

Because of variations in annual snowpack, snowmelt runoff is highly variable from year to year. During the historical period, the minimum observed runoff was a little less than half of normal, whereas the maximum observed runoff was almost twice normal. During the drought period beginning in 1987, runoff averaged about 60% of normal. In this report, dry years are defined to be the driest 20% of all years, which historically have involved runoff of 69% or less of normal. Wet years are the wettest 20% of all years, which historically have produced runoff of 132% or more of normal.

The No-Restriction (No-Project) Alternative

Under this alternative, no new restrictions would be placed on the diversions of water by the city under its water rights licenses. Minimum streamflows and lake levels would not be required. The city would be allowed to divert water based entirely on availability and need. Irrigation of in-basin lands would be discretionary and is assumed to continue at historical levels. Limiting streamflows in the Upper Owens River during exports would not be required. The alternative would entail continuation of practices that prevailed before the court's involvement in the diversion of Mono Basin waters and is therefore considered to be the "no-project" alternative.

Under this alternative, the lake surface would gradually fall to an average elevation of about 6,355 feet and fluctuate about 21 feet, depending on actual runoff. Approximately 85 thousand acre-feet per year (TAF/yr) (73%) would be exported from Mono Basin and 32 TAF/yr (27%) would be released to Mono Lake from the four streams, on average. During an average water year, none of the diverted tributary streams would have flows below the diversions in any months, but Rush and Lee Vining Creeks would be subject to floodflows from time to time that could exceed 500 cubic feet per second (cfs) in Rush Creek and 300 cfs in Lee Vining Creek.

The 6,372-Ft Alternative

This target elevation corresponds to the lowest lake level that the lake has reached in historical time, occurring at the end of 1981 after 40 years of streamflow diversions. The lake surface rose above this level through the remainder of the 1980s and, although declining toward it again, remains above it today (about 6,374 feet).

Under this alternative, the lake surface would normally fluctuate about 6.5 feet in elevation, depending on actual runoff, and would have an average elevation of 6,375 feet. Occasionally, the lake surface would rise as high as about 6,379 feet. During extreme drought, the lake surface might fall as low as about 6,370.4 feet. Approximately 64 TAF/yr (51%) would be exported from Mono Basin and 61 TAF/yr (49%) would be released to Mono Lake, on average. During most years, streamflows would not climb above minimum levels that are imposed in the simulations. These flow levels are those low flows occurring no more than 10% of the time. Rush and Lee Vining Creeks would be subject to spilling flows from time to time, however.

The 6,377-Ft Alternative

This target elevation corresponds to that level beneath which no diversions are currently allowed under the court's preliminary injunction. It is the interim minimum target lake level, intended to protect the lake's public trust resources until action can be taken by the SWRCB. The lake level dropped below this elevation in late 1976 after 35 years of streamflow diversions but rose above it temporarily between 1983 and 1989 because of a wet period.

Under this alternative, the lake surface would normally fluctuate about 6.5 feet in elevation, depending on actual runoff, and would rise to an average elevation of 6,379 feet. Occasionally, the lake surface would rise as high as about 6,383 feet. During extreme drought, the lake surface might fall as low as about 6,373 feet. Approximately 52 TAF/yr (41%) would be exported from Mono Basin and 74 TAF/yr (59%) would be released to Mono Lake, on average.

In addition to having at least 10% of normal flows in the diverted streams in each month, this alternative would provide for system maintenance flows in June equal to historical median flows above the diversions. Larger spilling flows would occur from time to time.

The 6,383.5-Ft Alternative

This target elevation corresponds to the midpoint of the range of lake levels (6,390-6,377 feet) recommended by the U.S. Forest Service (USFS) in its management plan for the Mono Basin National Forest Scenic Area. The declining lake surface passed through this elevation in 1973 after 32 years of streamflow diversions. During the wet period of the mid-1980s, this elevation was not attained.

Under this alternative, the lake surface would normally fluctuate about 6 feet in elevation, depending on actual runoff, and would rise to an average elevation of 6,385.7 feet after 5-10 years. Occasionally, the lake surface would rise as high as about 6,389 feet. During extreme drought, the lake surface might fall as low as about 6,378 feet. Approximately 44 TAF/yr (35%) would be exported from Mono Basin and 82 TAF/yr (65%) would be released to Mono Lake, on average. The streamflow pattern for this alternative would be similar to that for the 6,377-Ft Alternative but with higher average streamflows.

The 6,390-Ft Alternative

This target elevation corresponds to the upper lake level recommended in the USFS management plan. The lake surface dropped below this elevation in 1965 after 24 years of streamflow diversions and has remained lower.

Under this alternative, the lake surface would normally fluctuate about 6 feet in elevation and would reach an average elevation of 6,391.6 feet after about 30 years. Occasionally, the lake surface would rise as high as 6,395 feet and, during extreme drought, fall as low as 6,383 feet. During the first 50 years under this alternative, approximately 30 TAF/yr (24%) would be exported from Mono Basin and 96 TAF/yr (76%) would be released to Mono Lake, on average. After equilibrium were attained, exports would rise to 37 TAF/yr (29%) and lake releases would fall to 89 TAF/yr (71%). The streamflow pattern for this alternative would be similar to that for the 6,377-Ft and 6,383-Ft Alternatives, except that higher flows would be released in wetter periods. Large spilling flows would occur from time to time that could exceed 490 cfs in Rush Creek and 320 cfs in Lee Vining Creek.

The 6,410-Ft Alternative

This target elevation corresponds to an intermediate elevation between the 6,390-Ft Alternative and the No-Diversion Alternative, providing an alternative that could reflect substantial streamflows if required by the SWRCB to protect public trust resources. The lake surface dropped below this elevation in 1951 after 10 years of streamflow diversions and has remained below this elevation.

Under this alternative, the lake surface would normally fluctuate about 7 feet in elevation, depending on actual runoff, and would eventually reach an average elevation of 6,410.8 feet in about 80 years. Occasionally, the lake surface would rise as high as 6,415 feet and, during extreme drought, fall as low as 6,401 feet. During the transition period, approximately 11 TAF/yr (9%) would be exported from Mono Basin and 115 TAF/yr (91%) would be released to Mono Lake, on average. After equilibrium were obtained, exports would rise to 22 TAF/yr (17%) and lake releases would fall to 104 TAF/yr (83%). Streamflow pattern would be similar to those of the previous alternatives, except for higher peak flows in spring, higher flows in wet years, and slightly larger spills from time to time.

The No-Diversion Alternative

Under this alternative, diversions of the four tributary streams would be entirely curtailed. Streamflow and lake level would be determined by natural weather events and patterns, and the lake surface would rise toward or beyond the prediversion level.

After a transition period of more than 100 years, the lake surface would eventually reach an estimated average elevation of about 6,425 to 6,430 feet and would normally fluctuate about 10 feet in elevation thereafter, depending on actual runoff. No water would be exported from Mono Basin.

EVALUATING ENVIRONMENTAL CHANGES FOR THE ALTERNATIVES

In this EIR, project impacts for each alternative are described as expected changes from the resource conditions existing in 1989, just before the court's issuance of the preliminary lake level injunction. At that time, the lake stood at an elevation of 6,376 feet and minimum streamflows were required in Rush and Lee Vining Creeks of 19 and 5 cfs, respectively. No water was being released to Parker and Walker Creeks below the diversions, and no minimum flows were required. These conditions are called the "point of reference" in this EIR.

For assessment of some resource impacts such as power and water supply, the long-term implications of adhering to these minimum streamflows require characterization over some period of time. Accordingly, a "point-of-reference scenario" that evaluates conditions over a 20-year analysis period (1992-2011) was developed similarly to the alternatives simulations, using the water balance and aqueduct operations model and the historical hydrological data applied over 25-year and 50-year periods.

Cumulative impacts are assessed considering closely related past, present, and reasonably foreseeable future projects. The city's diversions since 1941 are considered a closely related project. Thus, a lake surface elevation of 6,417 feet, undiverted streamflows, and prediversion resource conditions constitute the basis of the major portion of the cumulative impact assessments in this report.

IMPACTS OF THE ALTERNATIVES

In addition to identifying significant adverse project effects and cumulative effects of the alternatives as required by CEQA, this document identifies project benefits. This forecasting allows the SWRCB to satisfy the judicial mandate of adopting an alternative that balances protection of public trust values with the city's needs for water and power.

The Mono Lake water balance model and the aqueduct operations model provide a unique opportunity to simulate many effects of the alternatives quantitatively. Although all effects of the alternatives cannot be characterized numerically, this simulation approach provides the framework for an objective treatment of Mono Basin issues. In some instances, quantified changes are given in absolute terms (e.g., acreages); in other cases, absolute values cannot be reliably forecasted but relative values among the alternatives can still be reliably estimated. Thus, the EIR relies on the measurement of impacts and benefits through the use of several numerical models and estimation procedures employing quantifiable variables. These models and estimates are based on results of the hydrologic simulations of the alternatives.

The results of these assessments are summarized in Table S-1. Resource topics in the table conform to the sequence of chapters in the document. Values of variables are given for each alternative, the point of reference or point-of-reference scenario, and the prediversion condition. Project and cumulative effects considered significantly adverse are indicated by footnote, as is the availability of measures to substantially mitigate the impacts.

The summary comparisons in the table are necessarily brief and not fully explanatory, but they provide an indication of the range of variables assessed and the general relationships of these variables to lake level, streamflow, and export as embodied by the alternatives. Table S-1 therefore can be used as an overview to guide the reader to the resource (e.g., wildlife or fisheries) chapters of interest.

Each resource chapter of the EIR describes the prediversion and point-of-reference environmental setting for the resource, impact assessment methodology, criteria for significance of impacts, and effects of the alternatives in both comparative and alternative-by-alternative format. A summary comparison of the effects of the alternatives in each chapter provides a more thorough tabular summary and explanation of the values of impact variables among the alternatives, providing the basis for those appearing in Table S-1.

MITIGATION MEASURES

Feasible mitigation measures are not available for many impacts, but most impacts can be avoided or reduced through selection of another alternative. Some impacts, particularly cumulative impacts, can be mitigated as indicated in Table S-1. The measures available to provide mitigation are shown in Table S-2.

CONCLUSIONS

Effects on Fisheries in the Tributary Streams

In addition to meeting its responsibilities under CEQA, the SWRCB must also meet specific criteria established in court orders addressing fisheries resources in Mono Lake tributaries. The California Court of Appeals has directed the SWRCB to exercise its ministerial duty to amend the Los Angeles Department of Water and Power's (LADWP's) water right licenses for appropriation of the Mono Lake tributaries to include conditions in accordance with California Fish and Game Code Sections 5937 and 5946. Most importantly, the court further specified that licenses require LADWP to "release sufficient water into the streams from its dams to reestablish and maintain the fisheries that existed in them prior to its diversion of water". This standard has an overriding influence on the evaluation and selection of alternative lake levels, as described at the end of this chapter.

Several factors limit reestablishing pre-1941 fishery conditions in the Mono Lake tributary streams. Pre-1941 fishery conditions cannot be accurately described and, consequently, it would be difficult to ascertain whether the objective of reestablishing the pre-1941 conditions was ever met. It was recognized early during preparation of the habitat restoration program ordered by the El Dorado Superior Court that existing conditions may preclude restoration of some specific pre-1941 physical conditions. The Restoration Technical Committee therefore agreed to and adopted the goal of developing and implementing programs to establish aquatic and riparian conditions and resource values equivalent to those existing in the streams before 1941 as an acceptable substitute for the court-ordered goal of reestablishing the conditions that benefited the fisheries that existed in the creeks before 1941. Establishing even equivalent conditions that benefited the pre-1941 fishery is impossible in the short term and possible in the long term only if aggressive and substantial habitat restoration, in concert with major instream flow releases, is successfully undertaken.

Compared to the 1989 point of reference, all alternatives (except the No-Restriction Alternative) have substantial fishery benefits in the Mono Lake tributaries. Compared to the pre-1941 conditions, however, significant cumulative impacts were identified for all alternatives. Similarly, none of the alternatives can restore and maintain pre-1941 fishery conditions within less than 50 or more years. Major geomorphic alterations are simply too great to allow restoration of the complex habitat functions present in lower Rush and Lee Vining Creeks in the pre-1941 period. Successful restoration efforts now will require greater short-term control of high flows while channel and habitat conditions are stabilized and restored.

California Department of Fish and Game (DFG) Stream Evaluation Reports provide fishery protection flows and other measures to optimize fishery conditions in Mono Lake tributaries. It is unclear whether these reports represent DFG's formal recommendations for each stream or are consultants' recommendations only. Nonetheless, the Stream Evaluation Reports represent the best available information provided by DFG for establishing conditions that approach, to the greatest degree possible, the pre-1941 habitat conditions desired by the court.

Aqueduct model simulations, based on preliminary Stream Evaluation Report instream flow recommendations (see Table 2-6 in Chapter 2 or Table 3D-32 in Chapter 3D), were used to evaluate the implications of possible fisheries instream flow requirements. The recommended flows would cause the surface elevation of Mono Lake to rise to an average elevation of 6,381 feet, with a maximum Rush Creek flow of 60 cfs, or to 6,385 feet, with a maximum Rush Creek flow of 100 cfs (see Figure 2-17 in Chapter 2 or Figure 3D-24 in Chapter 3D). Uncontrolled spills would not likely occur in Mono Basin tributaries under the conditions specified. Minimum instream flow recommendations for Rush Creek would be met in most years, but available flows in Lee Vining, Parker, and Walker Creeks would often be insufficient to meet the specified minimum instream flows in dry and normal runoff years.

These simulated lake level ranges, when compared to the lake level regimes described for each alternative, indicate the degree to which each alternative is capable of meeting the pending DFG instream flow recommendations for protection of fishery resources. The 6,383.5-Ft Alternative is the alternative that most closely satisfies preliminary DFG recommendations developed to optimize fisheries conditions. The average lake level (6,385 feet) based on the 6,383.5-Ft Alternative would meet instream flow requirements based on DFG's preliminary stream evaluation reports.

Environmentally Superior Alternative

In accordance with CEQA, this report focuses on predictable changes in the environment for each of the project alternatives. The changes in the environment include changes in land, water, atmospheric conditions, aquatic ecosystems, plant and wildlife communities, and objects of historical and aesthetic significance.

The City of Los Angeles may compensate for a reduction of water supply from Mono Basin in a variety of ways, each of which could have different environmental effects in the Los Angeles area or other areas of the state. Without knowing what particular actions the city may take, it would be speculative to attempt any detailed analysis of the effects of those actions. This document, however, provides an assessment of direct effects on the city's water and power supply, and on agricultural and recreational activity in Mono Basin and the Owens River basin. These resource utilization effects must be considered by the SWRCB, together with environmental impacts and public trust values within Mono Basin, in reaching a decision on amending the city's water rights.

For the physical environment, identification of the environmentally superior alternative depends on the frame of reference used to examine the effects of the alternatives. The results of two approaches are described below. The first approach focuses on impacts relative to the 1989 point of reference, addressing which alternatives minimize adverse changes from current or point-of-reference conditions. The second approach focuses on the degree to which each alternative would restore prediversion conditions, addressing which alternatives would minimize cumulative impacts. To assist this assessment, Tables S-3 and S-4 tabulate the occurrence of significant physical environmental impacts, as well as resource utilization impacts, for each alternative relative to the point of reference and the prediversion condition, respectively.

As required by CEQA, economic effects of the alternatives are not considered directly in identifying the environmentally superior alternative. Economic effects have been used, however, to help evaluate the significance of physical environmental changes.

Environmentally Superior Alternative Relative to the Point of Reference

Based on assessment of unmitigable impacts (Table S-3), the 6,383.5-Ft Alternative appears to be the environmentally superior alternative, and it comes closest to satisfying preliminary DFG recommendations developed to optimize fishery conditions as described previously. For this project the no-action alternative, which is the No-Restriction Alternative, is not the environmentally superior alternative; it would entail substantial losses of many environmental resources.

Higher lake level alternatives cause significant losses of tufa towers (both toppling and inundation) and complete loss of sand tufa, as well as significant losses of wildlife value as shoreline habitats are inundated. At even higher levels, the potential for significant channel erosion along the tributary streams would also materialize.

Other impacts are associated with lower lake levels. The 6,377-Ft Alternative would result in reductions in gull nesting and water bird food supply during extended drought and in insufficiently frequent high streamflows during snowmelt for optimum riparian restoration and maintenance. At the lower lake level of the 6,372-Ft Alternative, these impacts would commonly occur, and additional stream channel incision would be expected.

Environmentally Superior Alternative Relative to Prediversion Conditions

Based on an assessment of unmitigable cumulative impacts relative to prediversion conditions (Table S-4), the 6,390-Ft Alternative appears to be the environmentally superior alternative, although this judgment cannot be conclusively drawn.

The 6,390-Ft Alternative would offer substantially less lake-fringing aquatic habitats to migrating ducks than the higher 6,410-Ft Alternative (although extensive habitat restoration might provide major compensation). The 6,410-Ft Alternative, however, would result in high streamflows damaging to tributary fisheries that may be too high to be effectively mitigated. The 6,390-Ft Alternative would result in flows closer to the optimum flows for fisheries embodied in DFG's preliminary recommendations described previously.

Of the lower lake level alternatives, the 6,383.5-Ft Alternative would entail significant occurrence of dust storms and a significant reduction in brine shrimp productivity (which does not appear to significantly affect foraging water birds). The losses of lake-fringing aquatic habitats would be greater than for the 6,390-Ft Alternative. Under even lower lake levels, these effects would be more intense and additional impacts would occur (Table S-4).

Considering All Effects on Key Resources

The SWRCB will balance public trust values with the need for Los Angeles' water supply by weighing all the resources and impacts involved. Both project effects and cumulative effects will be considered for both physical environmental resources and resource utilization. Balancing may ascribe different weights to different resources and impacts, based on information in the EIR and subsequent hearing testimony.

Some of the resource areas expected to be considered key are:

- fish productivity in the diverted streams,
- lake invertebrate productivity and water bird food supply,
- gull nesting,
- riparian habitat maintenance and restoration,
- dust storms,
- tufa persistence and visibility,
- recreation use levels, and
- Los Angeles water supply.

Significant impacts in these areas for each alternative, considering either project effects or cumulative effects as appropriate, are shown on Figure S-2. This form of comparison reveals an alternative or range of alternatives that may provide an appropriate balance, and the impact tradeoffs implicit in making that decision. For the resource topics shown in Figure S-2, the 6,383.5-Ft Alternative appears to be optimum among the alternatives evaluated. Even at this level, extensive dust storms violating state and federal air quality standards would continue to occur, although less frequently and over considerably smaller area than occur currently. On the other hand, LADWP would need to participate in additional water reclamation and conservation programs to avoid a significant cost increase under this alternative, and additional restoration efforts to prevent adverse effects of high streamflows on fisheries would be required. At higher lake level alternatives, losses of tufa would be significant, and at lower lake level alternatives, dust storms would become more intense, frequent, and widespread and biological impacts would begin to materialize.

These observations are consistent with the USFS's comprehensive management plan for the Mono Basin National Forest Scenic Area, which recommended a lake management regime corresponding to the 6,383.5-Ft Alternative.

In economic terms, the 6,383.5-Ft and 6,490-Ft Alternatives offer substantial net benefits; a much smaller net benefit would accrue from the 6,377-Ft Alternative. Other alternatives would entail net economic losses.

Other Conclusions

Mono Lake Candidacy for Designation as an Outstanding National Resource Water

Mono Lake meets federal criteria for nomination as an Outstanding National Resource Water, as defined in the Clean Water Act. Actual designation would be made by the SWRCB or the Lahontan Regional Water Quality Control Board if either agency determines that Mono Lake is an outstanding national resource of exceptional recreational or ecological significance. Adoption of a minimum target lake level of about 6,380 feet would be consistent with such designation.

Irreversible Environmental Changes

The major irreversible effect of lake level lowering is the downcutting of tributary streams near the lake (incision), resulting in loss of wetland and riparian habitat directly through erosion and indirectly through lowering of the water table. Riparian losses caused by stream dewatering are reversible, although decades or centuries would be required for natural restoration.

Riparian habitat losses along the lower reaches of Rush and Lee Vining Creeks have been substantial since diversions began, both in terms of acreage and wildlife habitat value. By the point of reference, 156 acres of woody riparian vegetation were lost. This trend would continue under the No-Restriction Alternative, but under all other alternatives, natural restoration initiated by rewatering would continue. In this report, it is estimated that about one-half of the riparian losses might be restored by stream rewatering and that one-half has been irreversibly lost through stream incision. The other alternatives differ little in this regard; higher lake level alternatives create more riparian habitat because of higher streamflows but lose a corresponding acreage through lake inundation.

Growth-Inducing Impact

All the alternatives would provide reduced water supply for the City of Los Angeles compared to the No-Restriction Alternative, which would continue historical export levels. Thus, none of these other alternatives would have a growth-inducing impact. With higher lake level alternatives and correspondingly reduced water exports, the city would have to develop alternative sources of water and power; growth in the Los Angeles urban area would tend to be limited rather than induced. Under the No-Restriction Alternative, however, further growth in the area would be encouraged in the southern California area.

Short-Term Uses and the Maintenance and Enhancement of Long-Term Productivity

All the competing uses for waters from Mono Basin entail long-term, productive, beneficial uses. The issue is therefore inapplicable.

Table S-1. Comparison of the Alternatives

Water Quality

Alternative or Condition	Mono Lake Salinity (g/l)	Arsenic Concentrations in Aqueduct Water[b] (μg/l)	Nutrient Levels in Upper Owens River Ecosystem[c] (mg/l)
Point of reference	90	23	0.26
No restriction	133[a]	23	0.25
6,372 Ft	92[a]	--	--
6,377 Ft	86	--	--
6,383.5 Ft	76	--	--
6,390 Ft	69	--	--
6,410 Ft	54	--	--
No diversion	48	26	0.85
Prediversion	48	26	0.85

[a] Significantly above federal antidegradation threshold of 85 grams per liter (g/l).

[b] Maximum contaminant level for drinking water is 50 micrograms per liter (μg/l).

[c] Recommended upper limit is 0.03 milligrams per liter (mg/l).

--= not evaluated.

Table S-1. Continued

Tributary Riparian Vegetation

Alternative or Condition	Frequency of Channel Dewatering	Erosion Potential		Frequency of Recruitment Flows (%)		Riparian Vegetation and Wetlands (% of Prediversion)
		Banks	Incision	Rush and Lee Vining	Parker and Walker	
Point of reference	Very low[d]	High	Low	25	100[d]	61
No restriction	High*	High	Extreme*	23	0*[m]	<50*√
6,372 Ft	Very low	Low-moderate	Moderate*	7*	7*[m]	63-82√[m]
6,377 Ft	Very low	Moderate	Low	9*, 52	85	61-81√[m]
6,383.5 Ft	Very low	High	Very low	41	85	60-80√[m]
6,390 Ft	Very low	High	Very low	47	85	60-79√[m]
6,410 Ft	Very low	Very high*	Very low	55	85	59-79√[m]
No diversion	Very low	Very high*	Very low	47	85	60-80√[m]
Prediversion	Moderate	--	Very low	--	--	100

[d] Assumes point of reference included current required flows for Parker and Walker Creeks.

* Significant project impact.

√ Significant cumulative impact.

[m] Impact substantially mitigable.

-- = not evaluated.

Table S-1. Continued

Lake-Fringing Vegetation and Aquatic Habitats

Alternative or Condition	Vegetated Wetlands (ac)	Lagoons (ac)	Alkali Lakebed (ac)
Point of reference	2,796	1	5,368
No restriction	313*√	0*m√	9,512*√
6,372 Ft	2,859	1√	3,883√
6,377 Ft	2,625	1√	1,492√
6,383.5 Ft	2,325*	6√	521√
6,390 Ft	2,071*	16√	377√
6,410 Ft	754*	261	157
No diversion	358*	261	0
Prediversion	356	260	0

* Significant project impact.

√ Significant cumulative impact.

m Impact substantially mitigable.

Table S-1. Continued

Upper Owens River Vegetation

Alternative or Condition	Channel Stability	Meadow and Marsh Extent	Threat of Willow Elimination	Willow Productivity (% of POR)
Point of reference	Low	See text	Moderately high	100
No restriction	Very low*√	Same as POR	Same as POR√m	98
6,372 Ft	Moderately low√m	Same as POR	Same as POR√m	102
6,377 Ft	Moderately low√m	Same as POR	Same as POR√m	104
6,383.5 Ft	Moderate√m	Same as POR	Same as POR√m	105
6,390 Ft	Moderate√m	Same as POR	Same as POR√m	106
6,410 Ft	Moderately high	Same as POR	Less than POR	109
No diversion	High	Somewhat less than POR*	Less than POR	96
Prediversion	High	Somewhat less than POR	Less than POR	96

* Significant project impact.

√ Significant cumulative impact.

m Impact substantially mitigable.

Aquatic Resources of the Tributary Streams

Alternative or Condition	Meets Prediversion Fishery Condition Standards Set by Court	Rush Creek: % Change in Brown Trout Adult Habitat	Rush Creek: % Change in Brown Trout Spawning Habitat	Rush Creek: % of Years Flows Exceed 100 cfs[a]	Lee Vining Creek: % Change in Brown Trout Adult Habitat	Lee Vining Creek: % Change in Brown Trout Spawning Habitat	Lee Vining Creek: % of Years Flows Exceed 100 cfs[b]	Effect on Parker and Walker Creeks
Point of reference	No	0	0	30	0	0	30	NA
No restriction	No	-75*	-79*	40	-55*	-57*	30	None
6,372 Ft	No	+16	+69	<10	+91	+209	10	Substantial benefits
6,377 Ft	No	+17	+73	80*[m]	+93	+218	80*[m]	Substantial benefits
6,383.5 Ft	No	+18	+75	80*[m]	+96	+220	80*[m]	Substantial benefits
6,390 Ft	No	+19	+78	80*[m]	+98	+228	80*[m]	Substantial benefits
6,410 Ft	No	+20	+105	80*[m]	+108	+288	80*[m]	Substantial benefits
No diversion	No	+20	+107	80*[m]	+109	+317	80*[m]	Substantial benefits
Prediversion	Yes	Unk	Unk	80	Unk	Unk	80	NA

Note: Significant cumulative fisheries impacts (√) for Rush, Lee Vining, Parker, and Walker Creeks apply to all alternatives. Impacts include permanently altered channel morphology, constraints on fish passage and spawning gravel movement due to the presence of the diversion facilities, and resulting decreases in the prediversion fish populations. These cumulative impacts are partially mitigable through restoration. The 6,383.5-Ft Alternative is the nearest alternative that satisfies preliminary DFG recommendations developed to optimize fishery conditions and approach pre-1941 fishery conditions to the greatest extent possible.

* Significant project impact.

[m] Impact substantially mitigable.

Unk = unknown.

[a] Preliminary DFG-recommended maximum flow limit.

[b] Maximum flow limit to avoid significant adverse impacts on brown trout population.

Table S-1. Continued

Aquatic Resources of the Upper Owens River

Alternative or Condition	Average % Change in Brown Trout Adult Habitat	Average % Change in Rainbow Trout Adult Habitat	Significant Impacts from Water Temperature Increases	Significant Impacts from Water Quality Degradation
Point of reference	0	0	NA	NA
No restriction	+4	+4	No	No
6,372 Ft	-4	-4	No	No
6,377 Ft	-12*√	-12*√	No	No
6,383.5 Ft	-21*√	-20*√	Yes*√	Yes*√
6,390 Ft	-26*√	-24*√	Yes*√	Yes*√
6,410 Ft	-36*√	-34*√	Yes*√	Yes*√
No diversion	-36*√	-34*√	Yes*√	Yes*√
Prediversion	Unk	Unk	Yes	Yes

Note: Significant project and cumulative impacts are partially or substantially mitigable depending on Grant Lake reservoir operations.

* Significant project impact.

√ Significant cumulative impact.

Unk = unknown.

Table S-1. Continued

Aquatic Resources of Grant Lake and Lake Crowley Reservoirs and Middle Owens River

Alternative or Condition	Grant Lake Reservoir Net Effects	Lake Crowley Reservoir Net Effects	Middle Owens River Net Effects
Point of reference	NA	NA	NA
No restriction	No significant change	Minor improvement	Less than significant adverse
6,372 Ft	Less than significant adverse	Less than significant adverse	Minor benefits
6,377 Ft	Less than significant adverse	Less than significant adverse	Minor benefits
6,383.5 Ft	Less than significant adverse	Less than significant adverse	Minor benefits
6,390 Ft	Less than significant adverse	Less than significant adverse	Minor benefits
6,410 Ft	Less than significant adverse	Less than significant adverse	Minor benefits
No diversion	Substantial benefits	Less than significant adverse	Minor benefits
Prediversion	NA	NA	NA

Note: Significant cumulative fisheries impacts on native species (√) for the Middle Owens River apply to all alternatives. They include altered channel morphology from LADWP facilities and operations and grazing and competition from introduced species. Some of these impacts are mitigable.

Table S-1. Continued

Alternative or Condition	Mono Lake Alkali Fly Productivity: Third Instar Production (MT/Lake)	Mono Lake Alkali Fly Productivity: Drift Density (number/m²)	Mono Lake Brine Shrimp Productivity: Total (Thousands of MT N/Lake)	Mono Lake Brine Shrimp Productivity: Cysts (Millions/m²)
Point of reference	919	16.5	0.59	1.41
No restriction	146*	5.6*	0.33*√	0.68*√
6,372 Ft	832	15.5	0.52√	1.21*√
6,377 Ft	1,210	19.0	0.64√	1.55√
6,383.5 Ft	1,353	19.6	0.74√	1.98√
6,390 Ft	1,341	19.0	0.88	2.57
6,410 Ft	(855)	(11.0)	--[e]	--[e]
No Diversion	(708)	(8.9)	--[e]	--[e]
Prediversion	Unk	Unk	--[e]	--[e]

[e] Similar to or greater than 6,390-Ft Alternative.

* Significant project impact based only on change in productivity; for effects on feeding bird populations, see the "Wildlife" chapter.

√ Significant cumulative impact based only on change in productivity; for effects on feeding bird populations, see the "Wildlife" chapter.

[m] Impact substantially mitigable.

( ) Reliability uncertain.

-- = not evaluated.

Unk = unknown.

Table S-1. Continued

	Wildlife					
Alternative or Condition	% Change in Potential Gull Nesting Capacity	Invertebrate Food for Water Birds	Potential Habitat for Migratory Ducks	Potential Snowy Plover Nesting Habitat	Wildlife Habitat Values of Mono Lake Shoreline Vegetation	Wildlife Habitat Values of Tributary Streams
Point of reference		Moderate	Low	High	Moderate	Low
No restriction	-82*√	Low or nonexistent*√	Absent*√	Low*	Low or none*	None*√
6,372 Ft	-16*√	Low*√	Low√	High	Moderate	Moderate√[m]
6,377 Ft	+440*	Moderate*	Low√	High	Moderate	Moderate√[m]
6,383.5 Ft	+390	High	Moderately low√	High	Moderate	Moderately high√[m]
6,390 Ft	+326	High	Moderate√	High	Moderately low*	Moderately high√[m]
6,410 Ft	+262	Unk	High	Moderate	Low*	Moderately high√[m]
No diversion	+251	Unk	High	Low*	Low*	Moderately high√[m]
Prediversion	+256	Unk	High	Unk	Low	High

* Significant project impact.

√ Significant cumulative impact.

[m] Impact substantially mitigable.

Unk = unknown.

Table S-1. Continued

	Land Use		Air Quality		
Alternative or Condition	Forage Production (AUMs)	Probability of LADWP Land Disposal	Maximum PM_{10} Concentration in Key Areas[f] ($\mu g/m^3$)	Frequency of PM_{10} Concentrations above State Standards[g] (events/yr)	Maximum Extent of PM_{10} Concentrations above State Standards[g] (ac)
Point of reference	13,900	Very low	970	13-14	About 56,000
No restriction	13,900	Very low	Over 1,100*√	More than 15*√	Over 65,000
6,372 Ft	6,000√[m]	Moderate	About 970√	About 13-14√	About 56,000
6,377 Ft	6,000√[m]	Moderate	About 850√	Fewer than 13√	About 29,500
6,383.5 Ft	6,000√[m]	Moderate	About 650√	Fewer than 10√	About 16,000
6,390 Ft	6,000√[m]	Moderate	About 75	About 1-2	About 3,000
6,410 Ft	6,000√[m]	Moderate	Below 50	Fewer than 1	0
No diversion	6,000√[m]	High	Below 50	Fewer than 1	0
Prediversion	24,500	N/A	Below 50	Fewer than 1	0

[f] Major public access areas or monitoring station locations.

[g] State standard is 50 $\mu g/m^3$.

* Significant project impact.

√ Significant cumulative impact.

[m] Impact substantially mitigable.

N/A = not applicable.

Table S-1. Continued

Visual Resources[i]

Alternative or Condition	Mono Lake Tufa	Phalaropes	Grant Lake Reservoir Drawdown (in wet years)	Lake Crowley Reservoir Drawdown (in wet years)
Point of reference	See "Visual Resource" chapter	See "Wildlife" chapter	30 feet	4 feet
No restriction	Emergence of additional tufa	Large decrease*√	20 feet	4 feet
6,372 Ft	Basal inundation of a few towers	Phalaropes restricted to east side*√	27 feet	6 feet
6,377 Ft	Toppling of a few South Tufa towers; basal inundation of a few other towers	Phalaropes more visible to visitors	17 feet	6 feet
6,383.5 Ft	Toppling of several South Tufa towers; complete submergence of up to 10%; basal submergence up to 50%	Phalaropes more visible to visitors	4 feet	9 feet*
6,390 Ft	Toppling of 50% South Tufa towers; complete submergence of nearly 20%; all sand tufa destroyed; basal submergence up to 60%*	Phalaropes more visible to visitors	4 feet	7 feet*
6,410 Ft	All towers at South Tufa toppled; 30-100% of groves completely submerged; all sand tufa destroyed*	Phalaropes more visible to visitors	4 feet	8 foot*
No diversion	Same as for 6,410 Ft*	Phalaropes more visible to visitors	0 feet	9 feet*
Prediversion	Nearly all tufa towers completely submerged	Phalaropes more visible to visitors; migratory waterfowl increase	N/A	N/A

i Only those effects not covered in other resource topics shown; for other Mono Lake birds (gulls, waterflow), see "Wildlife" chapter.
* Significant project impact.
√ Significant cumulative impact.
N/A = not applicable.

Table S-1. Continued

Alternative or Condition	Recreation Opportunity (by Exceedance Frequency)[j] Mono Lake Lakeshore Inaccessible (<6,373.5 ft)	Upper Grant Lake Reservoir Inaccessible (<7,105 ft)	Grant Lake Reservoir Boat Ramp Unusable (<7,111 ft)	Lake Crowley Reservoir Boat Ramp Unusable (<6,760 ft)	Lake Crowley Reservoir Waterski Course Inaccessible (<6,773 ft)
Point of reference	0	50	50	0	20
No restriction	100*m	30	50	0	20
6,372 Ft	64*m	50	50	0	35
6,377 Ft	0	80*m	87*m	0	50*m
6,383.5 Ft	0	80*m	87*m	0	80*m
6,390 Ft	0	87*m	90*m	0	80*m
6,410 Ft	0	97*m	100*m	0	80*m
No diversion	0	0	0	0	80*m
Prediversion	0	N/A	N/A	N/A	N/A

[j] Only those effects not covered in other resource topics (e.g., fisheries, wildlife) shown.

* Significant project impact.

[m] Impact substantially mitigable.

N/A = not applicable.

Table S-1. Continued

Alternative or Condition	Recreation Use (% of POR days/visitor)				Cultural Resources
	Mono Lake	Tributary Streams	Grant Lake Reservoir	Lake Crowley Reservoir	Potential for Site Disturbance
Point of reference	100	100	100	100	Likely
No restriction	Unk*	-20*	9	3	Likely*[m]
6,372 Ft	0	-7	-5	-3	Likely*[m]
6,377 Ft	0	33	-6	0	Likely*[m]
6,383.5 Ft	6	60	-7	-9	Likely*[m]
6,390 Ft	12	Unk	-8	-9	Likely*[m]
6,410 Ft	-3	Unk	-9	-12*	Certain*[m]
No diversion	Unk	60	Unk	-12*	Certain*[m]
Prediversion	Unk	Unk	Unk	Unk	Likely

* Significant project impact.

[m] Impact substantially mitigable.

Unk = unknown.

Table S-1. Continued

Alternative or Condition	Water Supply: Annual Aqueduct Water Availability (TAF)	Water Supply: Annualized Cost of Los Angeles Total Water Supply (millions of 1992 dollars)	Water Supply: Cost Increase (%)	Water Supply: LADWP Share of MWD Supply (%)	Power Supply: Annual Aqueduct Energy (GWh)	Power Supply: Annualized Fuel Cost for System (millions of (1992 dollars)	Power Supply: Cost Increase from POR (%)
Point of reference	442	175		2.6	1,038	675.6	
No restriction	450	170	-3	2.3	1,072	674.4	-0.18
6,372 Ft	425	186	6	3.1	1,005	677.5	+0.28
6,377 Ft	414	191	9	3.4	984	678.3	+0.39
6,383.5 Ft	400	201	15*m	3.8	930	679.8	+0.61
6,390 Ft	395	205	17*m	3.9	904	680.6	+0.74
6,410 Ft	384	213	22*m	4.2	845	682.2	+0.97
No diversion	375	218	25*m	4.5	817	683.8	+1.20
Prediversion	Unk	Unk	Unk	Unk	Unk	Unk	Unk

* Significant project impact.

Unk = unknown.

Table S-1. Continued

Annual Economic Cost and Benefits Relative to the Point of Reference (Millions of 1992 Dollars)

Alternative or Condition	Water Supply Benefits	Power Generation Benefits	Recreation Benefits	Mono Lake Preservation Benefits	Net Benefits
Point of reference	--	--	--	--	--
No restriction	+5.1	+1.3	-2.9	-759.7	-753.0
6,372 Ft	-10.8	-1.9	+0.4	0.0	-12.3
6,377 Ft	-16.5	-2.7	+1.1	+22.6	+3.2
6,383.5 Ft	-24.7	-4.2	+1.9	+63.0	+31.8
6,390 Ft	-28.7	-5.0	+2.7	+85.9	+49.9
6,410 Ft	-35.4	-6.7	+1.2	0.0	-43.4
No diversion	-41.2	-8.2	+1.2	0.0	-50.9
Prediversion	--	--	--	--	--

-- = not evaluated.

Table S-2. Summary of Mitigation Measures

Significant Impact	Mitigation Measures
Vegetation	
Additional incision of the tributary streams	Construct hardened drop structures at the County Road crossings of Rush and Lee Vining Creeks
Erosion of the Parker and Walker Creek channels	Limit high flows in the near term to 23 and 15 cfs, respectively, by shunting higher flows to Grant Lake reservoir; allow increases in these limits as habitats recover or restoration succeeds
Erosion of Rush and Lee Vining Creek channels	Limit high flows in the near term to 350 and 250 cfs, respectively, shunting higher flows through the A-Ditch to Pumice Valley; allow increases in these limits as habitats recover or restoration succeeds
Cumulative losses of riparian vegetation and wetlands along the tributary streams	Seasonally rewater available overflow channels on all four tributary streams on at least a biannual basis
	Limit livestock grazing along the existing and potential riparian corridors through fencing or suspension of range use
	Plant woody riparian vegetation where absent along the tributary streams based on testing of soil condition and groundwater depth; prevent vehicular access
	Create freshwater ponds and riparian thickets at Cain Ranch and along lower Rush Creek
	Plant or protect woody riparian vegetation offsite in Mono Basin if onsite mitigation is insufficient
Losses of lakebed wetlands	Create lakebed wetlands and ponds where water supply is available using habitat restoration technologies
Channel instability along the Upper Owens River	Adopt ramping standards for streamflow changes; limit export volumes so a flow of 300 cfs is not exceeded in the river channel below East Portal
Fisheries	
Reduction in adult and spawning habitat	Establish minimum instream flow requirements that promote reestablishment and maintenance of prediversion fisheries and develop and implement appropriate habitat restoration plans, including gravel restoration plans
Adverse effects of high streamflows	Limit release flows in Rush Creek to 80 cfs whenever possible
	Limit release flows in Lee Vining Creek to 100 cfs whenever possible
	Ramp flow changes at unimpaired historical rates

Table S-2. Continued

Significant Impact	Mitigation Measures
	Establish sluicing criteria
	Discharge higher flows into overflow channels
	Install current deflectors, woody debris, and vegetation to stabilize eroding streambanks
	Install pools, backwaters, and overflow channels to create refuge habitat
	Periodically add spawning gravels or scarify existing spawning gravels if surveys indicate a need
Reduced brown trout habitat in the Upper Owens River	Adjust operations to provide nearly constant export rates year round, limiting flows in the river below East Portal to 150-200 cfs whenever possible and above 75 cfs at all times
Reduced fish productivity in Grant Lake reservoir	Develop and implement a fish stocking program
Winter mortality of trout	Limit flows in Lee Vining Creek to a maximum of 20 cfs from October through March
Aquatic Productivity	
Decreased alkali fly productivity	Place concrete blocks or fragments in the littoral zone of the selected equilibrium lake level below the normal lowstand, if consistent with USFS management policy for the scenic area
Wildlife	
Loss of migratory duck habitat	Construct open-water ponds using surface water or groundwater sources
Loss of habitat values of tributary streams	See the discussion above for tributary streams under "Vegetation"
Land Use	
Loss of forage production	Continue irrigation of Cain Ranch lands below the conduit
Potential growth inducement of land disposal	Impose county planning and zoning controls; USFS acquire lands affecting the Mono Basin National Forest Scenic Area
Air Quality	
PM_{10} standards exceeded	No feasible measures available

Table S-2. Continued

Significant Impact	Mitigation Measures
Visual Resources[a]	
Loss of tufa or phalarope visibility	No feasible measures available
Recreation[a]	
Reduced boating and waterskiing opportunities	Construct substitute waterskiing course at Lake Crowley reservoir in location relatively insensitive to lake level; extend boat ramp at Grant Lake reservoir marina
Inaccessibility of Upper Grant reservoir	Modify water releases to maintain higher lake levels during recreation
Reduced shoreline access at Mono Lake	Extend roads and construct new parking lots closer to lakeshore
Reduced Mono Lake beach recreation	Construct sandy beaches
Cultural Resources	
Loss or degradation of known or undiscovered cultural sites along tributary streams, Upper Owens River, and Mono Lake vicinity	Identify areas of direct or indirect effect; survey areas for cultural resources; consult Native American community; and develop a cultural resource treatment plan that includes avoidance, monitoring ground disturbance, test excavation and data recovery, closure of access routes, and fencing as warranted
Water Supply	
Cost increase for sufficient supply	Identify and develop water reclamation projects; develop replacement supplies using Assembly Bill 444 funds; participate in water transfers program authorized by HR 929; participate in Metropolitan Water District's rebate programs; implement and monitor compliance with all Best Management Practices identified in the Urban Water Master Plan

[a] Mitigation measures for visual resource and recreation impacts related to "Fishery Resources" and "Wildlife" are described under these topics.

Table S-3. Significant Impacts of the Alternatives Relative to the Point of Reference

Significant Impact	Alternatives						
	No Restriction	6,372-Ft	6,377-Ft	6,383.5-Ft	6,390-Ft	6,410-Ft	No Diversion
Physical Environmental Resources							
Riparian vegetation							
Erosion potential	X	X				X	X
Streamflow sufficiency	X	X	X				
Extent	X						
Lake-fringing vegetation							
Aquatic habitats	(X)						
Wetland vegetation	X			X	X	X	X
Upper Owens River vegetation							
Erosion potential	X						
Extent							X
Tributary aquatic resources							
Habitat extent	X						
Excessive high flows[a]			(X)	(X)	(X)	(X)	(X)
Upper Owens River aquatic resources							
Habitat extent[a]			(X)	(X)	(X)	(X)	(X)
Water temperature or quality[a]				(X)	(X)	(X)	(X)
Other aquatic resources							
Grant Lake reservoir							
Lake Crowley reservoir							
Middle Owens River							
Mono Lake invertebrate productivity							
Alkali fly	X						
Brine shrimp	X	X					
Wildlife							
Gull nesting	X	X	X				
Water bird food supply	X	X	X				
Duck habitat	X						
Shoreline habitats	X				X	X	X
Tributary stream habitats	X						
Air quality							
Dust storm occurrence	X						
Water quality							
Drinking water quality							
Stream nutrient levels							
Cultural resources							
Archeological sites	(X)	(X)	(X)	(X)	(X)	(X)	(X)
Visual quality							
Tufa					X	X	X
Other elements	X	X					
Resource Utilization							
Recreation							
Mono Lake shore access	(X)	(X)					
Reservoir recreation access			X	X	X	X	X
Mono Basin recreational use	X						
Lake Crowley recreational use						X	X
Land use							
Irrigated agriculture							
Los Angeles water supply cost				X	X	X	X
Los Angeles power supply cost							

Note: Parentheses (X) indicate impact is substantially mitigable.

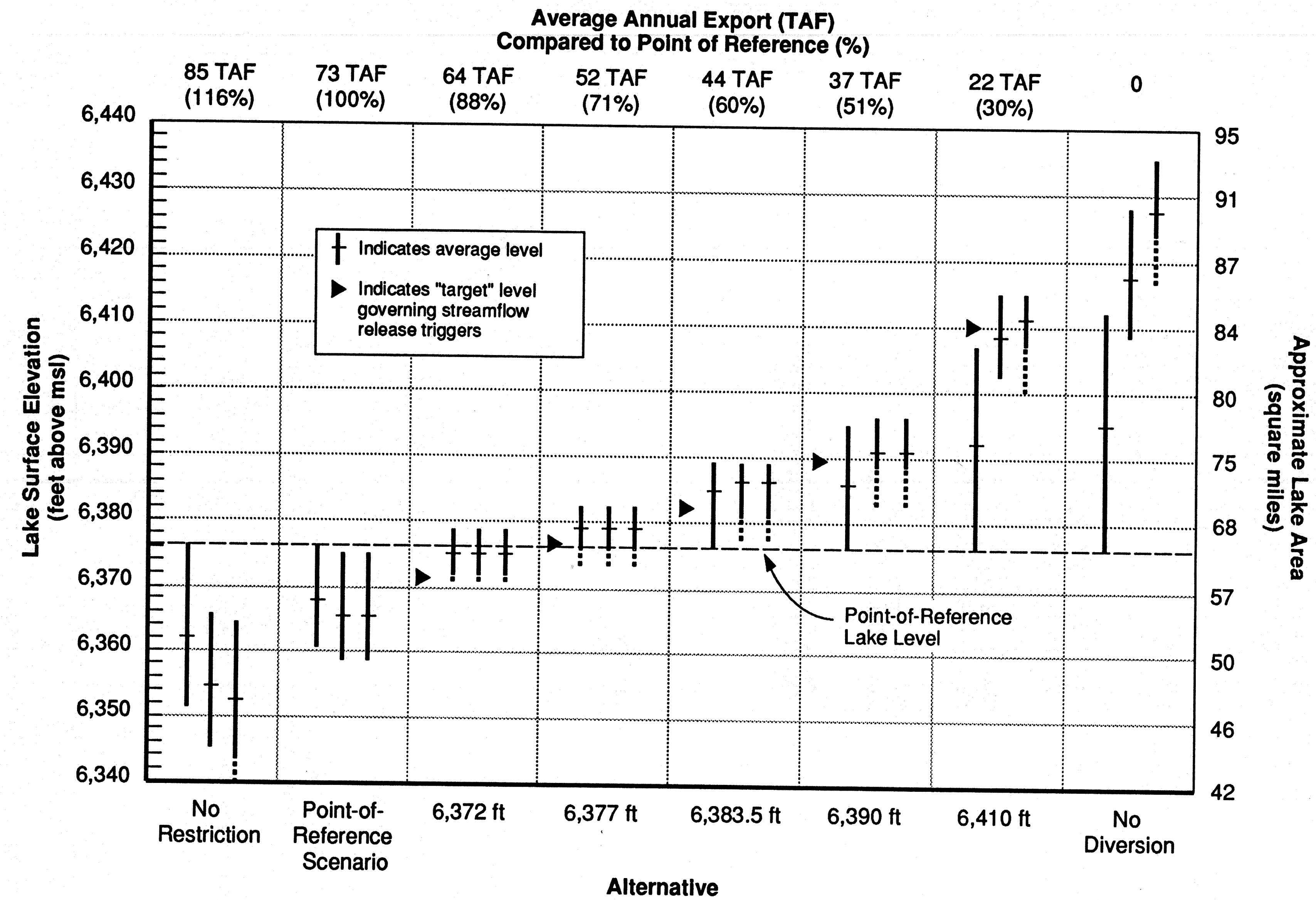
[a] Mitigation would be increasingly difficult for the higher lake level alternatives.

Table S-4. Significant Cumulative Impacts of the Alternatives Relative to the Prediversion Conditions

Significant Impact	Alternatives						
	No Restriction	6,372-Ft	6,377-Ft	6,383.5-Ft	6,390-Ft	6,410-Ft	No Diversion
Physical Environmental Resources							
Riparian vegetation							
Erosion potential							
Streamflow sufficiency							
Extent	X	(X)	(X)	(X)	(X)	(X)	(X)
Lake-fringing vegetation							
Aquatic habitats	X	X	X	X	X		
Wetland vegetation	X						
Upper Owens River vegetation							
Erosion potential	X	(X)	(X)	(X)	(X)		
Extent	(X)	(X)	(X)	(X)	(X)		
Tributary aquatic resources							
Habitat conditions[a]	X	X	X	X	X	X	X
Upper Owens River aquatic resources							
Habitat extent[b]			(X)	(X)	(X)	(X)	(X)
Water temperature or quality[b]				(X)	(X)	(X)	(X)
Other aquatic resources							
Grant Lake reservoir							
Lake Crowley reservoir							
Middle Owens River[c]	(X)	(X)	(X)	(X)	(X)	(X)	(X)
Mono Lake invertebrate productivity							
Alkali fly[d]							
Brine shrimp	X	X	X	X			
Wildlife							
Gull nesting	X	X					
Water bird food supply	X	X					
Duck habitat	X	X	X	X	X		
Shoreline habitats							
Tributary stream habitats	X	(X)	(X)	(X)	(X)	(X)	(X)
Air quality							
Dust storm occurrence	X	X	X	X			
Water quality							
Drinking water quality							
Stream nutrient levels							
Cultural resources							
Archeological sites							
Visual quality							
Tufa							
Other elements	X	X					
Resource Utilization							
Recreation							
Mono Lake beach and motorboat use	X	X	X	X	X		
Reservoir recreation access							
Mono Basin recreational use							
Lake Crowley recreational use							
Land use							
Irrigated agriculture		(X)	(X)	(X)	(X)	(X)	
Los Angeles water supply cost							
Los Angeles power supply cost							

Note: Parentheses (X) indicate impact is substantially mitigable.

[a] Cumulative fishery impacts are only partially mitigable.
[b] Mitigation would be increasingly difficult for the higher lake level alternatives.
[c] At least partial mitigation is feasible.
[d] Prediversion condition unknown.



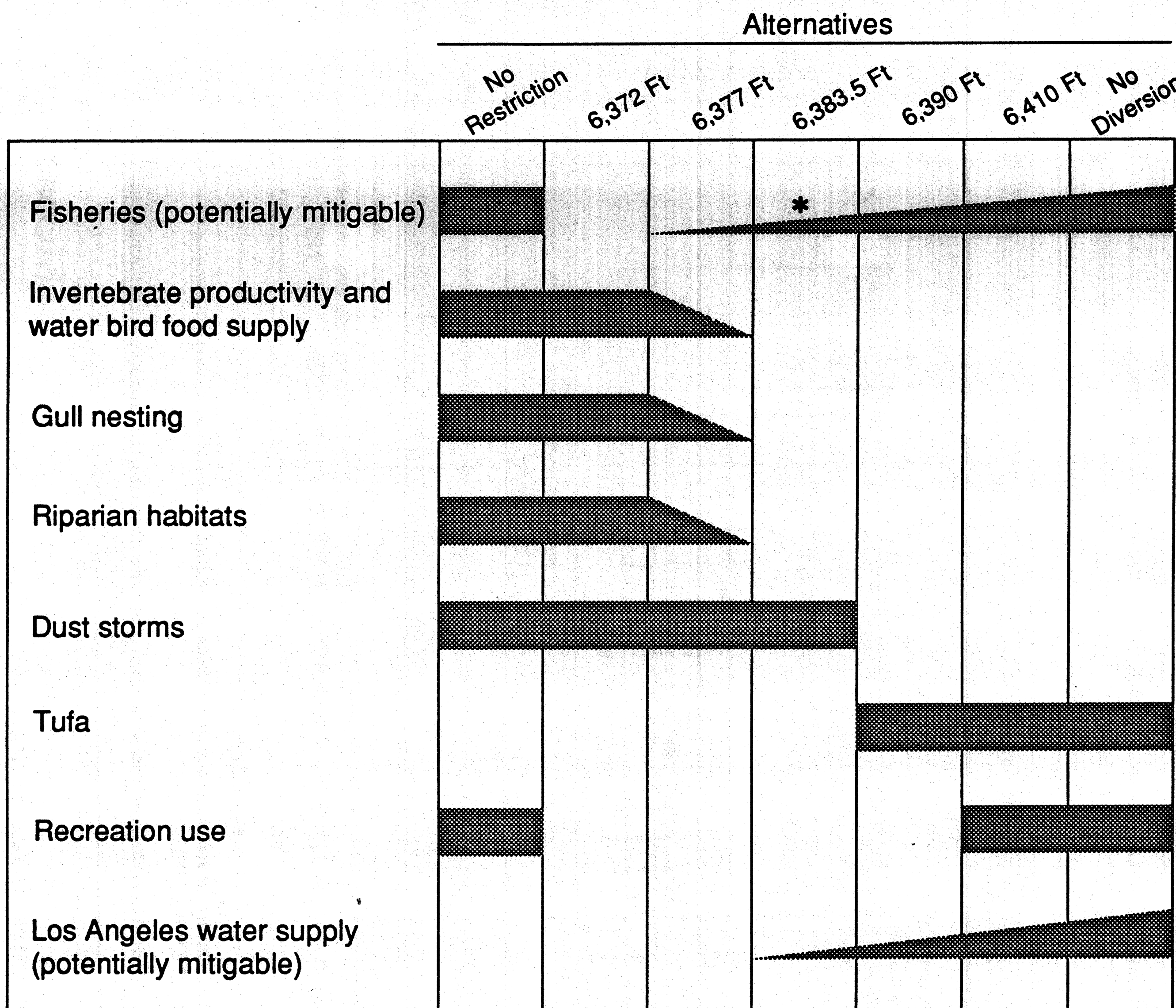
Notes: Normal range of lake level fluctuation indicated by solid bars; possible declines during extreme drought are indicated by dashes (where dashes omitted, effect of extreme drought not estimated).

The three bars for each alternative represent simulated lake level fluctuations over three successive 50-year periods; the left-hand bar represents the first 50 years of simulation and the right-hand bar represents "dynamic equilibrium".

Figure S-1.
Project Alternatives Showing Lake Levels over Three 50-Year Periods

MONO BASIN EIR

Prepared by Jones & Stokes Associates



▒ Indicates selected significant project impacts and cumulative impacts for the alternatives.

* Indicates alternative most closely satisfying preliminary DFG recommendations developed to optimize fisheries conditions.

Notes: Impacts on invertebrate productivity and water bird food supply, gull nesting, and riparian habitats may be significant only for dry-year conditions under the 6,377-Ft Alternative.

Impacts on water supply and on tributary stream fisheries from high flows and on Upper Owens River fisheries from low flows are increasingly difficult to mitigate for the higher lake level alternatives.

Figure S-2.
Comparison of Key Significant Environmental Impacts

Table of Contents

Appendix W. Recreation Resources

Appendix X. Economics

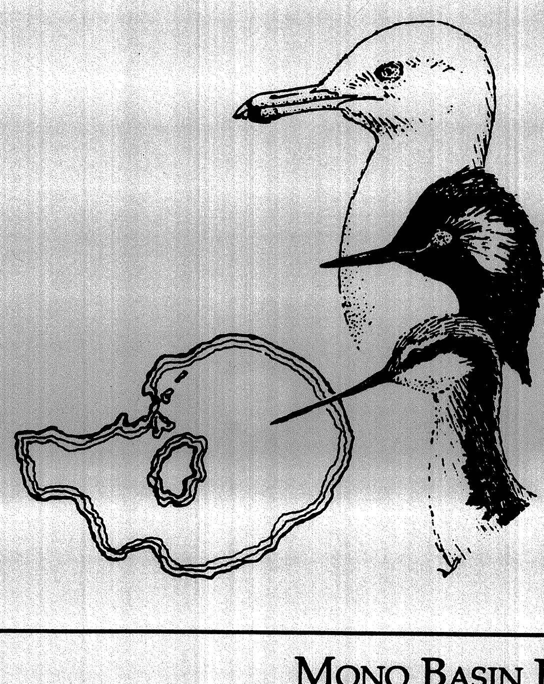
List of Tables and Figures

Table

List of Figures

Figure

Chapter 1. Introduction



Chapter 1. Introduction

PROPOSED PROJECT AND PROJECT OBJECTIVE

The California State Water Resources Control Board (SWRCB) proposes to amend the City of Los Angeles' water right licenses for diversions from streams tributary to Mono Lake. The license amendments will require adequate flows in the streams below the diversions for protection of fish and will include requirements for protection of public resource values in the lake and in its basin. Specifically, SWRCB proposes to establish, through prescribed regulatory procedures:

- instream flow requirements for the Mono Lake tributaries from which the city diverts water, including Rush, Parker, Walker, and Lee Vining Creeks, as necessary to comply with the Public Trust Doctrine and with the California Fish and Game Code and judicial rulings requiring that license conditions be sufficient to maintain fisheries equivalent to prediversion levels and

- water surface elevation requirements for Mono Lake and other conditions necessary to provide appropriate protection of public trust resources and beneficial uses of Mono Lake and its tributaries.

For purposes of the California Environmental Quality Act (CEQA), the project is the establishment of required conditions for Mono Lake and the diverted streams and the modification of the City of Los Angeles' diversions to conform to those requirements by amendment of its water right licenses. The purpose of the project is to ensure that continued export of surface waters from Mono Basin by the Los Angeles Department of Water and Power (LADWP) conforms to state law, including legal requirements to restore and protect public trust resources.

PROJECT LOCATION AND ENVIRONMENTAL CONTEXT

Mono Lake and the diverted tributary streams are located in Mono County, California, in a closed basin east of the crest of the Sierra Nevada (Figure 1-1). (A small portion of the basin lies in Mineral County, Nevada.) The lake (Figure 1-2), because of its great age, has become hypersaline and alkaline through evaporation in the arid Great Basin environment, giving rise to a unique ecological system of lake-dwelling invertebrates preyed on by large numbers of migrating and nesting birds.

For the more than 50 years since 1941, portions of the waters of four of the major tributary streams (Figure 1-3), which flow from the eastern slopes of the snowy Sierra Nevada, have been exported south from Mono Basin via the Mono Craters Tunnel to the Upper Owens River by LADWP.

Commingling with waters of the Upper Owens River and other Owens Basin streams, the diverted waters then flow south to a regulating reservoir, Lake Crowley, impounding the Owens River (Figure 1-4). Continuing to increase from other tributary inflows, these waters pass through three power generating stations and two other impoundments (i.e., Pleasant Valley Reservoir and Tinemaha Reservoir) until they enter the city's aqueduct south of Bishop in Inyo County (Figure 1-5). The double-barreled aqueduct leads to a reservoir in Los Angeles County, from which water is distributed to commerce and the populace. Mono Basin exports make up about one-fifth of the waters delivered through the aqueduct.

CITY OF LOS ANGELES WATER RIGHTS

In 1940, the City of Los Angeles was granted permits by the State of California allowing the appropriation of the flows from Rush, Lee Vining, Parker, and Walker Creeks into its newly constructed Mono Basin export system. Limited capacity of the Los Angles aqueduct downstream prevented full appropriation of Mono Basin waters for many years. By 1970, however, the aqueduct system had been expanded, and full diversion during periods of average runoff became common.

In 1974, SWRCB issued licenses confirming the city's right to divert water from the Mono Lake tributaries. From 1974 until 1989, the city annually exported an average of 83,000 acre-feet of water from Mono Basin.

EFFECT OF PAST DIVERSIONS ON MONO LAKE AND ITS TRIBUTARIES

Over 50 years of water diversion and basin export by the city (Figure 1-6) have been accompanied by a decline in lake surface elevation of slightly more than 40 feet (Figure 1-7), causing the lake surface area to diminish about 25%. Salinity and alkalinity of the lake waters have increased, bird-nesting islands have lost their security from mainland predators, riparian and freshwater habitats along the tributary streams have been irreversibly lost through erosion, and occasional massive dust storms have been induced from salt efflorescence on exposed lakebeds. Yet the lake's fascinating complex of tufa formations, formed underwater during higher lake levels, has been increasingly exposed for the enjoyment of the curious explorer.

Water exported to the Upper Owens River for conveyance to the city's aqueduct intake has had both beneficial and adverse effects on the river. Water export to the Upper

Owens River affects water management of the entire Owens Basin system of reservoirs, diversions, groundwater withdrawal and recharge, and rangeland irrigation for livestock.

LEGAL HISTORY OF THE MONO LAKE CONTROVERSY

The legal history of the Mono Lake controversy is described in detail in Appendix R.

Water Appropriations and the Public Trust

In 1983, in response to a suit filed by the National Audubon Society, the California Supreme Court held that the public trust mandated reconsideration of the City of Los Angeles' water rights in Mono Basin. The court noted that Mono Lake is a scenic and ecological treasure of national significance and that the lake's value as a recreational and ecological resource was diminished by recession of the water level.

The court found that the city's water rights were granted without consideration of impacts on these resources and that therefore SWRCB or the court should reconsider the city's water rights. The court noted that before continued stream diversions could be approved, the effect of such diversion on interests protected by the public trust should be considered and that harm to those interests should be minimized or avoided if feasible.

Protection of Fisheries

After substantial runoff in the mid-1980s, water and fish were spilled over LADWP's diversion dams on Rush and Lee Vining Creek. Lawsuits by Dahlgren and the Mono Lake Committee seeking streamflow releases to keep these fish in good condition resulted in preliminary injunctions requiring minimum streamflows year-round as follows:

- Rush Creek - 19 cubic feet per second (issued by Mono County Superior Court in March 1985) and
- Lee Vining Creek - 5 cubic feet per second (issued by Mono County Superior Court in October 1987).

No minimum streamflows were required for Parker and Walker Creeks, which are tributaries of Rush Creek, and total diversion of these streams during normal runoff conditions continued until 1990.

Two cases subsequently brought by California Trout allowed the California Court of Appeal to apply the public trust doctrine to existing state law for protection of fisheries in diverted streams. In "Caltrout I", the court found that the city's 1974 water rights licenses must be conditioned to allow bypass streamflow around the diversions sufficient "to keep in good condition any fish that may be planted or exist below the diversion dam" (California Fish and Game Code Section 5937).

In "Caltrout II", the court found that SWRCB must require the city to "release sufficient water . . . to reestablish and maintain the fisheries that existed . . . prior to its diversion of water." The court noted that this requirement is not subject to balancing preservation of public trust values with the city's need for water.

Recent Proceedings

On August 22, 1989, Judge Finney of the Superior Court for El Dorado County, who was assigned all Mono Basin water rights cases by the California Judicial Council, entered a preliminary injunction requiring the City of Los Angeles to maintain the water surface elevation of Mono Lake at 6,377 feet for the remainder of that water year. As subsequently described in Chapter 2, the lake level on that date, and the streamflows that were required a few years earlier (as noted above), are used in this report as the point of reference for evaluating impacts of water diversion alternatives.

On September 29, 1989, after a hearing to consider SWRCB's statement of scope and procedures for its proposed review of the city's water rights, the court issued an order staying further judicial proceedings on the merits of the coordinated Mono Basin water rights cases pending action by SWRCB.

The court has continued to address interim relief issues. Lengthy evidentiary hearings were held in 1990 regarding the propriety of the interim requirements for minimum streamflows and lake level imposed by the court. The results of these hearings (issued in June 1990 and April 1991) were that the minimum lake surface elevation of 6,377 feet was reaffirmed, but that minimum release streamflows, when natural flows allow, should be amended as shown in Table 1-1. These requirements, currently in effect, will remain in effect until the SWRCB process is complete or until revised by the court.

SCOPING OF ENVIRONMENTAL ISSUES

In September 1989, SWRCB held a public scoping workshop in Sacramento to identify environmental issues to be addressed in an environmental impact report (EIR) for the project.

On October 10, 1989, SWRCB established technical advisory groups to assist SWRCB in reviewing the implications of the city's water rights. Five groups were formed to assist in the following resource areas:

- wildlife, riparian vegetation, wetlands, and land use;
- fisheries and aquatic resources;
- hydrology, operations, and water use;

- water quality; and
- air quality.

The purpose of these groups was to assist SWRCB staff in identifying and evaluating technical information pertinent to each subject area and to develop the resource issues needing evaluation in the EIR. Meetings of these groups began in October 1989 and extended for different periods, in some cases through 1991.

On January 4, 1990, a notice of preparation of an EIR was circulated to public agencies and released to the public, providing 60 days for submission of comments on the appropriate scope of the report. This notice was mailed to more than 500 groups and individuals and published widely in newspapers. The notice listed 73 environmental issues identified at the public scoping meeting and by the technical advisory groups. Probable environmental effects were tentatively identified as follows:

- Mono Lake - changes in lake level, volume, and salinity; invertebrate productivity; air quality; wildlife habitat; and aesthetic quality;

- Mono Lake tributary streams - changes in streamflow, reservoir storage volume, water temperatures, invertebrate populations, channel morphology, riparian vegetation, wildlife and fish populations, and recreation opportunities;

- Owens River and reservoirs - changes in streamflow, reservoir storage volume, water temperature, invertebrate populations, channel morphology, riparian vegetation, wildlife and fish populations, energy production, and recreation opportunities; and

- City of Los Angeles - changes in water supply.

The notice of preparation also identified the three documents presenting the most recent scientific information about the Mono Lake ecosystems prior to this report:

- Mono Basin Ecosystem Study Committee of the National Research Council, National Academy of Sciences (NAS). 1987. *The Mono Basin ecosystem: effects of changing lake level.* Washington, DC.

- Botkin, D. B. et al. 1988. *The future of Mono Lake: report of the Community and Organization Research Institute (CORI) blue ribbon panel.* Report No. 68 of the Water Resources Center, University of California. Riverside, CA.

- Inyo National Forest. 1990. *Final environmental impact statement and comprehensive management plan, Mono Basin National Forest Scenic Area.* Washington, DC.

In March 1990, SWRCB staff reviewed submitted comments, prepared a scope of work for the EIR, and requested proposals for preparation of the EIR from more than 40 resource-management consultants. Four proposals were submitted, and the proposing consultants were interviewed by the following three review teams:

- SWRCB staff;
- Los Angeles Department of Water and Power staff; and
- a team composed of representatives of
  - Mono Lake Committee,
  - California Trout,
  - Audubon Society,
  - U.S. Forest Service, Inyo National Forest,
  - Mono County, and
  - California Department of Fish and Game.

The review teams submitted recommendations to SWRCB staff, and in June 1990, Jones & Stokes Associates of Sacramento was selected as SWRCB's prime consultant, with EDAW of San Francisco selected to evaluate the visual resource issues. Detailed work planning was initiated shortly thereafter and continued for various topic areas through March 1991.

In preparing this report, the SWRCB consultant has used information from the NAS report, the CORI report, and the U.S. Forest Service's environmental impact statement for the Mono Basin National Forest Scenic Area. In addition, the SWRCB consultant has used numerous other technical studies and reports prepared by various experts on the Mono Basin under the direction of SWRCB staff. These reports are identified as Mono Basin Auxiliary Reports and are cited throughout the document.

Additional technical experts were consulted throughout the development of study protocols and development of the resource chapters of this EIR. The SWRCB consultant and SWRCB staff have worked closely with the California Department of Fish and Game (DFG) and its technical consultants conducting instream flow studies on the Mono Lake tributaries and the Upper Owens River to obtain current information regarding streamflows and fishery habitat conditions. This report is the result of the combined efforts of the SWRCB consultant, SWRCB staff, the participants in the technical advisory groups, and the numerous other technical experts.

SUBSEQUENT ENVIRONMENTAL IMPACT REPORT PROCESS

This report is being circulated for 90 days to interested parties for review and submission of written comments. Following this period, public hearings will be held in Sacramento to receive evidence related to the amendment of the City of Los Angeles' water right licenses.

Based on submitted comments, modifications to this draft report may be made before any SWRCB decisions. Modifications may include examination of modified alternatives adjusted for impact mitigation purposes. Responses to comments and a final EIR will be prepared before final SWRCB decisions are made.

INTENDED USES OF THIS DOCUMENT

SWRCB will use this document to evaluate the environmental impacts of various alternatives available for establishing required fishery protection flows and appropriate measures to protect public trust resources. SWRCB will make decisions regarding fishery protection measures and public trust resources following a public hearing process during which this document and other evidence will be considered.

SWRCB will incorporate appropriate instream flow requirements, lake elevation requirements, and any measures necessary to protect public trust resources into the city's water right licenses.

This document will also be used to evaluate the potential for Mono Lake to be designated as an Outstanding National Resources Water (ONRW) pursuant to the Clean Water Act.

CHARACTER AND ORGANIZATION OF THE EIR

This EIR evaluates a series of water-rights alternatives, each of which represents a lake-level target and minimum streamflows based on assumed stream diversion rules. The lake-level targets were developed by SWRCB staff during the scoping process. Chapter 2, "Project Alternatives and Points of Reference", describes seven such alternatives, ranging from no restrictions on diversion to no diversion, and their development using complex numerical hydrologic models. Because a computerized model was used to formulate alternatives, the alternatives can be modified and evaluated during the EIR review and public hearing processes to assist SWRCB's decisions.

Chapter 3 is an assessment of environmental benefits and adverse effects in each of 14 resource topic areas. By presenting an examination of the wide range of alternatives, this report reveals the full range of possible benefits and impacts for any SWRCB decision. The resources examined in separate subchapters include:

- hydrology - Chapter 3A,
- water quality - Chapter 3B,
- vegetation - Chapter 3C,
- fishery resources - Chapter 3D,
- Mono Lake aquatic productivity - Chapter 3E,
- wildlife - Chapter 3F,
- land use - Chapter 3G,
- air quality - Chapter 3H,

- visual resources - Chapter 3I,
- recreation - Chapter 3J,
- cultural resources - Chapter 3K,
- Los Angeles water supply - Chapter 3L,
- power generation - Chapter 3M, and
- economics - Chapter 3N.

Each chapter is arranged with text first, followed by all cited tables, followed by all cited figures.

A summary comparison of impacts and benefits of the alternatives and other discussions required by CEQA is contained in the preceding "Summary" section of this report.

This report is supplemented by a separate volume of appendices that contain important scientific and historical data on which conclusions of this report are drawn. The appendices are listed in the table of contents of the EIR.

Portions of the EIR and appendices are supported by a series of auxiliary reports, which are hereby incorporated by reference into this EIR. A list of these reports appears in an appendix to this EIR. These reports were prepared by SWRCB's contractor, its subcontractors, and other entities contracting directly to LADWP. These reports provide background information drawn on for preparation of this report, subject to interpretation by SWRCB's staff and its contractor. The information and conclusions of auxiliary reports are solely the responsibilities of the authors. Copies of these reports are available for the cost of reproduction from the SWRCB's Division of Water Rights.

DEFINITION OF KEY TERMS

Much of the terminology used in this report is defined in the resource chapter to which it is applicable. CEQA gives rise to additional terminology used in this report, which is defined in the State CEQA Guidelines and in manuals to CEQA's use (e.g., Bass and Herson 1992).

A key term from CEQA is "significant effect", which is a substantial adverse impact on the physical environment. In this report, because benefits to public resource values are also disclosed, "significance" applies to both beneficial and adverse effects. Statutory responsibilities to mitigate adverse impacts, if feasible, or to find that a project's benefits outweigh its unavoidable impacts, are triggered by a determination of significance.

Terms used repeatedly in this report, especially the names of organizations and units of water measure, are referred to by their acronyms, which are usually defined in each chapter. A few of the more common terms are listed below:

Organizations

- California State Water Resources Control Board (SWRCB)
- Los Angeles Department of Water and Power (LADWP)
- U.S. Forest Service (USFS)
- Mono Lake Committee (MLC)
- California Department of Fish and Game (DFG)
- Mono Basin Water Rights Draft Environmental Impact Report (Mono Basin EIR)

Water Measures

- acre-foot (af) - volume of water 1-foot deep over 1 acre (325,000 gallons)
- thousand acre-feet (TAF)
- cubic feet per second (cfs) - flow rate of water

CITATIONS

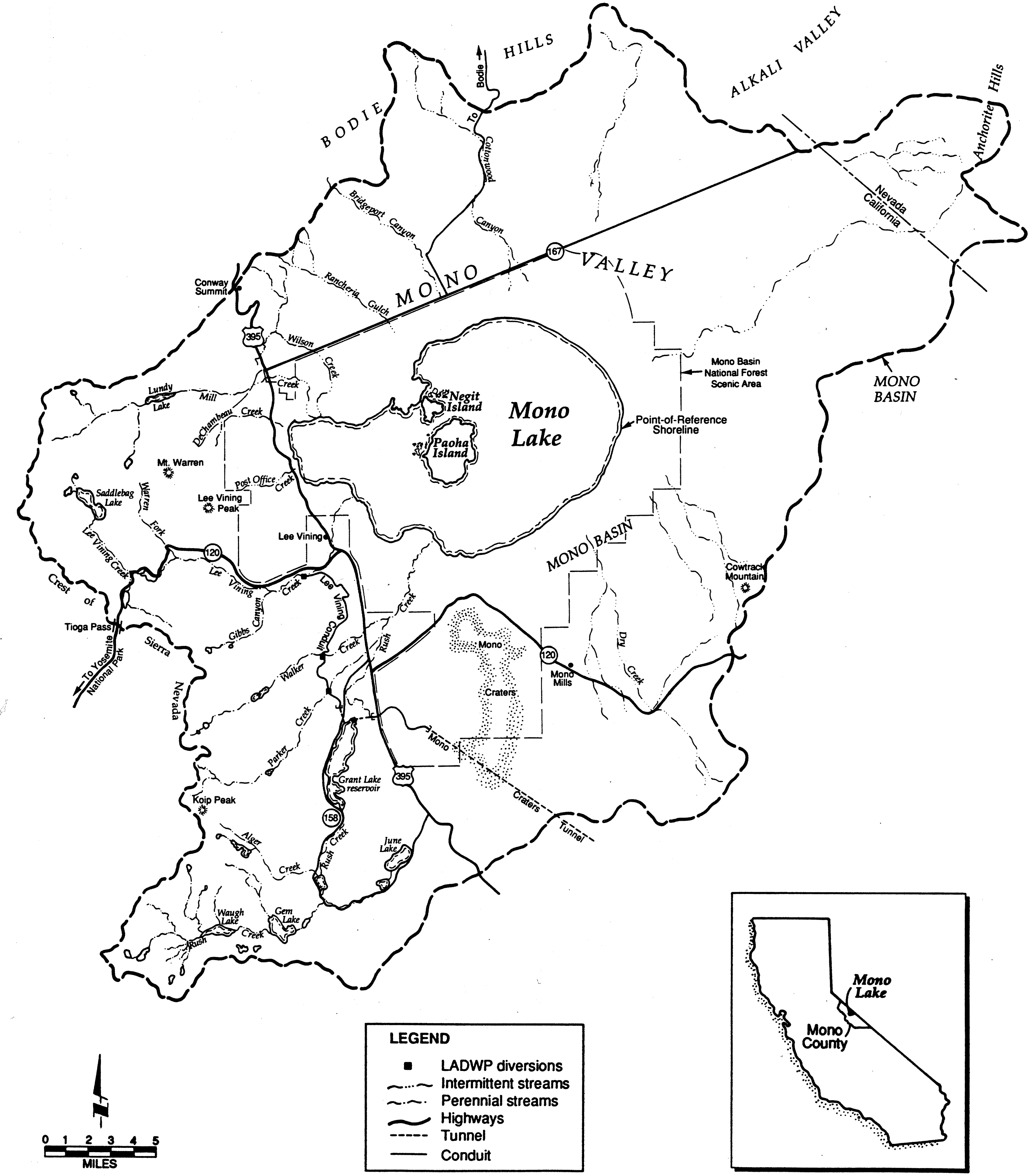
Bass, Ronald E., and Albert I. Herson. 1992. Successful CEQA compliance: a step-by-step approach. January. First edition. Solano Press Books. Point Arena, CA.

Table 1-1. Court-Ordered Interim Flows for Mono Lake Tributaries[a]

Stream	Minimum Flows: April-September	Minimum Flows: October-March	Spring Flushing Flows[b]
Rush Creek	40	28.0	165
Lee Vining Creek	35	25.0	160
Parker Creek	9	6.0	23
Walker Creek	6	4.5	15

[a] Established by El Dorado County Superior Court preliminary injunction issued June 14, 1990.

[b] These flows are intended for channel maintenance purposes and are to extend for 3 days in below normal runoff years or for 30 days in normal to above normal runoff years; these flows apply only in even-numbered years for Walker and Lee Vining Creeks.



Note: In 1989 Parker and Walker Creeks were intermittent below the LADWP diversions.

Figure 1-1.
Mono Basin

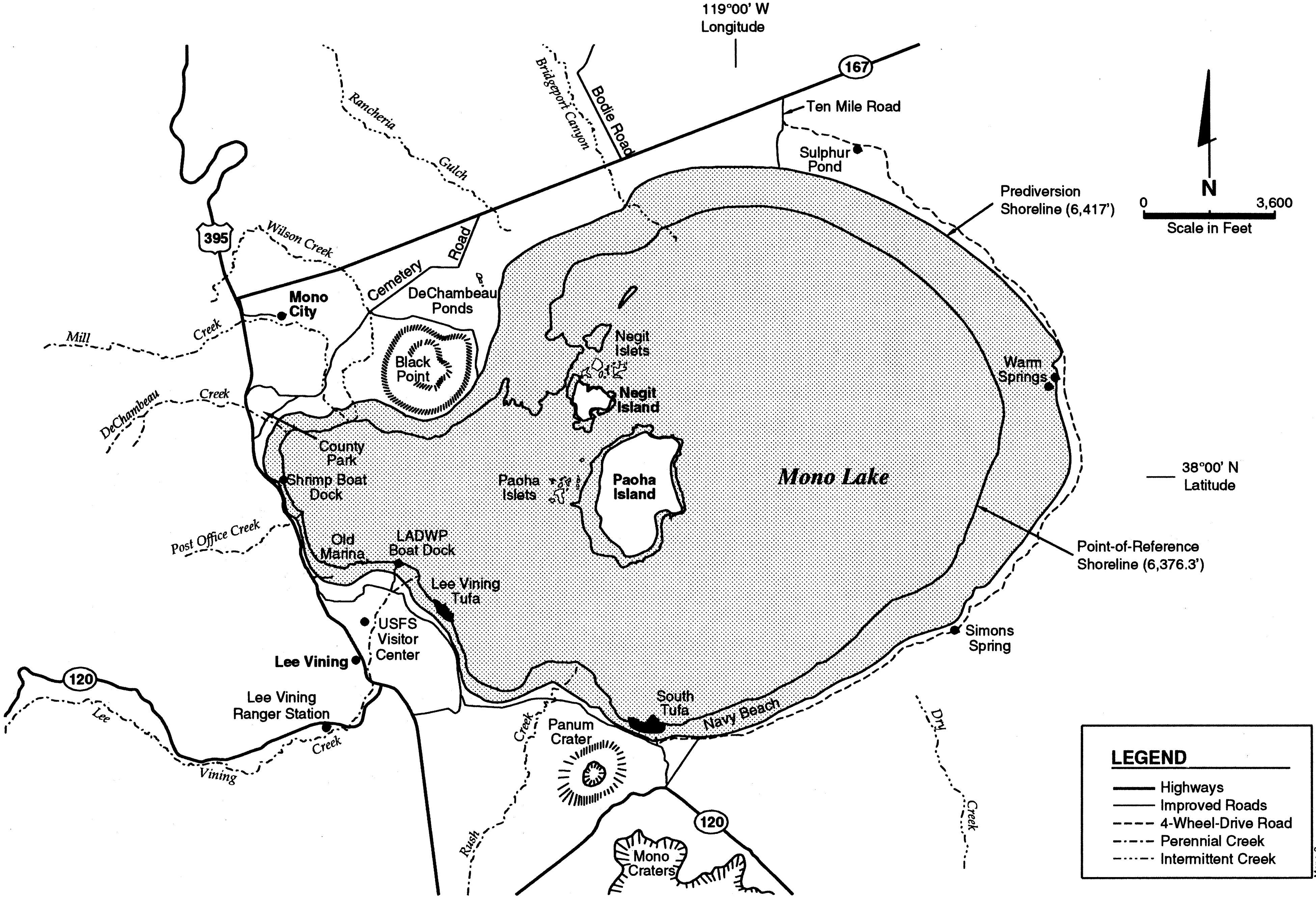


Figure 1-2.
Mono Lake

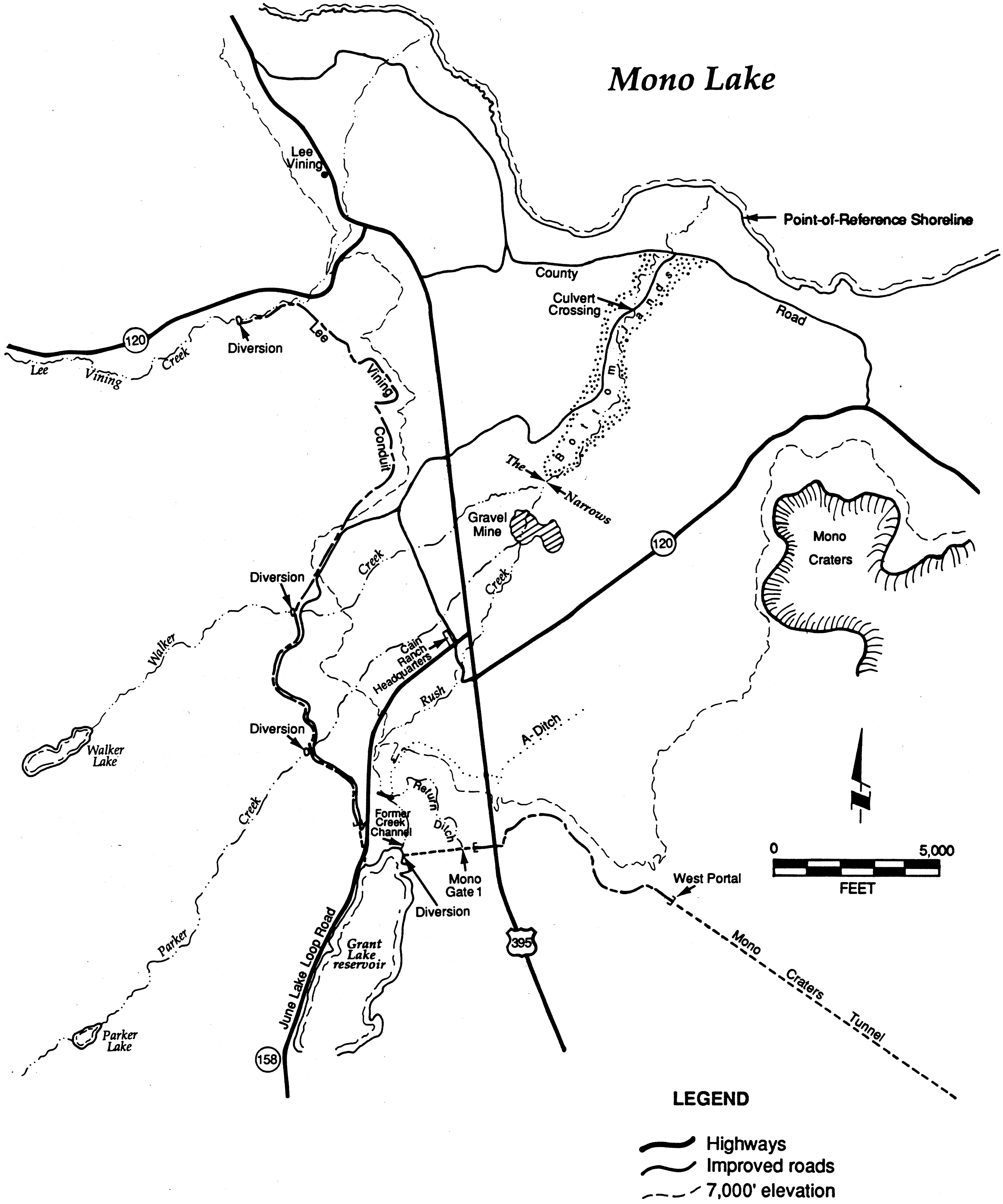


Figure 1-3.
Diverted Tributary Streams

Mono Basin EIR

Prepared by Jones & Stokes Associates

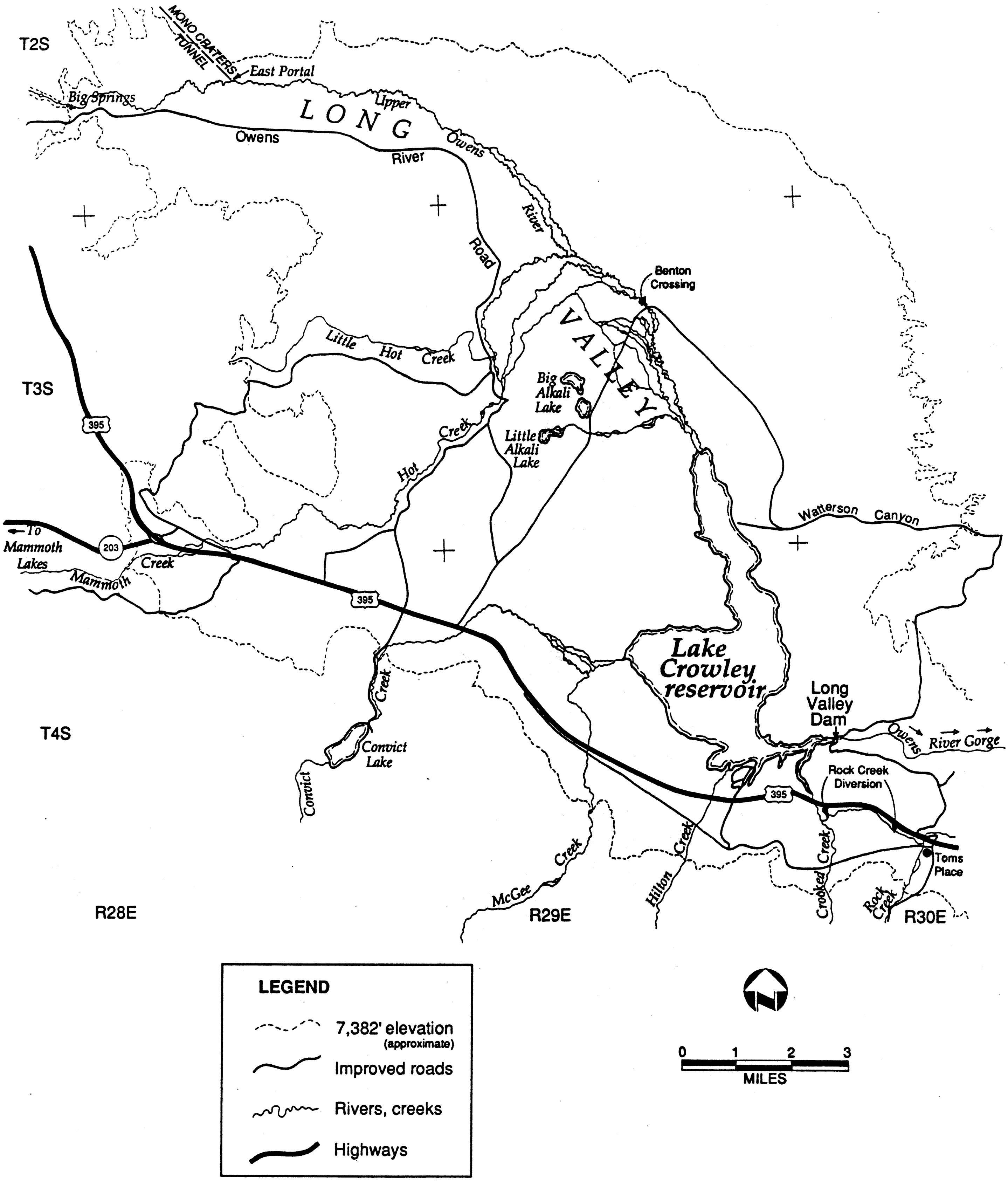
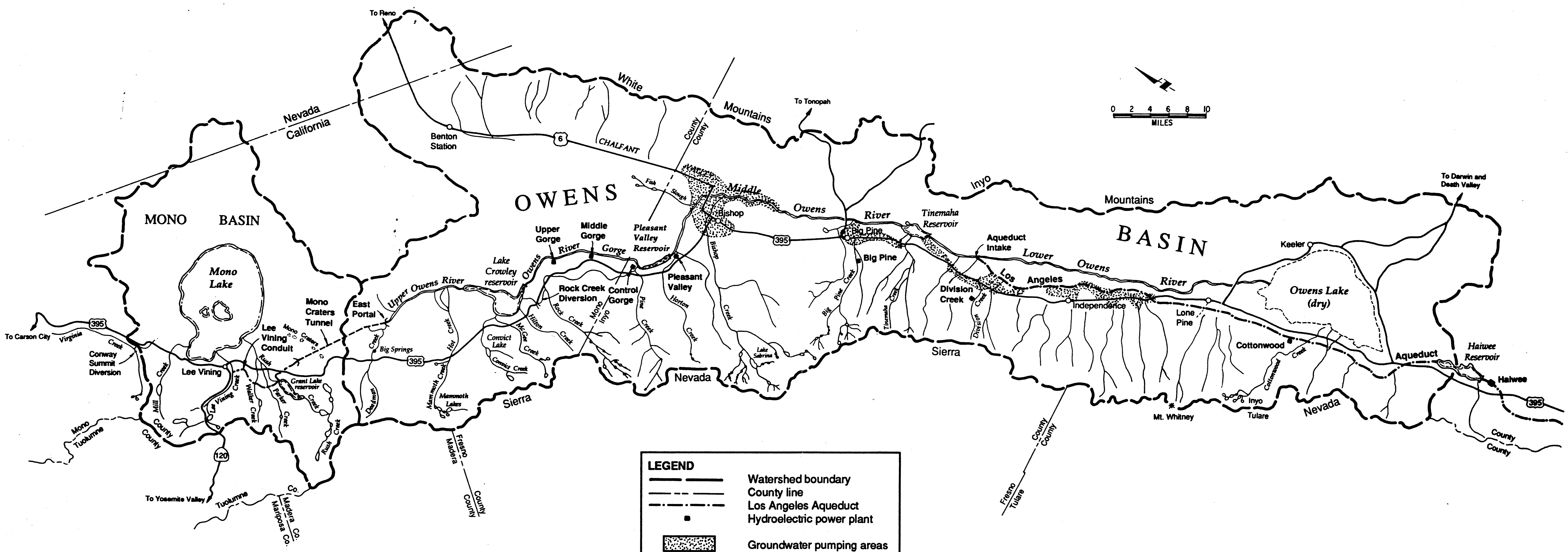


Figure 1-4.
Upper Owens River

Figure 1-5.
Los Angeles Aqueduct System
in Mono and Owens Basins



Note: The four groundwater pumping areas depicted on this map represent approximately 175 pump-equipped LADWP wells. There are three additional wells within the town of Lone Pine that are not depicted on this map.

Sources: Adapted from DWR 1960 and LADWP 1990

MONO BASIN EIR

Prepared by Jones & Stokes Associates

Figure 1-6.
Historical Runoff, Exports, and
Releases to Mono Lake, 1912-1991

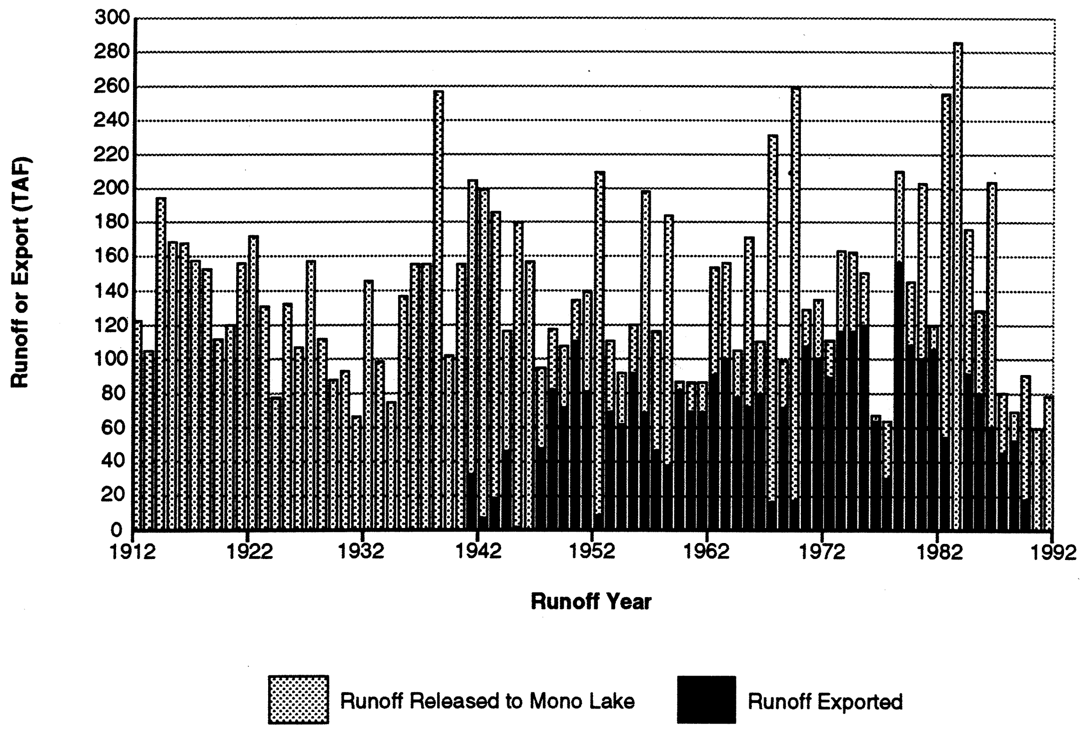
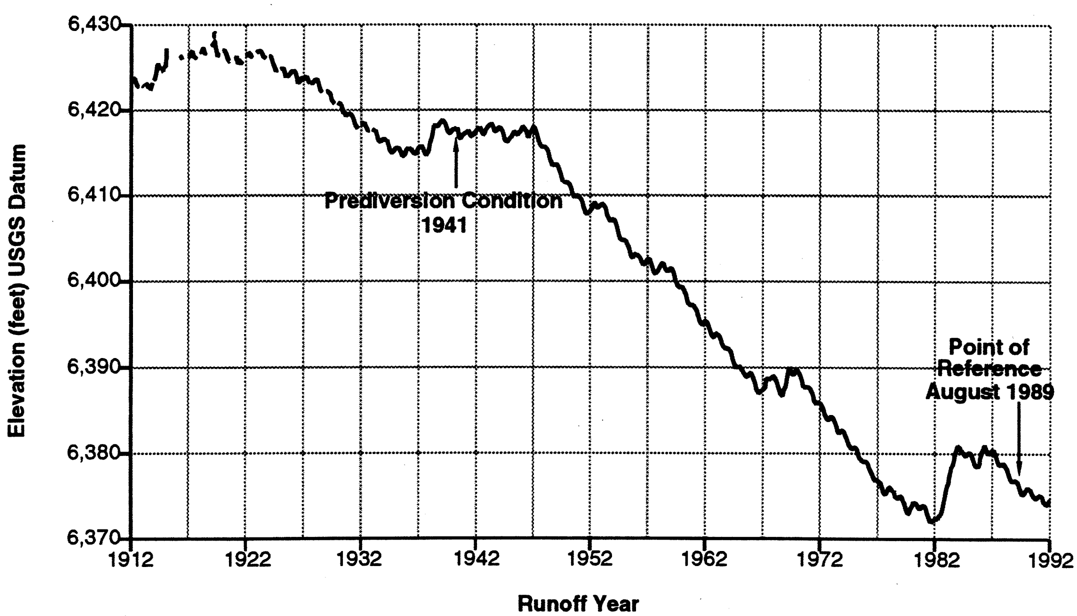


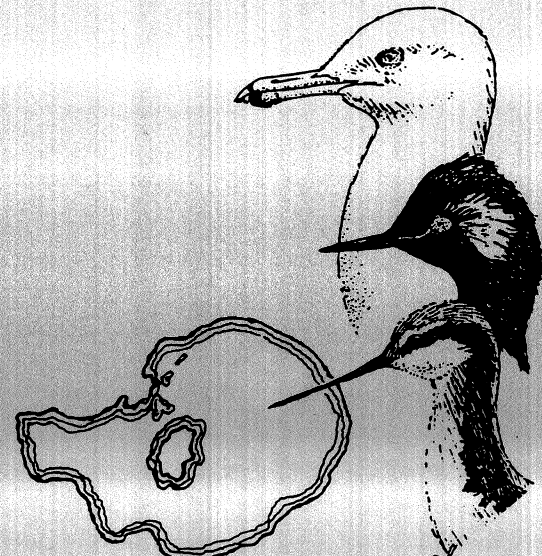
Figure 1-7.
Historical Mono Lake Surface Elevations, 1912-1991



Note: Breaks in the record prior to the early 1930s occur because of intermittent data collection.

Mono-7

Chapter 2. Project Alternatives and Points of Reference



Chapter 2. Project Alternatives and Points of Reference

This chapter describes the project alternatives and points of reference for impact assessments.

The first major section describes the process for developing the water rights alternatives. The alternative development process included preparing several numerical models for predictive purposes. The assumptions underlying these models are explained in this section. Diversion management rules that constitute the alternatives, and were used in modeling simulations of them, also are described in this section.

The second major section describes each alternative. Alternatives represent different sets of terms and conditions, or diversion rules, that could be incorporated into LADWP's water rights licenses to achieve certain desired results. This section focuses on intended effects of the alternatives, including lake levels, streamflows, and exports to the Los Angeles Aqueduct predicted through model simulations.

Seven alternatives have been defined. The No-Restriction and No-Diversion Alternatives define the full range of possibilities, but the No-Restriction Alternative cannot meet the project objectives as described in the preceding chapter. Five intermediate alternatives are formulated that can meet project objectives to varying degrees; they entail minimum required streamflows supplemented as needed through additional streamflow releases intended to keep the lake surface above selected target elevations whenever possible.

For all simulations of the alternatives, the historical 1940-1989 hydrologic record was used to represent the normal range of climatic variation that could be expected to occur in the future. The simulations revealed that the assumed diversion rules would generally, but not always, prevent the lake surface from falling below the target lake level of the alternative. Estimates of minimum lake elevations under each alternative for prolonged droughts also were estimated based on data from the current drought and other dry years of record.

The third major section of this chapter presents the points of reference and baseline scenarios for assessing environmental impacts of the project alternatives and cumulative impacts of ongoing water diversions in Mono Basin.

PROCESS FOR DEVELOPING PROJECT ALTERNATIVES

Introduction

Project alternatives must be formulated to functionally link possible streamflow and lake level. Requirements for each cannot be independently specified because streamflows affect lake level.

Snowpack is highly variable in the Sierra Nevada, and runoff to Mono Lake fluctuates substantially from year to year. This natural variation in runoff will continue to cause substantial fluctuations in the lake level. Nonetheless, under a particular diversion management regime, the long-term average inflows produce lake surface elevations that fluctuate around some average elevation. This condition is termed "dynamic equilibrium". One of the major needs in developing each alternative is to establish streamflow requirements that are consistent with desired lake surface elevations.

The simulations of the project alternatives considered in this EIR assume two streamflow release components. Some of the needed long-term lake inflow can be obtained by specifying minimum monthly flows in the four tributaries below the diversions. For example, possible fish flows to satisfy the Fish and Game Code could be provided by specifying such minimum streamflows. Additional long-term average inflow to Mono Lake can then be secured by annually specifying additional lake releases into the streams, specified as fractions of the projected annual runoff every spring. These fractions could depend on the elevation of the lake surface in relation to the target management level at that time.

To develop such alternatives, the streamflow patterns of the four diverted tributaries were first analyzed using observed monthly runoff from the 1940-1989 historical period. These hydrologic data are described in Chapter 3A, "Hydrology", and are summarized in the first section below.

Second, the relationships between streamflows and lake volume and surface elevation were identified through the development of a monthly Mono Lake water balance model, as described in Appendix A and summarized in the second section below.

The relationship between lake volume and water quality is described in Chapter 3B, "Water Quality". The patterns of fluctuation in lake salinity were not used as standards to define the alternatives but were derived from model simulations of each alternative.

Third, relationships were established between available water exports from Mono Basin and the city's water demand, other supplies available to the aqueduct from Owens Valley streams and the groundwater basin, and water conveyance and storage constraints throughout the system. The relationships of these factors were simulated with a monthly model of the LADWP aqueduct system, described in Auxiliary Report No. 5, "Los Angeles

Aqueduct Monthly Program Documentation" (Luhdorff & Scalmanini 1992), which is summarized in the third section below.

Finally, the aqueduct model was used to develop simulations of specific project alternatives that embody consistent sets of streamflow requirements and lake levels, by providing minimum specified streamflows, accounting for in-basin irrigation, triggering supplemental lake releases when needed, respecting aqueduct-operating constraints, and meeting water supply targets whenever possible. The assumptions governing the alternatives are described in the last section below, and the detailed simulation results are available in Auxiliary Report No. 18, "Summary of Hydrologic Simulations" (Jones & Stokes Associates 1993).

Determining Tributary Streamflow Patterns

Characterizing Normal Runoff Conditions

The available runoff at the LADWP aqueduct diversion locations in Rush, Lee Vining, Walker, and Parker Creeks in Mono Basin is the basic variable affecting alternative diversion rules. The runoff is a combination of baseflow and seasonal snowmelt. Streamflow generally varies slowly, allowing the use of monthly average streamflow data in the modeling. Southern California Edison (SCE) operates hydroelectric power plants with seasonal storage reservoirs upstream on Rush and Lee Vining Creeks, so the observed historical monthly streamflows, called "runoff" herein, include the effects of that seasonal storage.

LADWP has maintained streamflow measurement stations (flumes or weirs) on all four diverted streams since before diversions began. These daily streamflow records have been adjusted to account for upstream irrigation uses. Figure 1-6 in the preceding chapter shows the total annual runoff for the four tributary streams for the 1940-1989 runoff years. The runoff year begins on April 1, just before the seasonal snowmelt runoff period of May through July.

The runoff from each of the four streams reflects the snowmelt runoff and baseflow from its watershed, each having a different area, elevation distribution, and aspect relative to the Sierra Nevada crest. The distribution of annual runoff among the four diverted streams for the 1940-1989 period is shown on Table 2-1 in the order that these streams are located along the diversion facility.

Characterizing Annual Runoff Variations

Because of variations in annual snowpack, snowmelt runoff is highly variable from year to year. The minimum observed runoff was a little less than one-half of normal (44% in 1977), whereas the maximum observed runoff was almost twice normal (194% in 1983).

During the drought period beginning in 1987, runoff averaged about 60% of normal. Runoff variations for each of the four streams generally follow the same pattern.

The historical distribution of annual runoff volumes can be used to predict the likelihood of encountering a particular runoff volume in the future. The frequency with which runoff in the four streams was less than specific amounts in the 50-year period is given in Table 2-2. For example, the 10 lowest runoff years of the 50-year sequence represent the lowest 20% of the cumulative runoff distribution. The maximum runoff of these 10 years (i.e., 85,150 af) was approximately 69% of average runoff (i.e., 123,405 af). Thus, a runoff volume less than or equal to this value occurred 20% of the time in the 50-year historical record, or, put another way, can be expected to occur once each 5 years on average.

Under feasible project alternatives, allowed diversion amounts in a particular year should vary with the amount of runoff. Runoff probabilities have been used to classify "dry", "normal", and "wet" runoff years. The 20% and 80% cumulative runoff occurrence frequencies were used to classify runoff years into these three types. Thus, the dry year category (i.e., the 20% of the years that were driest) corresponds to less than 69% of average runoff and the wet year category represents those years having more than 132% of average runoff (Table 2-2).

Characterizing Monthly Runoff Variations

The monthly runoff variations of the four diverted streams are typical of eastern Sierra Nevada streams. Monthly runoff is dominated by spring snowmelt in May through July, but a substantial baseflow is sustained throughout late summer, fall, and winter. Years with lower-than-normal snowpack produce almost as much baseflow, but without the high runoff peak during snowmelt. Because Lee Vining and Rush Creeks are regulated upstream for hydropower, some of the spring snowmelt is redistributed into summer and fall months, providing a very uniform baseflow. Walker and Parker Creeks are not regulated and therefore have greater variations in baseflow.

Developing the Mono Lake Water Balance Model

The monthly Mono Lake water balance model (Appendix A) was developed to identify and quantify the relationships between Mono Lake tributary streamflows, groundwater inflows, precipitation on the lake surface, and evaporation from the lake surface with the lake water volume, surface area, and surface elevation. A monthly water budget approach was used. Because Mono Lake is in a closed basin, the only outflow from the lake is surface evaporation. Inflows include direct precipitation, measured and unmeasured streamflow, and groundwater seepage.

Determining Mono Lake Bathymetry

The relationships between lake elevation, surface area, and water volume are defined by the bathymetry of Mono Lake. Bathymetric data for elevations below 6,370 feet were obtained from nearly 30,000 measurements from ship-based soundings (Pelagos 1987). Data for higher elevations were obtained from photogrammetric interpretation of aerial photographs taken when the lake surface was at an elevation of 6,372.7 feet, just above its historic lowstand (Pacific Western Aerial Surveys 1986).

The data for elevations above 6,365 feet were recently (October 1992) revised by SWRCB consultants during preparation of this report, based on mapping of lakeshores and relict shorelines of known lake surface elevations that appear on aerial photographs taken over the past several years (Appendix G). The sensitivity of the water balance model to the new bathymetric data was evaluated by applying the model to extreme drought conditions (see "Predicting Minimum Lake Levels from Prolonged Drought" below). The effect of using the revised bathymetric data in lakewide water balance proved to be minor, and for this reason the original Pacific Western Aerial Surveys data continued to be employed in water balance model.

Estimating Evaporative Losses

Evaporative losses are the largest quantity in the water balance model for Mono Lake, but they are the most difficult to estimate. No direct measurements are available. An average annual evaporation rate was therefore estimated through two approaches. First, a range of values was used iteratively in the model to simulate lake surface elevation changes over the past 50 years of hydrologic record. This approach revealed the range of evaporation rates that would give reasonable correlation with the actual changes in lake level over the historical period.

The second approach was to identify evaporation rates that would adequately explain observed surface water temperature data based on models developed by the University of California (UC) Santa Barbara group studying the lake's aquatic productivity (Romero 1992).

The selected evaporation rate represents a balance between those rates obtained by the two approaches. The selected rate, 48 inches per year, and the monthly distribution of rates consistent with the annual rate were assumed to be constant for all years and are applied to the surface area of the lake at the beginning of the month in model simulations.

Estimating Precipitation Gains

The monthly direct precipitation contribution to the lake volume was estimated using the observed monthly Cain Ranch rainfall multiplied by the lake area. The average 1940-1989 Cain Ranch annual precipitation was approximately 11 inches, although precipitation varied considerably from year to year. This approach may overestimate lakewide average precipitation, because the Cain Ranch is near the base of the Sierra Nevada, whereas the lake extends several miles eastward. No other weather monitoring stations are situated around the lake, however. Any amount overestimated is probably not substantial and is accounted for in the "residual" of the water balance equation, described below.

Estimating Tributary Inflows

Monthly tributary flows above the aqueduct conduit for the four diverted tributary streams, as well as the releases made to the streams below the conduit, are available from LADWP and were used in the water balance model. Uncertainties in these records include unmeasured irrigation diversions and returns, local runoff and channel losses between the conduit gages and the lake, and measurement errors during high runoff. These unknown quantities also are part of the residual term.

Streamflow records also are available for Mill Creek and DeChambeau Creeks, which are not diverted by the LADWP. Because both streams are used extensively for irrigation purposes, monthly inflows to the lake from them cannot be accurately estimated from the records.

Estimating Other Inflows and Accommodating Estimation Errors

Other inflows include streamflows reaching the lake from Mill and Dechambeau Creeks and other streams (as just noted) and groundwater inflows. Groundwater inflows arise principally from infiltrating precipitation, irrigation water, and tributary streamflow.

Estimation errors arise from assumptions employed regarding the constancy of monthly evaporation rates from year to year, the use of monthly Cain Ranch precipitation to represent monthly lakewide totals, and the accuracy with which gauged streamflow releases represent actual releases.

The combination of other inflows and estimation errors are called the "residual" in the water balance model. To determine the monthly residual, the monthly lake volume changes for the historical 1940-1989 period were first calculated. These monthly volume changes were obtained by multiplying measured monthly lake surface elevation changes by the surface area of the lake at the beginning of the month (taken from the bathymetry tables described previously).

The difference between estimated gains (the measured monthly releases to Mono Lake from the four diverted streams and the monthly direct precipitation) and the estimated monthly evaporation losses were then compared to the calculated monthly volume change to yield the monthly residual.

Because a significant portion of the residuals were inflows from other tributary streams (e.g., Mill and DeChambeau Creeks), the monthly residuals were correlated with the undiverted runoff in the LADWP-diverted tributary streams. As expected, higher residuals generally corresponded to higher runoff, subject to considerable scatter. A relationship was developed from this correlation, characterizing the predicted monthly residual as a constant plus an amount equal to some fraction of the runoff in the LADWP-diverted streams for that month.

Thus, the residual term in the water balance was estimated to be a monthly inflow of a constant 33,780 af plus an amount equal to 22.8% of undiverted runoff from the four LADWP-diverted streams. The constant term embodies chiefly groundwater inflows, while the variable term embodies chiefly flows in the other tributaries. As described previously, estimation errors also are included in these residuals.

Evaluating Performance of the Water Balance Model

To gauge the accuracy of its predictive capability, the water balance model was applied to the historical runoff, diversion, and precipitation data from 1940 to 1989 to assess how accurately the observed variations in lake surface elevation were predicted. Discrepancies between predicted and actual data are dependent primarily on the magnitude of scatter in the residual terms that were averaged.

A series of such model runs were made, varying the assumed annual evaporation rate in each (Luhdorff & Scalmanini 1992). Using the adopted annual evaporation rate of 48 inches, the model accurately reflected rises and fall of the lake surface, with an average error of an estimated 0.5 foot.

Adjusting the Water Balance Model for Extreme Drought Conditions

During formulation and use of the water balance model, it became apparent that extreme drought conditions, unprecedented in the historical period of record, were prevailing in Mono Basin. Because the minimum lake surface elevation that might be reached under lake management alternatives is important to the assessment of some environmental impacts, it was determined that the water balance model, for application to extreme drought scenarios as described later in this chapter, should be adjusted to precisely embody relationships between annual runoff, precipitation, and lake volume changes occurring during the current drought. During the drought period, observed runoff and local precipitation were about 60% of the 50-year average.

This adjustment approach led to the estimation of a new constant residual term based solely on data for 1987 through fall 1992 for extreme drought scenarios (Appendix H). The 1987-1992 residual constant was found to be about 70% of the 50-year average residual constant, presumably reflecting the reduction in groundwater inflows during the drought period.

Developing the LADWP Aqueduct Operations Model

The aqueduct operations model was developed to allow simulation of alternative water rights terms and conditions to predict their effects on Mono Lake level, diverted tributary streamflows, and downstream aqueduct water and power supply over a period of assumed representative hydrologic conditions.

The Los Angeles aqueduct system, from the Mono tributary streams, through the Owens River and its impoundments, and into the aqueduct intake portals, was represented in the model. These impoundments and many other water sources, including springs, streams, and groundwater in the Owens Valley, as well as irrigation uses there, are characterized in the model. The model simulates the entire aqueduct system because it was recognized that exports from Mono Basin cannot be made independently of events and conditions in the Owens River basin and the need for additional water supplies in Los Angeles during any given period.

Using the Historical Hydrological Record

The historical records of local rainfall and runoff in the tributary steams from 1940 through 1989 compiled by LADWP were adopted for all uses of the aqueduct model to characterize the normal range of hydrologic events that would reasonably be expected in the future. Use of the historical hydrologic data also is needed for consistency with use of historical aqueduct-operations data needed to provide realistic simulations of aqueduct system operations. These operational characterizations are described below.

For some model simulations, such as managing the lake at a considerably higher or lower elevation than the present level, the historical 50-year period is not of sufficient length. In these cases, the historical sequence is used repeatedly as required.

Setting Targets for Water Exports to Los Angeles

Monthly export targets for water exports to Los Angeles from the whole aqueduct system, including Owens River, tributaries, and groundwater pumping, were used in the model. In model simulations, exports are constrained to meet but not exceed these targets when possible, subject to other model constraints. Different export targets were established for dry, average, and wet runoff years based on average historical annual exports during the years classified into these types in the 1971-1989 period when both aqueduct barrels were operating. These total export targets for system deliveries to Los Angeles are 400, 480, and 540 thousand acre-feet per year (TAF/yr) for dry, average, and wet runoff years, respectively, for a long-term average of 470 TAF/yr.

The system export targets vary through the seasons; they are set at the aqueduct capacity of 1,600 af/day for April-September when alternative sources of supply are most expensive and are reduced in the other months to meet the annual export target.

Limiting Mono Basin Exports to Conveyance Capacities

Two constraints reflecting maximum rates of Mono Basin exports are used in the model. First, the flow capacity of the Mono Craters Tunnel, approximately 290 cubic feet per second (cfs), is imposed for basin exports. Second, the maximum flow of the Upper Owens River downstream of the tunnel discharge (or East Portal) is limited to 400 cfs, reflecting a current operational constraint to prevent channel damage adopted by LADWP in consultation with one of the landowners along the stream. The flow in the river is a combination of the natural streamflow, the Mono Basin export, and a relatively constant groundwater inflow to the tunnel, all of which can be characterized from historical gauge data.

Managing Reservoir Storage

Controls on reservoir water levels are provided in the model, particularly for Grant Lake reservoir (on Rush Creek, the largest tributary of Mono Lake) and Lake Crowley reservoir (on the Upper Owens River). In the model, when sufficient water is available, reservoir storage is kept near maximum storage targets of 30 TAF and 150 TAF, respectively, which are about two-thirds to three-fourths of storage capacities. During periods of water shortage, however, water levels are allowed to decline to minimum levels of 20 and 120 TAF, respectively. Exports are curtailed, if needed, to maintain these minimum levels.

Additional but relatively minor storage in Tinemaha and Haiwee Reservoirs that regulate aqueduct intake also is included in the model.

Accounting for Owens Valley Gains and Losses

The aqueduct system obtains most of the water for export to Los Angeles from runoff in Owens Valley. Historical monthly runoff data for Owens Valley streams are used in the model.

Average rates of Owens Basin gains or losses due to reservoir evaporation, irrigation diversions, enhancement and mitigation uses, channel losses, and other gains or losses for each month were developed from LADWP records from the 1970-1989 period. They were derived from 1970-1989 runoff and export volumes to provide an accurate water balance for that period. These constant monthly rates were incorporated into the model.

Limiting Owens Valley Groundwater Pumping

Groundwater historically has been pumped from Owens Valley aquifers by LADWP during drier years to supplement reduced surface water supplies. The operational manual adopted to implement the recent agreement between Inyo County and the City of Los Angeles to limit groundwater pumping prescribes a maximum annual withdrawal of approximately 190 TAF/yr (County of Inyo and City of Los Angeles 1990); this constraint is used in the model.

The agreement also has the effect of limiting the average annual groundwater withdrawal to about 110 TAF/yr. Initial model runs simulating maximum exports from Mono Basin, subject to the other aqueduct operations constraints described, resulted in a annual sequence of groundwater withdrawals averaging about this amount. This sequence was therefore adopted in the model to specify the annual Owens River basin groundwater withdrawals for all subsequent simulations.

The effect of these constraints is to limit the degree to which groundwater pumping in the Owens River basin can be used to replace water that is being retained in Mono Basin under the various alternatives.

Developing an Extended Drought Model

During periods of extended drought, the balance of water gains and losses in Mono Lake differs from that developed from the 50-year period of record, as described earlier. In such periods, the applicability of the aqueduct operations model is diminished, because under most lake management alternatives diversions would cease. A revised water balance model is needed to depict the minimum lake surface elevation that would be expected to occur under each management alternative during extended drought periods. This model is described in Appendix H and is generally discussed below.

Predicting Probabilities of Prolonged Drought

The frequency with which sequences of dry years has occurred, compared to the frequency of any particular year being dry, indicates that dry years are not randomly distributed, but that they do occur as sequences, or "droughts".

The probable duration of an extended drought was estimated from the historical record, which was expanded for this purpose from 1895 to fall 1992 for a 98-year period. During this time, two major droughts occurred: the 1923-1935 drought (13 years), when runoff averaged 74% of the historical average, and the 1987-1992 drought (6 years), when runoff averaged 60% of the historical average (Appendix H). During a 7-year portion of the earlier drought, runoff averaged 65% of the historical average. Thus, two droughts having 60-65% of historical average runoff lasting 6-7 years have occurred in the last 100 years, implying an annual probability of occurrence of 2%.

To estimate the duration of a drought having a 1% annual probability of occurrence, it is necessary to calculate cumulative frequencies of dry-year (less than 69% of average historical runoff) sequences of different duration from the historical record (Appendix H). This approach leads to a conclusion that the duration of a drought with runoff averaging 60% of the long-term average having 1% chance of being initiated in any given year is estimated to be 8 years.

Predicting Minimum Lake Levels from Prolonged Drought

Minimum lake levels during drought conditions having a 1% probability for various lake level management alternatives can be directly estimated using the adjusted water balance model for extended drought conditions having 60% of historical average runoff. The 1% probability lake level estimates were obtained by starting drought simulations at the median lake level of the lake level alternative, once dynamic equilibrium is attained, and running the adjusted model for 8 simulated years.

Formulating Alternatives

Alternative terms and conditions for the relicensing of the City of Los Angeles' water rights have been formulated according to three objectives:

- the full range of feasible alternatives is considered,
- the alternatives are implementable, and
- the effects of the alternatives are predictable.

Diversion alternatives meeting these objectives have been formulated by:

- assuming specified minimum streamflows and ecosystem maintenance flows for the four diverted streams,
- characterizing future diversions of the diverted streams for in-basin irrigation purposes, and
- prescribing alternative target lake levels and operational mechanisms to attain them.

Making Streamflow Assumptions

Assumptions about minimum and periodic maintenance streamflows below the diversions are major elements of most of the alternatives. Both types of assumptions are based on the historical record of streamflows above the diversions so that assumed minimum flows to the lake are distributed among the diverted streams in proportion to stream size. Simulated releases below the diversions must equal or exceed the assumed minimum and maintenance streamflows except under very dry conditions when runoff is below these levels. Streamflow simulations, described below, assume that 45-52% of runoff remains in the streams below the diversions on the average, depending on the particular alternative.

Minimum Streamflows. Minimum monthly streamflows are assumed in simulating the alternatives for all but the No-Restriction Alternative. The assumed flows are not necessarily the minimum flows needed to keep fish in good condition in the tributary streams. SWRCB will determine minimum required flows for fisheries after it considers impact assessment information in Chapter 3D, "Fisheries", and after development of DFG recommendations based on instream flow studies conducted in each creek. DFG instream flow studies were not completed and available for simulating the alternatives evaluated in this EIR.

Minimum monthly flows assumed for simulating the alternatives are those with a 10% cumulative frequency of occurring (Table 2-2) based on the 1940-1989 historical period. If runoff is sufficient, these are the minimum flows that are simulated to be released. These streamflows for each creek are given in Table 2-3. These monthly minimum flows would provide approximately 55.6 TAF inflow to Mono Lake, which is about 45% of the average runoff.

Ecosystem Maintenance Flows. Periodic high flows are useful in the tributary stream system for a variety of reasons. The preliminary court injunction of 1990 specifies "flushing" flows for channel maintenance purposes. Seasonal high flows are potentially valuable for flushing debris and sediment from the channel, cleansing spawning gravel beds, germinating seeds of riparian species, and watering overflow channels and basins to promote vegetative growth.

For simulations of most alternatives, maintenance flows are assumed to occur every June in each creek at a level corresponding to the median June flow above the diversions during the historical 1940-1989 period (Table 2-3), if sufficient runoff is present. The median June flows provide an additional 9.3 TAF of annual inflow to the lake.

For the 6,372-Ft Alternative, the additional water provided by the median June flows would be excessive, causing the lake level to frequently rise well above the target lake level, so simulation of this alternative does not involve specified stream maintenance flows. No minimum streamflows are assumed for the No-Restriction Alternative.

Accommodating Mono Basin Irrigation Uses

Irrigation of LADWP-owned lands in Mono Basin from the stream diversions is being substantially curtailed. Diversions for irrigation began in the previous century by early ranchers and continued through summer 1990 by LADWP. LADWP recently has expressed an intent to permanently reduce irrigation uses (Kodama pers. comm.). Because a substantial amount of irrigation water is lost through evapotranspiration, irrigation diversions must be accounted for in formulating the alternatives.

Under all alternatives, except the No-Restriction Alternative, only 1 TAF/yr of water is assumed to be diverted from the four streams for irrigation (specifically, for USFS lands along Lee Vining Creek using the O-Ditch). For the No-Restriction Alternative and the 1989 point-of-reference condition for evaluating impacts, however, the average historical LADWP water diversion of about 8 TAF per year for irrigation of the Cain Ranch is assumed.

Providing Control of Lake Level

Targeting Lake Levels. Alternatives correspond to specified target lake levels. As described below, the alternatives are chosen to span the range from a low lake level that would result from assuming only minimum streamflows to a high level that represents no diversions. The alternative targets are levels at or above which the lake surface would generally remain as it fluctuates from year to year according to runoff variations. The target lake levels are reference levels to which actual lake level is annually compared, triggering appropriate releases, prescribed below, to achieve or maintain the target level.

Runoff that would be released to maintain the target lake level is called lake release. (Lake releases also include the assumed minimum flows and any operational spills downstream during periods when diversions are less than the maximum allowable.) In simulation of the alternatives, runoff in excess of the assumed minimum flows and lake releases required to maintain the target lake level can be exported by LADWP if needed to meet export demands. To ensure operational feasibility, the annual lake releases would be determined at the beginning of each runoff year (April 1) according to the lake surface elevation at that time. Lake level fluctuations during the remainder of the year would not influence the lake release amount.

Establishing Lake Level Triggers. The lake level triggers simulated for the alternatives are fractions of the projected runoff on April 1 that must be released to the lake. They vary according to the actual lake level in relation to the target lake level. The lake release rules are shown in Table 2-4.

Once the target elevation is first attained, the lake release rules for all alternatives are relatively simple, requiring 25%, 50%, and then all the runoff to be released as the lake surface fell within 3, 2, and 1 foot of the target elevation, respectively.

Preliminary simulations of the alternatives showed that for the higher lake level alternatives (6,383.5 feet elevation and above), many years could pass with no exports until the lake level rose from its present elevation and the target level was first reached. Only then would some runoff be available for export under these lake release rules. The elimination of all Mono Basin exports for several decades would not provide a balance between need for water supply and protection of public trust values.

For this reason, some exports would be allowed in wet and average years during the period of transition to dynamic equilibrium lake level in these alternatives (Table 2-4). Note, however, that in dry years when the lake elevation is less than 3 feet above the target level, no exports would be allowed during these transition periods.

Reducing Lake Level Fluctuation and Protecting the Upper Owens River Channel. Historically, LADWP used Mono Basin runoff as a supplemental water supply for its Owens Valley aqueduct system so that most of the available water was exported in dry years and a smaller fraction of available water was exported in wet years. This historical strategy created relatively large fluctuations in the lake level. Magnified fluctuations in lake level may have adverse environmental consequences (e.g., shore erosion, tufa undercutting, loss of vegetation).

Lake level fluctuations can be reduced by maintaining water exports from Mono Basin in wet periods even though other sources of water may be available to the downstream reservoirs and the aqueduct. This management concept is incorporated into the alternatives by increasing Mono Basin exports to a target level in all years once assumed lake releases and minimum streamflows in the diverted streams are provided.

Peak flows exceeding 400 cfs in the Upper Owens River below the East Portal can damage the channel as described previously. To achieve a balance between exporting surplus water and protecting the river channel, a flow of 300 cfs in the Upper Owens River is assumed in the simulations of alternatives as both a target and a maximum streamflow. This management rule was incorporated into the model simulations for all alternatives except one representing historical management. SWRCB may adopt other management rules after development of DFG instream flow recommendations or other identified requirements.

Prescribing Operational Protocols

For all alternatives, required lake releases in excess of minimum monthly flows are taken from runoff in excess of the minimums as soon as it is available until the total lake releases are satisfied for the year. This delays the period of diversion for export until all the supplemental releases have been made.

Supplemental lake releases are made in Lee Vining and Rush Creeks under all alternatives, but not in Walker or Parker Creeks. Lee Vining Creek diversions must remain less than the conduit capacity of 300 cfs. Although Lee Vining Creek runoff is usually less than the conduit capacity, any excess runoff is spilled down Lee Vining Creek and counted as lake release flow. Walker and Parker Creek runoff greater than their monthly minimum flows is diverted into the LADWP conduit to Grant Lake Reservoir. All available Rush Creek runoff is passed through Grant Lake Reservoir and released to Mono Lake until the supplemental lake release volume has been satisfied.

PROJECT ALTERNATIVES

Seven EIR alternatives have been formulated to span the possible range of tributary-streamflow and lake-level management alternatives. Two of them, the No-Restriction and No-Diversion Alternatives, define the extremes of the range. The No-Restriction Alternative does not meet the project objectives of restoring the conditions that benefited the prediversion fisheries in the tributary streams and protecting public trust resources where feasible in Mono Basin. The No-Diversion Alternative would preclude all export of water for urban uses. The five intermediate alternatives are based on operational rules specifying minimum streamflows, supplemented as needed to promote a surface elevation of Mono Lake at or above a particular target elevation.

Using Model Simulations to Predict Effects of the Alternatives

The alternative terms and conditions for the water rights licenses are alternative diversion operation rules intended to achieve specified lake level targets. The operation rules specify minimum streamflows and annual supplemental releases to Mono Lake based on the April 1 runoff forecast of each year, as described in the preceding section. The rules also include management actions to manage reservoir levels within specified ranges and to systematically export surplus water from the basin subject to conveyance capacities.

The effects of all these operation rules, as well as of downstream management of the entire Los Angeles aqueduct system, have been simulated through the aqueduct model (Appendix B). Although the model simulations are useful in predicting the effects of the alternatives, they do not in themselves constitute the alternatives.

The use of the historical hydrological record in the simulations illustrates this difference. The historical sequence of runoff years provides only one of many possible simulations of future events. In the characterizations of the alternatives below, simulations using the historical hydrological sequence are used to indicate the approximate normal range of lake levels, streamflows, reservoir levels, and water supplies that can reasonably be expected in the future. Frequency data for these variables derived from that simulation will be generally valid for runoff between the 10% and 90% cumulative runoff occurrence frequencies (as defined previously).

Because sequences of dry years may have important consequences for some public trust values, a separate extended drought analysis (Appendix H) has been used to predict extreme low lake levels. This analysis is especially useful because in the historical period, the extreme 1987-92 drought began when lake level was relatively high from a preceding wet period. Thus, using the historical sequence tends to underestimate the effects of the most severe drought of record. The extreme drought analysis results in a minimum lake level prediction that has a 1% probability of being initiated each year, based on the past 98 years of hydrological data.

Characterizing the Alternatives

The following sections on each alternative present the following information:

- general description of the alternative;
- the normal range of lake level fluctuation under the alternative, the time of transition to the normal range, and the minimum lake level predicted for an extended drought;
- the predicted water export volume; and
- tributary streamflow patterns.

Two figures illustrate each alternative. The first figure is a time series graph showing fluctuation of the lake surface elevation based on the particular management regime of the alternative simulated with hydrological data of the past 50 years. The second figure is a map showing the lake configuration at the target lake level in relation to the configurations before the diversion began and in 1989. Details of the simulation data are provided in Chapter 3A, "Hydrology", and in Auxiliary Report No. 18.

Comparing the Alternatives

A summary comparison of the alternatives is provided in Figures 2-1 and 2-2 and in Table 2-5. These exhibits compare the ranges of lake levels, tributary streamflow patterns, and lake level frequencies of the alternatives, respectively. Table 2-5 shows the percentage of the time that the lake surface would be at or below specific elevations after dynamic equilibrium is attained. For example, the 50% values indicate the median lake levels for the various alternatives; 50% of the time the lake level will be at or below these elevations. The 50% values are higher than the target minimum lake levels.

The No-Restriction (No-Project) Alternative

Under this alternative, no new restrictions would be placed on the diversions of water by LADWP under its existing water right licenses. Minimum streamflows and lake levels would not be required. LADWP would be allowed to divert water based entirely on availability and need. Irrigation of in-basin lands would be discretionary and is assumed to continue at historical levels. Maximizing exports to the Upper Owens River during periods when surplus water is available would not be pursued. The alternative would entail continuation of practices that prevailed prior to the courts' involvement in the diversion of Mono Basin waters and is therefore considered to be the "no-project" alternative.

Lake Elevation Pattern

Under this alternative, the lake surface, fluctuating in response to annual variations in runoff, would tend to fall until evaporation losses from the diminishing surface area of the lake were sufficiently reduced to balance the flows released to the lake (Figure 2-3). The transition period would be between 50 and 100 years. Thereafter, a dynamic equilibrium would prevail with a mean lake elevation of about 6,355 feet (Figure 2-4) and normal fluctuations of about 21 feet. During extreme drought, the lake surface might fall as low as 6,336-6,337 feet (Table 2-5).

Mono Basin Export and Lake Release Pattern

On the average under this alternative, approximately 85 TAF/yr (73%) would be exported from Mono Basin and 32 TAF/yr (27%) would be released to Mono Lake from the four streams diverted by LADWP. Exports would range from 0 to 135 TAF/yr, and releases would range from 0 in many years to more than 220 TAF in infrequent, very wet periods.

Streamflow Pattern

During an average water year, none of the diverted tributary streams would have any flows below the diversions in any months (Figure 2-2). Even in very wet years, Parker and Walker Creeks would usually have no flow. In wet years, some flows in Rush and Lee Vining Creeks would occur, usually in June and July, and perhaps August.

Rush and Lee Vining Creeks would be subject to floodflows from time to time that could exceed 500 cfs in Rush Creek and 300 cfs in Lee Vining Creek. These flows, called "spills", occur when runoff exceeds the capacity of LADWP's diversion and storage system or when excess water in the Owens River basin reduces the need for Mono Basin exports.

The 6,372-Ft Alternative

This target elevation for long-term management of Mono Lake corresponds to the lowest lake level that the lake has reached in historical time, occurring at the end of 1981 after 40 years of streamflow diversions. The lake surface rose above this level through the remainder of the 1980s and, although declining toward it again, remains above it today. (This level is slightly lower than the lake level shown on the 7.5-minute U.S. Geological Survey [USGS] topographic maps for Mono Basin.)

Lake Elevation Pattern

Under this alternative, the lake surface would normally fluctuate about 6.5 feet in elevation (Figure 2-5) and would have an average elevation of 6,375 feet (Figure 2-6). A very short transition period to this dynamic equilibrium condition would be required after the current drought ended. During extreme drought, the lake surface might fall as low as about 6,370.4 feet (Table 2-5).

Mono Basin Export and Lake Release Pattern

Under this alternative, approximately 64 TAF/yr (51%) would be exported from Mono Basin and 61 TAF/yr (49%) would be released to Mono Lake on the average. Exports would range from 8 to 140 TAF/yr, and releases would range from 48 to 102 TAF/yr in very wet periods.

Streamflow Pattern

During most years, flows in Rush Creek would seasonally vary between 20 and 60 cfs, and flows in Lee Vining Creek would vary between 15 and 95 cfs. Flows in the Rush Creek tributaries also would remain relatively constant, seasonally varying 2-10 cfs in Walker Creek and 3-21 cfs in Parker Creek (Figure 2-2). These flows would remain constant in most years because they are the minimum flows assumed in the simulation (occurring at least 10% of the time above the diversions) (Table 2-3), and all excess runoff would be diverted for export in most years.

Larger ecosystem maintenance flows in June are not specified for this alternative, as they are for other alternatives, because, if they were specified, the lake level would rise substantially above the target level of the alternative. Thus, June flows under this alternative are about one-half to two-thirds of the median June flows above the diversions for the other alternatives. Rush and Lee Vining Creeks would be subject to spilling flows from time to time that could exceed 300 cfs in both Rush and Lee Vining Creeks.

The 6,377-Ft Alternative

This target elevation corresponds to that level beneath which no diversions are currently allowed under the preliminary injunction first mandated by the El Dorado County Superior Court in 1989 and reaffirmed in 1991. It is the interim protected lake level, intended to protect the lake's public trust resources until action can be taken by SWRCB.

The lake level dropped below this elevation in late 1976 after 35 years of streamflow diversions but rose above it temporarily between 1983 and 1989 because of a wet period.

Lake Elevation Pattern

Under this alternative, the lake surface would normally fluctuate about 6.5 feet in elevation (Figure 2-7) and would rise to an average elevation of 6,379 feet (Figure 2-8). A short transition period to this dynamic equilibrium condition would be required after the current drought ended. During extreme drought, the lake surface might fall as low as about 6,373 feet (Table 2-5).

Mono Basin Export and Lake Release Pattern

Under this alternative, approximately 52 TAF/yr (41%) would be exported from Mono Basin and 74 TAF/yr (59%) would be released to Mono Lake on the average. Exports would range from 2 to 140 TAF/yr, and releases would range from 30 to 130 TAF/yr in very wet periods.

Streamflow Pattern

During a normal year, flows in Rush Creek would seasonally vary between 20 and 160 cfs. Flows in Lee Vining Creek would generally vary between 15 and 180 cfs. Flows in the Rush Creek tributaries, remaining relatively constant from year-to-year, would seasonally vary between 2-21 cfs in Walker Creek and 3-32 cfs in Parker Creek (Figure 2-2). The high ends of these flow ranges represent assumed ecosystem maintenance releases equal to historical median June flows above the diversions (Table 2-3). Rush and Lee Vining Creeks also would be subject to spilling flows from time to time that could exceed 340 cfs in Rush Creek and 250 cfs in Lee Vining Creek.

The 6,383.5-Ft Alternative

This target elevation corresponds to the midpoint of the range of lake levels (6,390-6,377 feet) recommended by the USFS (1989) in its management plan for the Mono Basin

National Forest Scenic Area. The declining lake surface passed through this elevation in 1973 after 32 years of streamflow diversions. During the wet period of the mid-1980s, this elevation was not attained.

Lake Elevation Pattern

Under this alternative, the lake surface would normally fluctuate about 6 feet in elevation (Figure 2-9) and would rise to an average elevation of 6,385.7 feet (Figure 2-10). The transition period to this dynamic equilibrium condition would require 5-10 years after the present drought ended. During extreme drought, the lake surface might fall as low as about 6,378 feet (Table 2-5).

Mono Basin Export and Lake Release Pattern

Under this alternative, approximately 44 TAF/yr (35%) would be exported from Mono Basin and 82 TAF/yr (65%) would be released to Mono Lake on the average. Exports would range from 2 to 120 TAF/yr, and releases would range from 48 to 140 TAF/yr in very wet periods.

Streamflow Pattern

The streamflow pattern for this alternative would be very similar to that for the 6,377-feet alternative described previously, except that higher flows would be released in wetter periods (Figure 2-2). Ecosystem maintenance flows would be provided annually, equaling median historical June flows above the diversions.

Rush and Lee Vining Creeks would be subject to spilling flows from time to time that could exceed 340 cfs in Rush Creek and 300 cfs in Lee Vining Creek.

The 6,390-Ft Alternative

This target elevation corresponds to the upper lake level recommended by the USFS (1989) management plan.

The lake surface dropped below this elevation in 1965 after 24 years of streamflow diversions and has remained lower.

Lake Elevation Pattern

Under this alternative, the lake surface would normally fluctuate about 6 feet in elevation (Figure 2-11) and would reach an average elevation of 6,391.6 feet (Figure 2-12). The transition period to this dynamic equilibrium condition would require about 30 years. During extreme drought, the lake surface might fall as low as about 6,383 feet (Table 2-5).

Mono Basin Export and Lake Release Pattern

During the first 50 years under this alternative, approximately 30 TAF/yr (24%) would be exported from Mono Basin and 96 TAF/yr (76%) would be released to Mono Lake on the average. After dynamic equilibrium is attained, exports would rise to 37 TAF/yr (29%) and lake releases would fall to 89 TAF/yr (71%).

Exports would range from 2 to 120 TAF/yr, and releases would range from 58 to 126 TAF/yr in very wet periods.

Streamflow Pattern

The streamflow pattern for this alternative would be similar to that for the 6,377-Ft and 6,383-Ft Alternatives, except that higher flows would be released in wetter periods (Figure 2-2). Ecosystem maintenance flows would be provided annually, equaling median historical June flows above the diversions. Rush and Lee Vining Creeks would be subject to large spilling flows from time to time that could exceed 490 cfs in Rush Creek and 320 cfs in Lee Vining Creek.

The 6,410-Ft Alternative

This target elevation corresponds to an intermediate elevation between the 6,390-Ft Alternative and the No-Diversion Alternative, providing an alternative that could reflect substantial streamflows if required by SWRCB for purposes of compliance with the Fish and Game Code or for protection of public trust resources.

The lake surface dropped below this elevation in 1951 after 10 years of streamflow diversions and has remained below this elevation.

Lake Elevation Pattern

Under this alternative, the lake surface would normally fluctuate about 7 feet in elevation (Figure 2-13) and would eventually reach an average elevation of 6,410.8 feet (Figure 2-14). The transition period to this dynamic equilibrium condition would require about 80 years. During extreme drought, the lake surface might fall as low as about 6,401 feet (Table 2-5).

Mono Basin Export and Lake Release Pattern

During the transition period for this alternative, approximately 11 TAF/yr (9%) would be exported from Mono Basin and 115 TAF/yr (91%) would be released to Mono Lake on the average. After dynamic equilibrium is obtained, exports would rise to 22 TAF/yr (17%) and lake releases would fall to 104 TAF/yr (83%).

Exports would range from 0 to 120 TAF/yr, and releases would range from 64 to 184 TAF/yr in very wet periods.

Streamflow Pattern

The streamflow pattern for this alternative would be similar to that for the previous alternatives, except peak flows in spring in Rush and Lee Vining Creeks would be slightly higher in normal years, and even higher flows would be released in wetter periods (Figure 2-2). Rush and Lee Vining Creeks would be subject to large spilling flows from time to time that could exceed 490 cfs in Rush Creek and 350 cfs in Lee Vining Creek.

The No-Diversion Alternative

Under this alternative, diversions of the four tributary streams would be entirely curtailed. Streamflow and lake level would be determined by natural weather events and patterns, and the lake surface would rise toward the prediversion level.

Lake Elevation Pattern

Under this alternative, the transition period to this dynamic equilibrium condition would require longer than 100 years (Figure 2-15). The lake surface would eventually reach an estimated average elevation of about 6,425-30 feet (Figure 2-16) and would normally fluctuate about 10 feet in elevation thereafter. During extreme drought, the lake surface might fall as much as 11 feet below the equilibrium level (Table 2-5).

Mono Basin Export and Lake Release Pattern

No water would be exported from Mono Basin, and 124 TAF/yr would be released to Mono Lake on the average. Releases would vary annually between 55 and 240 TAF.

Streamflow Pattern

The pattern of streamflows above the diversion also would occur below them. This pattern constitutes natural runoff as modified by SCE's seasonal storage upstream on Rush and Lee Vining Creeks.

The spring streamflow pattern for this alternative, including spilling flows, would be similar to that for the 6,410-Ft Alternative, but flows in the other seasons would be considerably larger. During normal years, flows in Rush Creek would seasonally vary between 50 and 165 cfs. Flows in Lee Vining Creek would vary between 30 and 190 cfs. During snowmelt, Lee Vining Creek would experience higher flows than Rush Creek because of less upstream regulation by SCE for power generation. Flows in the Rush Creek tributaries would vary seasonally from 3 to 21 cfs in Walker Creek and 4 to 33 cfs in Parker Creek (Figure 2-2).

Other Alternatives Considered but Not Studied in Detail

This report identifies the environmental impacts associated with the SWRCB's proposal to add conditions to LADWP's water right licenses for protection of fish and other public trust resources. The selected alternatives described in this chapter span the range of feasible alternatives to be considered in balancing the protection of public trust values with other uses for Mono Basin water. Each of the described alternatives corresponds to an approximate level of inflow to Mono Lake on a long-term basis and a corresponding amount of water available to LADWP for export. No other alternatives are needed to provide information about the environmental effects of the range of feasible alternatives.

Other diversion and export management approaches, including other rules for determining annual lake releases not discussed above, can be considered as needed for purposes of mitigating significant environmental impacts of the alternatives. Where appropriate, other diversion and export management approaches are addressed in the impact sections of this report.

Relation of Identified Alternatives to Fishery Protection Flows

Identification of Fishery Protection Flows

The subject of instream flows needed to maintain the conditions that benefited the prediversion fishery is discussed in Chapter 3D, "Fisheries". SWRCB's decision on amendment of LADWP's water right licenses must include conditions for the protection of fish, as well as appropriate conditions for protection of other public trust values in Mono Basin. For purposes of this report, the definition of alternatives is based primarily on differing lake levels rather than on the quantity of water needed to provide instream fishery flows. Whatever fishery flows are eventually determined to be appropriate, however, will be associated with some net quantity of inflow to Mono Lake. The range of alternatives defined in this report is sufficiently broad to cover any potential level of inflow that would result from those fishery flows.

At this time, SWRCB has not determined the quantity of water needed for fishery protection or for other public trust purposes. In accordance with the Court of Appeal decision in *California Trout, Inc. v. Superior Court*, (1990) 218 Cal. App. ed. 187, 266 Cal. Rptr. 788, the quantity of water needed for protection of fish pursuant to Fish and Game Code Sections 5937 and 5946 is not subject to reduction to satisfy competing demands for water. The need for any additional water that may be needed for protection of public trust values, however, is subject to balancing against the public interest in meeting competing demands for water.

Implications of Fishery Protection Flows in DFG Stream Evaluation Reports

DFG has produced stream evaluation reports for the four diverted tributary streams (Beak Consultants 1991; EBASCO Environmental and Water Engineering and Technology 1991b, 1991c; Aquatic Systems Research 1992) and the Upper Owens River (EBASCO Environmental et al. 1993). These reports contain preliminary instream flow recommendations for each stream (Table 2-6).

The aqueduct model was used to predict long-term Mono Lake surface elevations resulting from these recommended flows, including the specified minimum, maximum, and flushing flow values. As for the alternative simulations, these diversion rules were combined with aqueduct operations constraints and applied to the 1940-1989 historical hydrology. In this simulation, however, no lake level targets and lake release rules were specified.

Two simulations were conducted, the first based on DFG's consultants' original flow recommendations for Rush Creek, which specify a maximum release of 60 cfs during the peak runoff period (Beak Consultants 1991), and the second based on DFG's subsequent flow recommendations, which specify a maximum release of 100 cfs (Gibbons pers. comm.). Recommended flows for Lee Vining, Parker, and Walker Creeks were identical for the two simulations.

The recommendation for flows for the Upper Owens River below the East Portal (a maximum flow limit of 200 cfs and a constant release rate) could not be modeled explicitly because changes would be required in operation of Grant Lake reservoir to distribute exports more evenly throughout the year. Model applications, however, suggest that total annual exports and Mono Lake surface elevations would not change appreciably with this additional constraint.

The recommended flows would cause the surface elevation of Mono Lake to rise to an average elevation of 6,381 feet, for the maximum Rush Creek flow of 60 cfs, or to

6,385 feet for the maximum Rush Creek flow of 100 cfs (Figure 2-17). The transition period to the dynamic equilibrium would be about 40 years, and lake levels would fluctuate 6-7 feet thereafter. The simulations indicate that uncontrolled spills would not likely occur in the Mono Basin tributaries under the conditions specified. Minimum instream flow recommendations for Rush Creek would be met in most years, but available flows in Lee Vining, Parker, and Walker Creeks would often be insufficient to meet the specified minimum flows in dry and normal runoff years.

These simulated lake level ranges, when compared to the lake level regimes described for each alternative, indicate the degree to which each alternative is capable of meeting the pending DFG instream flow recommendations for protection of fishery resources.

POINTS OF REFERENCE FOR EVALUATING ENVIRONMENTAL CHANGES

Impacts of the project alternatives must be measured as changes in environmental conditions from some baseline condition, called the "point-of-reference" in this EIR.

Point-of-Reference for Comparison of Project Impacts

As a point of reference for comparison of the environmental impacts of various alternatives, this EIR used the existing environmental conditions at Mono Lake and the tributary streams, which were present before the issuance of a preliminary injunction by the El Dorado County Superior Court on August 22, 1989. The preliminary injunction, as described in the court's August 22 minute order, effectively prohibited LADWP from diverting water from Mono Basin streams any time the lake level was below 6,377 feet. The point of reference used in this report included the approximate water level elevation of Mono Lake and streamflows present before the August 22 order.

Basis in CEQA

CEQA requires that the "environmental setting" be described in an EIR. CEQA guidelines define the environmental setting as the environment "as it exists before the commencement of the project" (State CEQA Guidelines, Section 15125). CEQA requires that resource conditions at the initiation of the environmental review and permitting process, rather than future conditions without the project, be considered as the environmental setting.

Resource Conditions

For most topic areas, actual resource conditions in 1989 define the environmental setting for this point of reference. Actual resource conditions are germane to the vegetation, wildlife, fisheries, visual quality, air quality, and cultural resource topics. It is recognized that court-mandated streamflows in effect in August 1989, had they remained in effect, would have caused the lake level to gradually fall even during average runoff conditions. Nonetheless, the environmental setting for these topics is considered to be the resource conditions associated with the lake level at that time, together with the mandated streamflows.

Point-of-Reference Scenario

Severe drought conditions prevailed during 1989 in California, so that water and power supply from Mono Basin exports were not representative of average conditions. Consideration of these topics, as well as associated economic effects, therefore requires that a point-of-reference scenario be established. For this purpose, the aqueduct model was used to simulate the pattern of water and power supply that would result from the pattern of observed runoff variations, if streamflows mandated in 1989 remained in effect. In this way, realistic water supply and power production implications of the 1989 point-of-reference conditions can be characterized.

The simulation of the point-of-reference scenario also provides a characterization of the pattern of lake levels that would have resulted from permanent adherence to the court-mandated streamflows in effect in 1989. After a transition period of generally declining lake level lasting about 20 years, a dynamic equilibrium would prevail with a mean lake elevation of about 6,365 feet and normal fluctuations of about 16 feet.

Mono Lake Level

In August 1989, the surface elevation of Mono Lake was 6,376.3 feet and in a generally declining trend. No legal mandate existed to maintain any specified lake level before issuance of the preliminary injunction by the El Dorado County Superior Court on August 22, 1989.

Diversions and Tributary Streamflows

Before the August 22, 1989 preliminary injunction discussed above, LADWP's diversions from the Mono Basin streams were subject to preliminary injunctions issued by the Mono County Superior Court. These injunctions established minimum flows in Rush Creek and Lee Vining Creek as follows:

- Rush Creek - 19 cfs minimum throughout the year, and
- Lee Vining Creek - 5 cfs minimum throughout the year.

No minimum stream flow requirements were in effect for Walker and Parker Creeks. The minimum stream flow requirements for Rush Creek and Lee Vining Creek, applied to the historical runoff record and accounting for a loss of 8 TAF/yr for in-basin irrigation, determine the pattern of streamflows at this point-of-reference (Figure 2-2). The aqueduct model shows that these minimum flows would have persisted throughout the year in normal and all drier years.

In wetter years these flows would have been exceeded in spring and early summer, and in the wettest years they could be exceeded year-round. Spring flows as high as about 550 cfs and 340 cfs could occur in Rush and Lee Vining Creeks, respectively.

Prediversion Conditions for Assessing Cumulative Impacts

Environmental conditions prior to the beginning of LADWP diversions in Mono Basin for export (i.e., pre-1941) define the resource values for examining cumulative impacts of the diversion alternatives.

Basis in CEQA

Cumulative impacts are environmental changes resulting from project impacts in combination with impacts of "closely related past, present, and reasonably foreseeable probable future projects" (State CEQA Guidelines, Section 15355). LADWP's diversions from 1941 to the 1989 point-of-reference constitute a closely related past project. Prior diversions by early ranchers also may be considered as closely related projects for certain impacts, although the magnitude of the impacts from these early diversions was less than impacts of LADWP diversions. Impacts of early diversions also are more difficult to accurately assess.

The construction of LADWP's diversion facilities in Mono Basin and the Upper Owens River basin is generally not considered to be a closely related project. Construction impacts, usually of a different character than diversion impacts, are therefore generally not added to project impacts in this EIR to identify cumulative impacts. Exceptions exist, however, such as the loss of riparian vegetation upstream on Rush Creek due to enlargement of Grant Lake reservoir, that must be added to the subsequent loss of downstream riparian vegetation from diverted streamflow.

With some exceptions, therefore, conditions in Mono Basin on completion of the diversion facilities but before actual diversion of waters is considered to be the resource values and environmental setting in this EIR for examining cumulative impacts of the diversion alternatives.

Mono Lake Level

At the time that LADWP began diverting water from the tributary streams in 1941, the water surface elevation of Mono Lake was 6,417 feet, or 41 feet higher than the 1989 point of reference for project impacts. This level was 11 feet lower than the historical highstand of 6,428 feet.

Tributary Streamflows

Runoff into the tributary streams in the water year ending on April 1, 1941, was very near the long-term average runoff. The preceding year had been a dry year, preceded by a wet year and three average years.

As noted previously, streamflows existing before LADWP diversions for export were diminished by irrigation diversions, which began in the 1860s. Diversions from Rush, Parker, and Walker Creeks were relatively large, resulting in dewatering of certain reaches during the irrigation season, especially during dry years. Much of the irrigation occurred on very permeable soils, resulting in the creation of springs in the Rush Creek bottomlands likely augmenting streamflow there. (Stine 1991.)

The fraction of streamflow diverted from Lee Vining Creek was relatively smaller than from the other streams, and none of its reaches were dewatered in dry years by irrigation (Stine 1991).

Because storage facilities on these streams available to the early irrigators were relatively small, highflows during snowmelt runoff were relatively unregulated. These high flows are therefore similar to high flows of the No-Diversion Alternative (Figure 2-2).

CITATIONS

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Kodama, Mitchell M. Southern District engineer. Los Angeles Aqueduct Division, Los Angeles, CA. September 27, 1992 - irrigation and grazing policy meeting.

Table 2-1. Distribution of Runoff among the Diverted Tributary Streams

Stream	Average Annual Runoff (af)	Average Annual Streamflow (cfs)	Percent of Total
Lee Vining Creek	49,197	68.0	40.0
Walker Creek	5,401	7.5	4.5
Parker Creek	9,126	12.5	7.0
Rush Creek	59,682	82.5	48.5
Total	123,406	170.5	100.0

Table 2-2. Runoff Frequencies

Frequency of Runoff Less than Specific Amount (%)	Specific Runoff Amount (TAF)	Percentage of Average Runoff[a]
0 (minimum)	54.3	44
10	71.6	58
20 (dry year threshold)	85.1	69
30	95.0	77
40	101.2	82
50 (median)	112.3	91[b]
60	130.8	106
70	143.1	116
80 (wet year threshold)	162.9	132
90	175.2	142
100 (maximum)	239.4	194

[a] Average runoff is 123,405 af/yr (i.e., 123.4 TAF/yr).

[b] The 50% runoff is less than average runoff because the median annual value does not equal the average annual value.

Table 2-3. Assumed Minimum and Ecosystem Maintenance Flows for Simulating the Alternatives

Month	Average Monthly Streamflow (cfs)			
	Lee Vining Creek	Walker Creek	Parker Creek	Rush Creek
April	25.9	1.1	4.2	31.6
May	75.7	2.5	7.4	50.0
June				
Most alternatives	183.3	20.7	31.9	159.4
6,372-Ft Alternative	93.7	10.0	20.7	61.5
July	47.2	4.8	18.3	40.7
August	29.1	3.2	11.0	26.9
September	19.9	2.2	5.7	33.5
October	18.8	2.3	3.8	34.9
November	17.7	2.5	3.1	32.7
December	19.0	2.5	3.3	25.9
January	19.2	2.2	3.2	27.5
February	17.7	2.2	3.0	27.5
March	16.2	2.1	3.3	21.2

Note: No minimum flows apply to the No-Restriction Alternative; ecosystem maintenance flows are assumed to occur in June.

Table 2-4. Assumed Lake Release as Percentage of Projected Runoff by Year Type

Target Lake Level	Actual Lake Level above Target Level											
	Less than 1 Ft			1-2 Ft			2-3 Ft			More Than 3 Ft		
	Year Type (Wet)	Year Type (Average)	Year Type (Dry)	Year Type (Wet)	Year Type (Average)	Year Type (Dry)	Year Type (Wet)	Year Type (Average)	Year Type (Dry)	Year Type (Wet)	Year Type (Average)	Year Type (Dry)
Alternatives after dynamic equilibrium	100	100	100	50	50	50	25	25	25	0	0	0
6,383.5-Ft Alternative during transition	70	85	100	60	75	100	50	65	100	0	0	0
6,390-Ft Alternative during transition	70	85	100	60	75	100	50	65	100	0	0	0
6,410-Ft Alternative during transition	95	90	100	85	80	100	75	70	100	0	0	0

Table 2-5. Cumulative Lake Level Frequencies at Dynamic Equilibrium

Frequency of Lake Surface Elevation Lower than Specific Elevation	Alternative						
	No Restriction	6,372-Ft	6,377-Ft	6,383.5-Ft	6,390-Ft	6,410-Ft	No Diversion
Normal maximum[a]	6,365.5	6,378.8	6,382.9	6,389.2	6,395.2	6,415.0	6,436.4
80%	6,360.6	6,376.2	6,380.1	6,386.6	6,392.5	6,412.0	6,429.1
50% (median)	6,352.4	6,374.9	6,379.1	6,385.7	6,391.6	6,410.8	6,427.4
20%	6,348.5	6,373.9	6,378.3	6,384.8	6,390.6	6,409.6	6,425.9
Normal minimum[a]	6,344.4	6,372.2	6,376.5	6,383.2	6,388.9	6,407.8	6,424.0
1%[b]	6,336.5	6,370.4	6,373.1	6,377.8	6,382.8	6,400.8	6,416.4

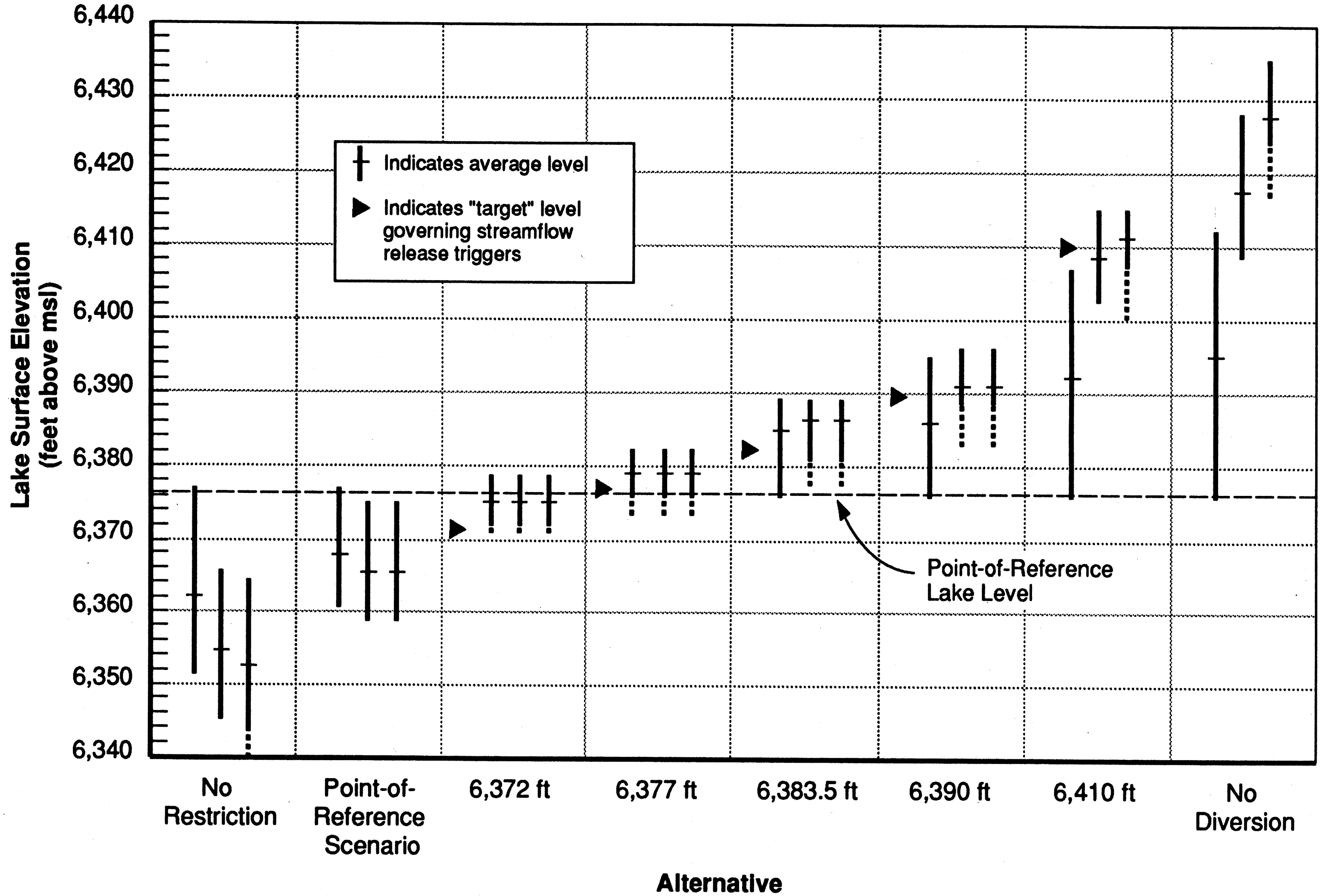
[a] Minimum and maximum elevations attained by the lake in simulations using the 1940-1989 historical hydrologic database.

[b] After 8-year drought having 60% of average runoff each year (Appendix H).

Source: LAAMP simulations of the alternatives (except 1% data).

Table 2-6. Preliminary Minimum Monthly Streamflows (cfs) for Lee Vining, Walker, Parker, and Rush Creeks from DFG Stream Evaluation Reports

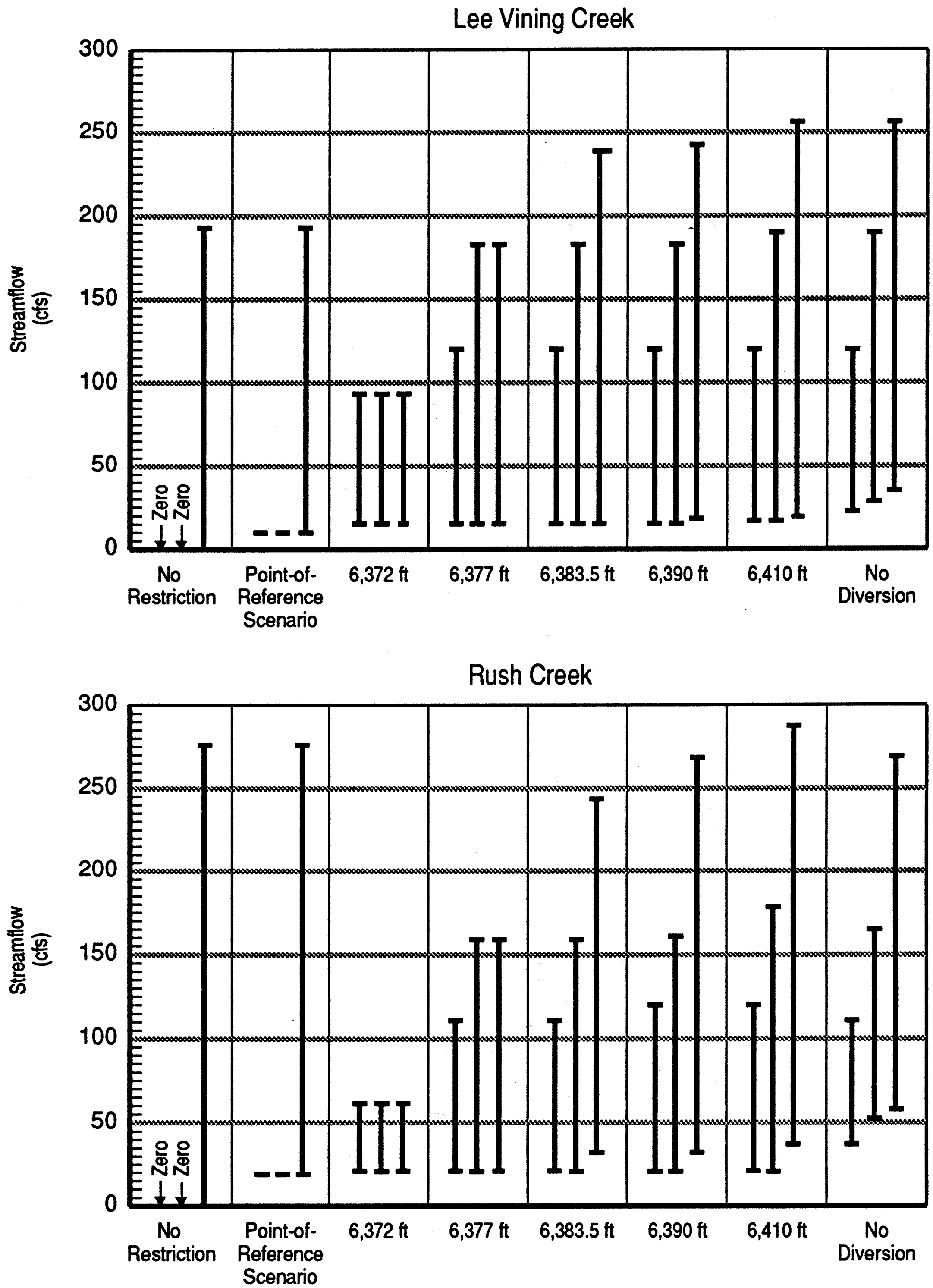
(See Figure 2-17)



Notes: Normal range of lake level fluctuation indicated by solid bars; possible declines during extreme drought are indicated by dashes.

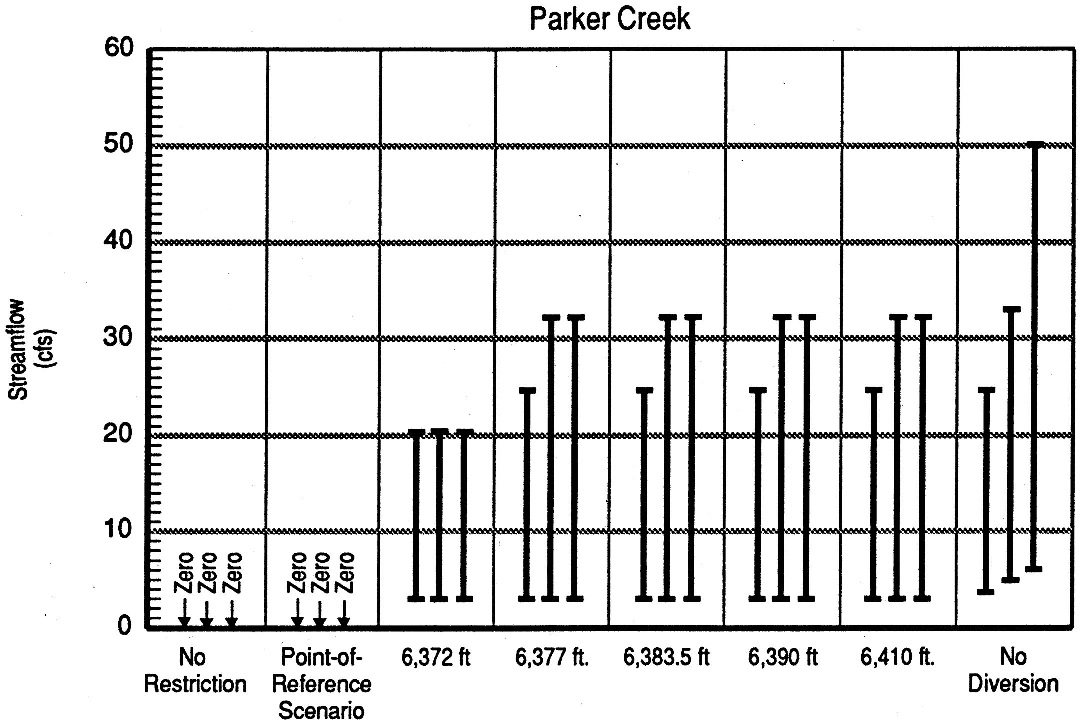
The three bars for each alternative represent simulated lake level fluctuations over three successive 50-year periods; the left-hand bar represents the first 50 years of simulation and the right-hand bar represents "dynamic equilibrium".

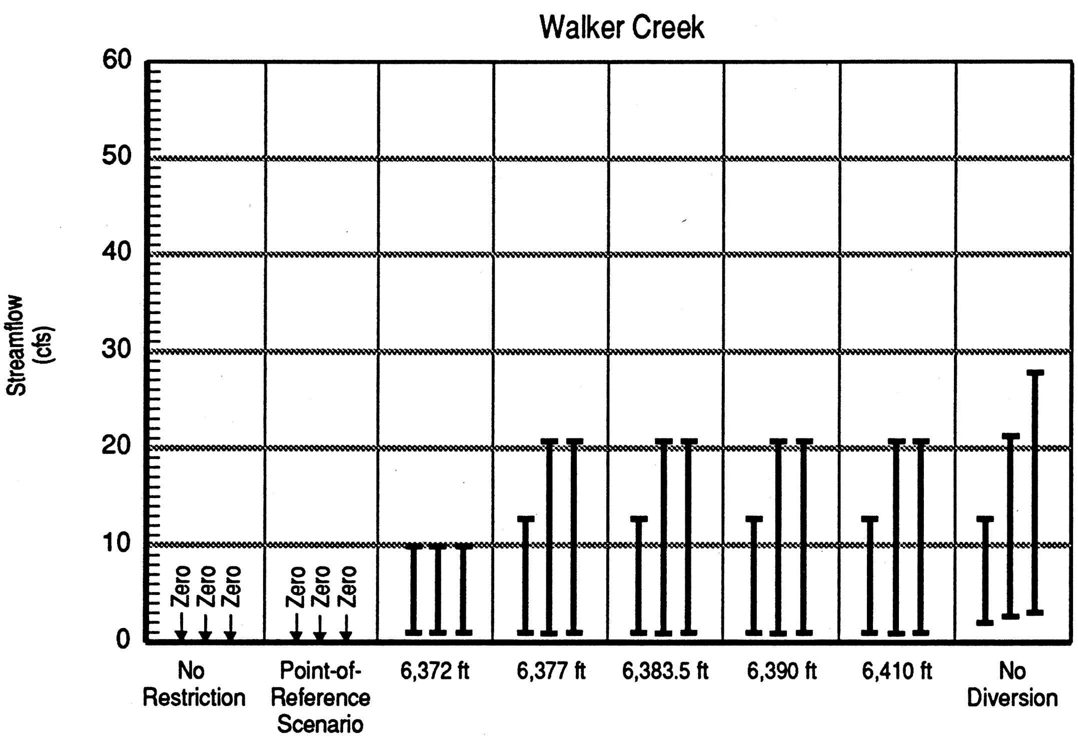
Figure 2-1.
Lake Level Ranges of the Alternatives Showing Lake Levels over Three 50-Year Periods



Note: The three bars for each alternative represent dry (20% driest years), normal, and wet (20% wettest years) conditions. The bars depict the annual range of monthly average streamflow. Runoff peaks occur in June or July, with the lowest flows persisting from September through March.

Figure 2-2a.
Streamflows for the Alternatives,
Lee Vining Creek and Rush Creek

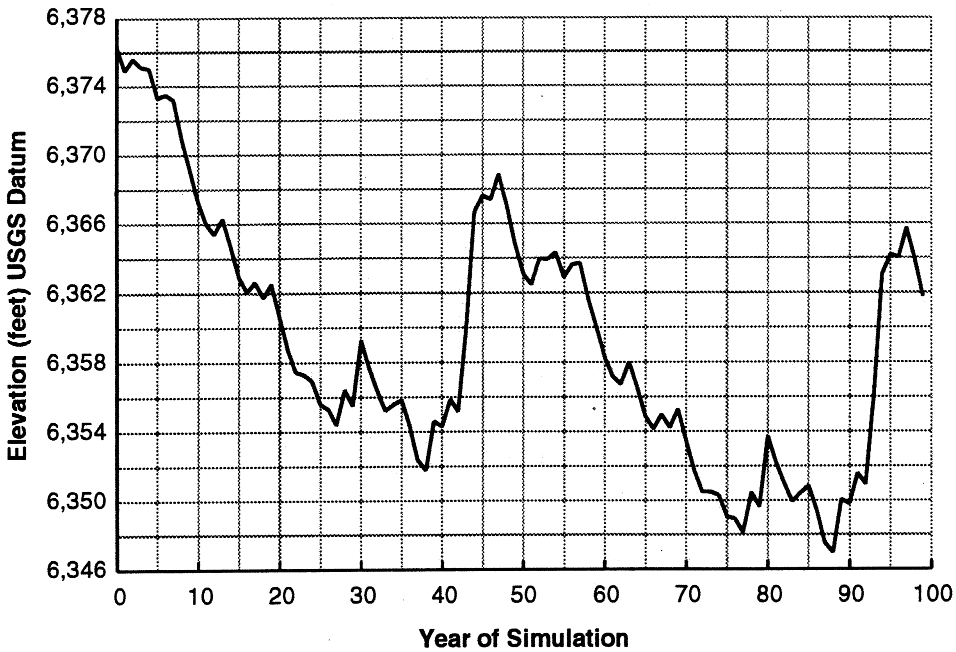




Note: The three bars for each alternative represent dry (20% driest years), normal, and wet (20% wettest years) conditions. The bars depict the annual range of monthly average streamflow. Runoff peaks occur in June or July, with the lowest flows persisting from September through March.

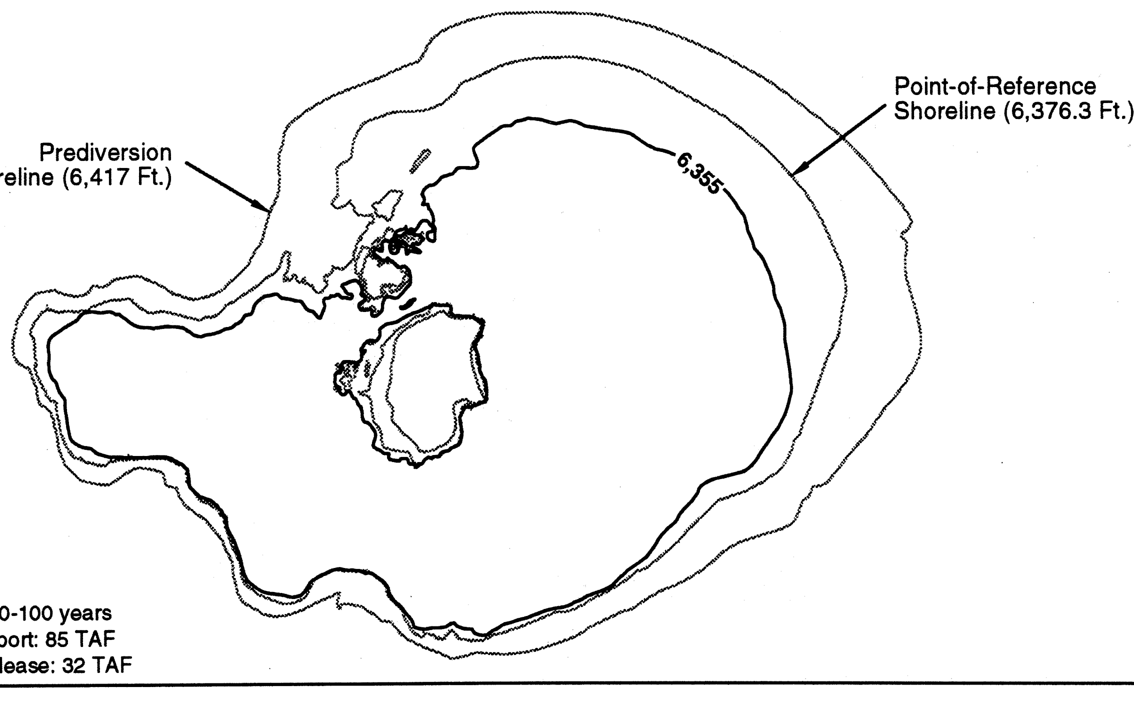
Figure 2-2b.
Streamflows for the Alternatives,
Parker Creek and Walker Creek

Figure 2-3.
Simulated Lake Surface Elevation - No-Restriction Alternative



Note: Simulation is based on 1940-1989 historical hydrology, beginning at the point-of-reference lake surface elevation.

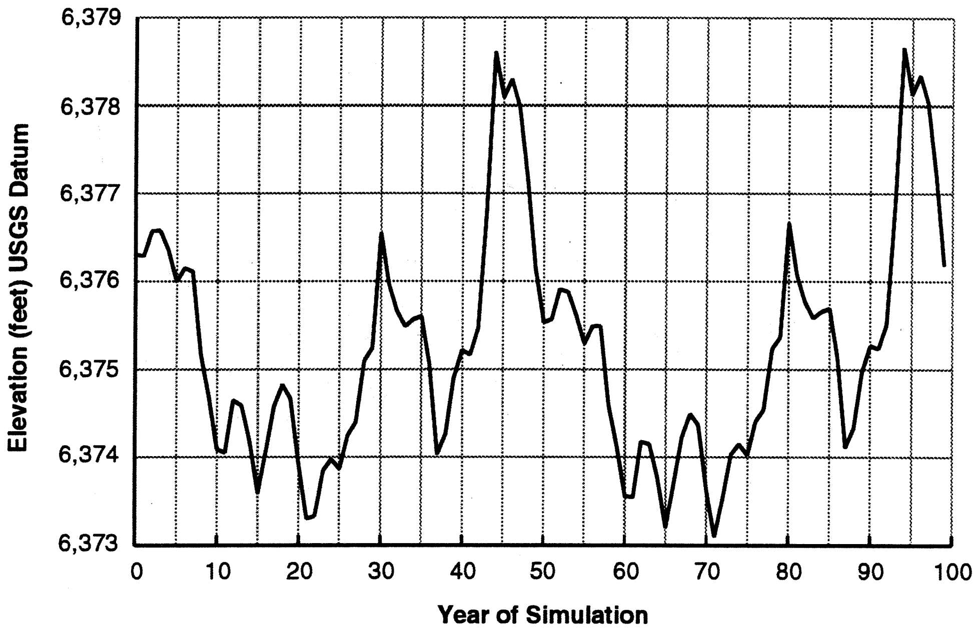
Figure 2-4.
Lake Configuration at Equilibrium Lake Level - No-Restriction Alternative



Transition Period: 50-100 years
Annual Average Export: 85 TAF
Annual Average Release: 32 TAF

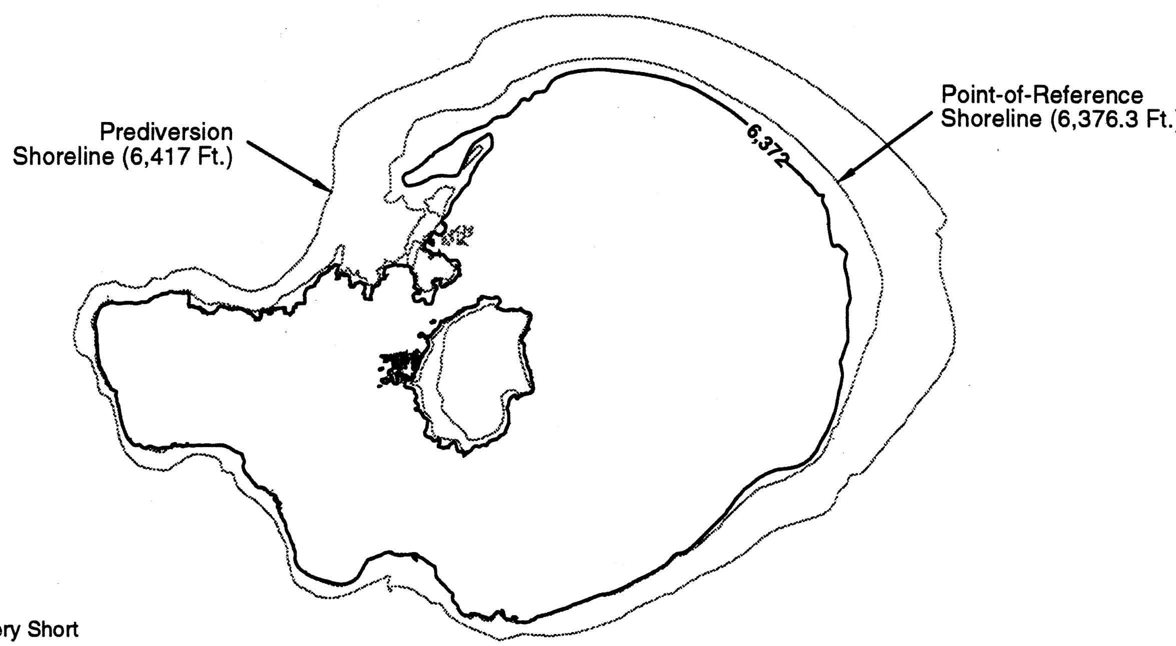
Mono-6

Figure 2-5.
Simulated Lake Surface Elevation - 6,372-Ft Alternative



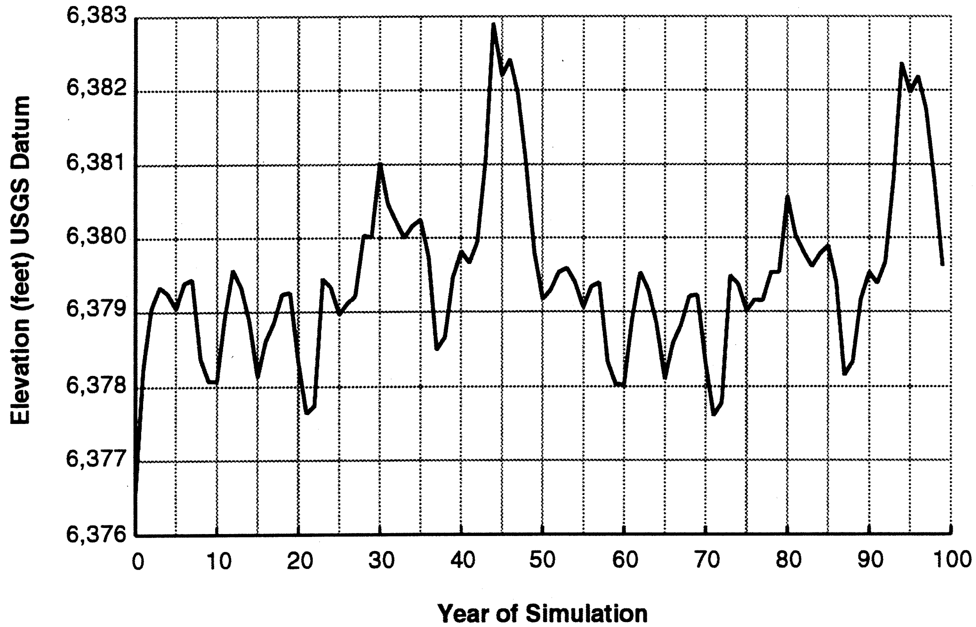
Note: Simulation is based on 1940-1989 historical hydrology, beginning at the point-of-reference lake surface elevation.

Figure 2-6.
Lake Configuration at the Protected Lake Level - 6,372-Ft Alternative



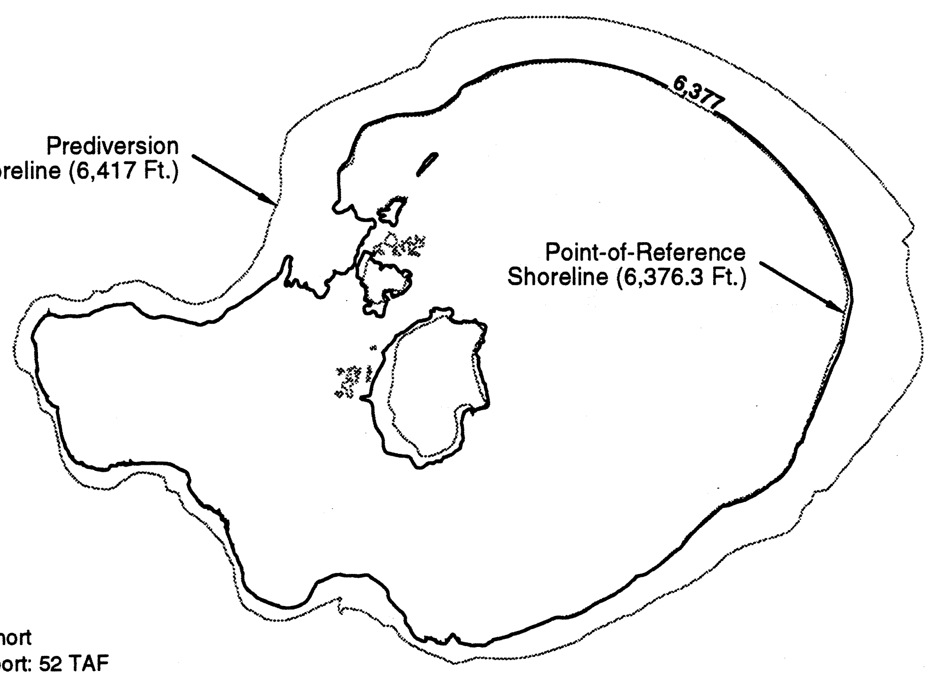
Transition Period: Very Short
Annual Average Export: 64 TAF
Annual Average Release: 61 TAF

Figure 2-7.
Simulated Lake Surface Elevation - 6,377-Ft Alternative



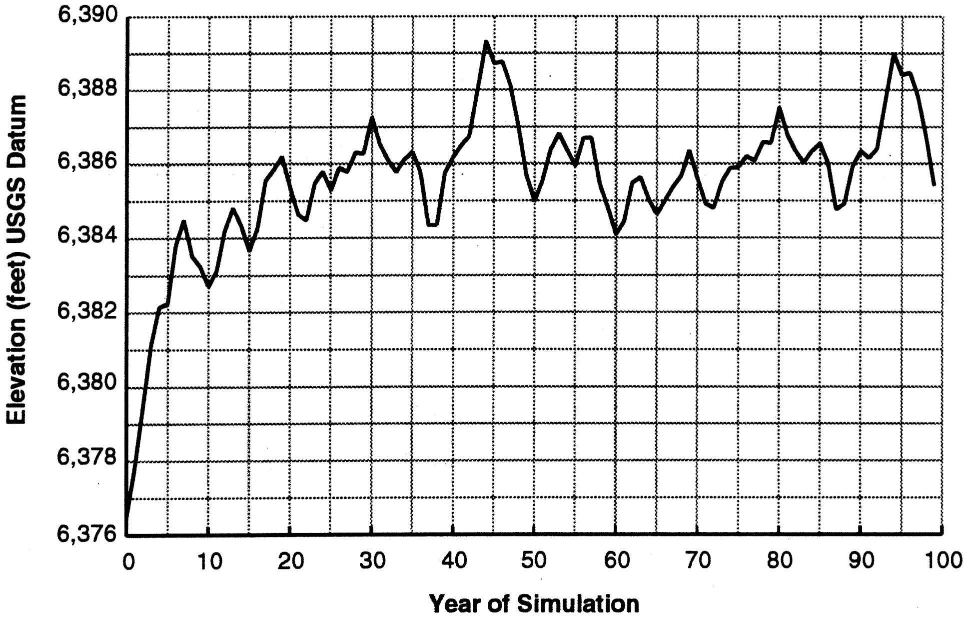
Note: Simulation is based on 1940-1989 historical hydrology, beginning at the point-of-reference lake surface elevation.

Figure 2-8.
Lake Configuration at the Protected Lake Level - 6,377-Ft Alternative



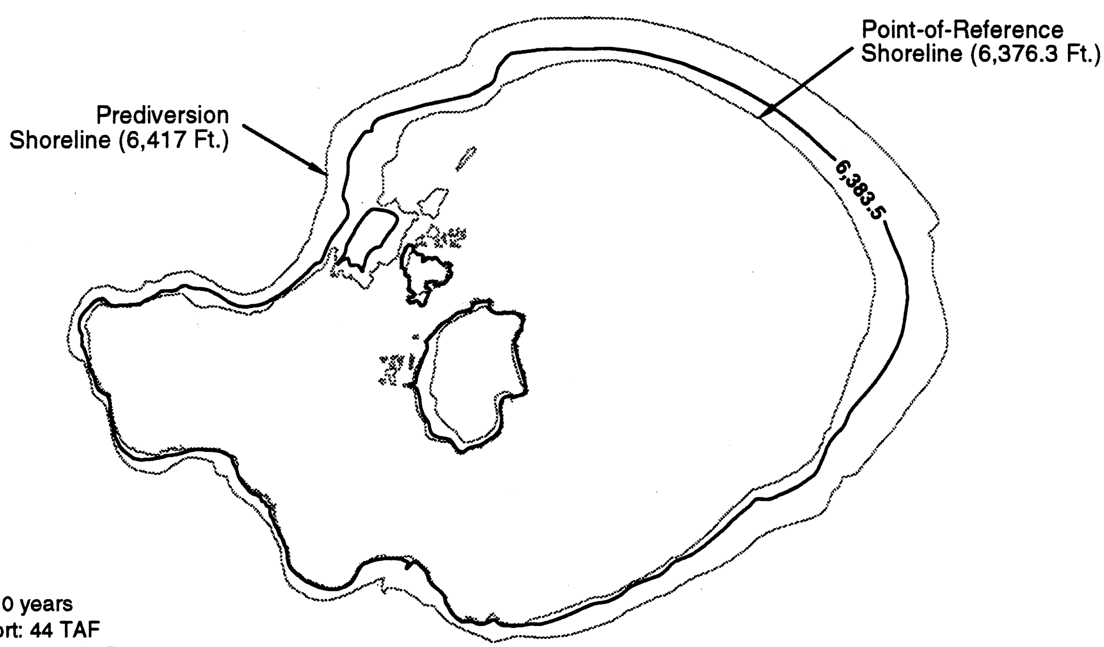
Transition Period: Short
Annual Average Export: 52 TAF
Annual Average Release: 74 TAF

Figure 2-9.
Simulated Lake Surface Elevation - 6,383.5-Ft Alternative



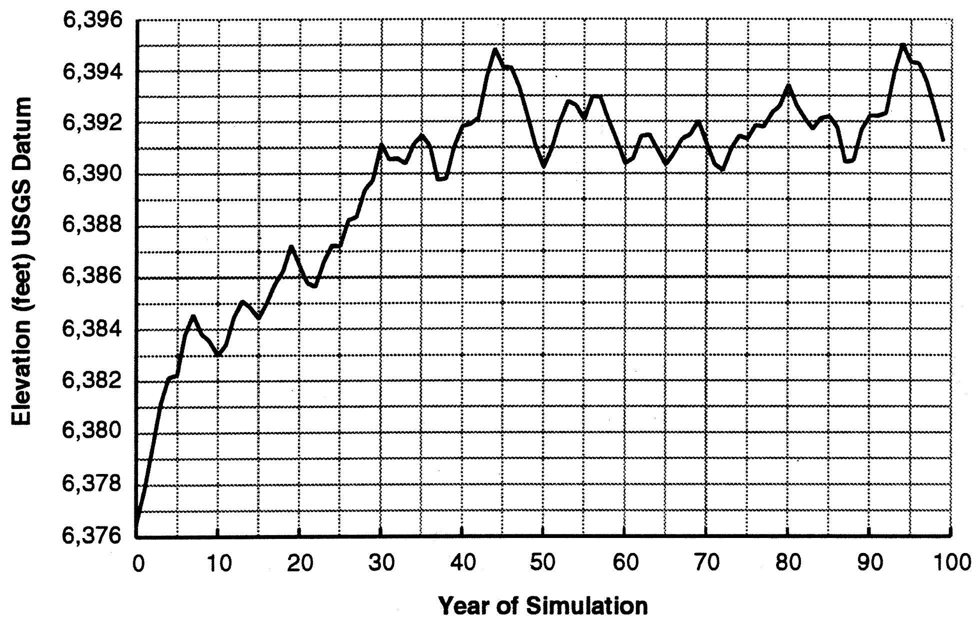
Note: Simulation is based on 1940-1989 historical hydrology, beginning at the point-of-reference lake surface elevation.

Figure 2-10.
Lake Configuration at the Protected Lake Level - 6,383.5-Ft Alternative



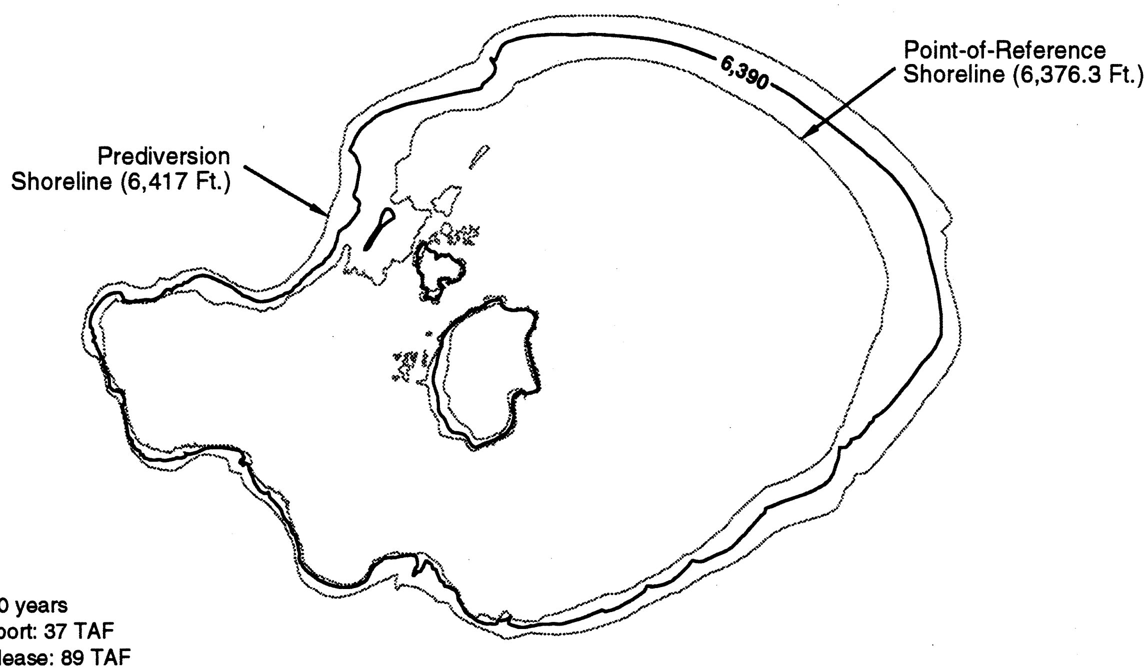
Transition Period: 5-10 years
Annual Average Export: 44 TAF
Annual Average Release: 82 TAF

Figure 2-11.
Simulated Lake Surface Elevation - 6,390-Ft Alternative



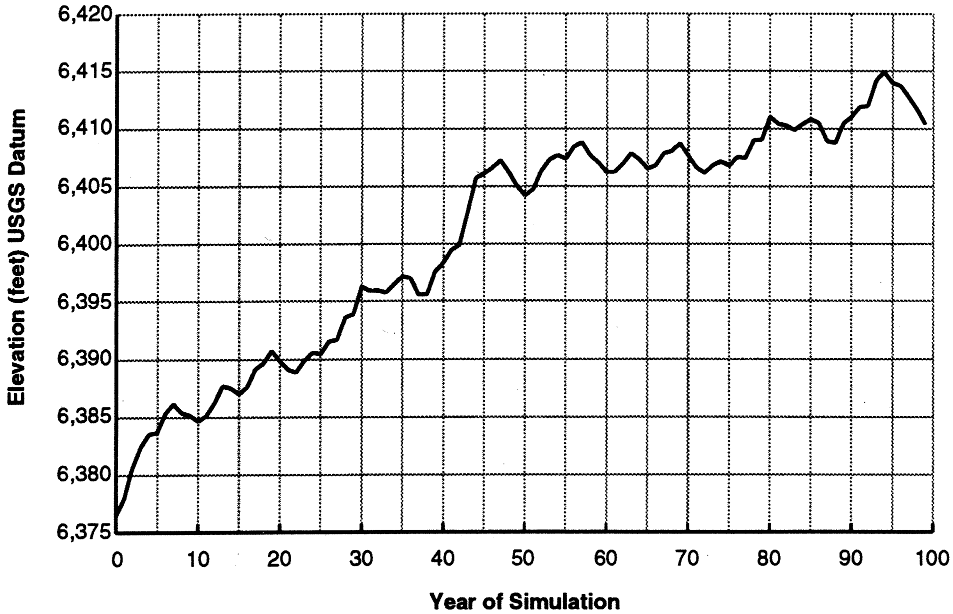
Note: Simulation is based on 1940-1989 historical hydrology, beginning at the point-of-reference lake surface elevation.

Figure 2-12.
Lake Configuration at the Protected Lake Level - 6,390-Ft Alternative



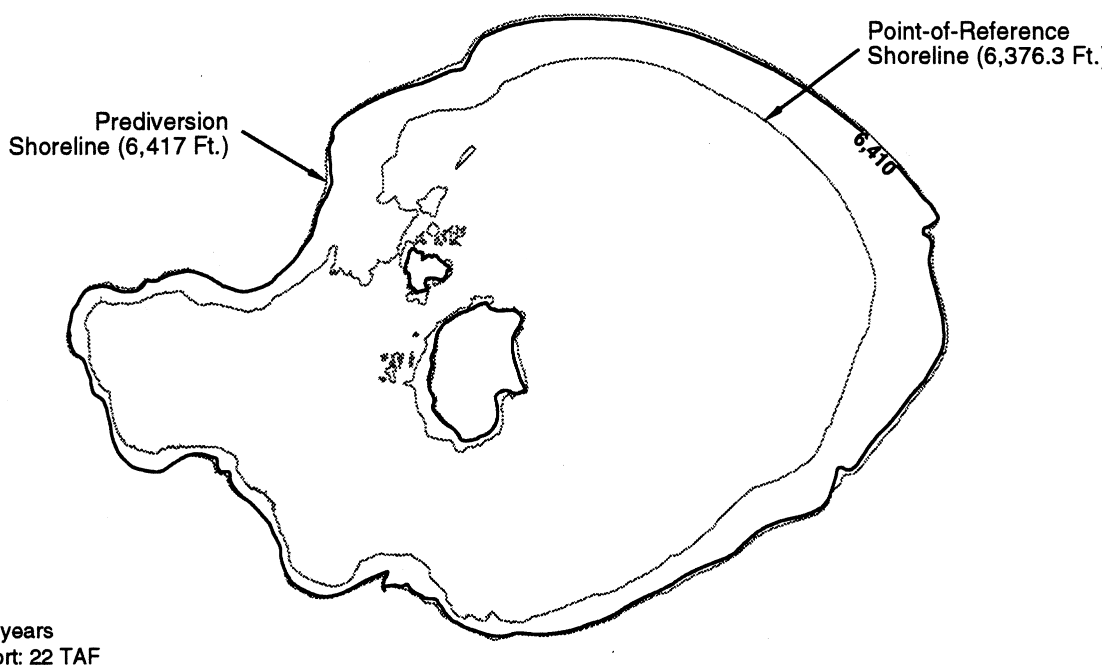
Transition Period: 30 years
Annual Average Export: 37 TAF
Annual Average Release: 89 TAF

Figure 2-13.
Simulated Lake Surface Elevation - 6,410-Ft Alternative



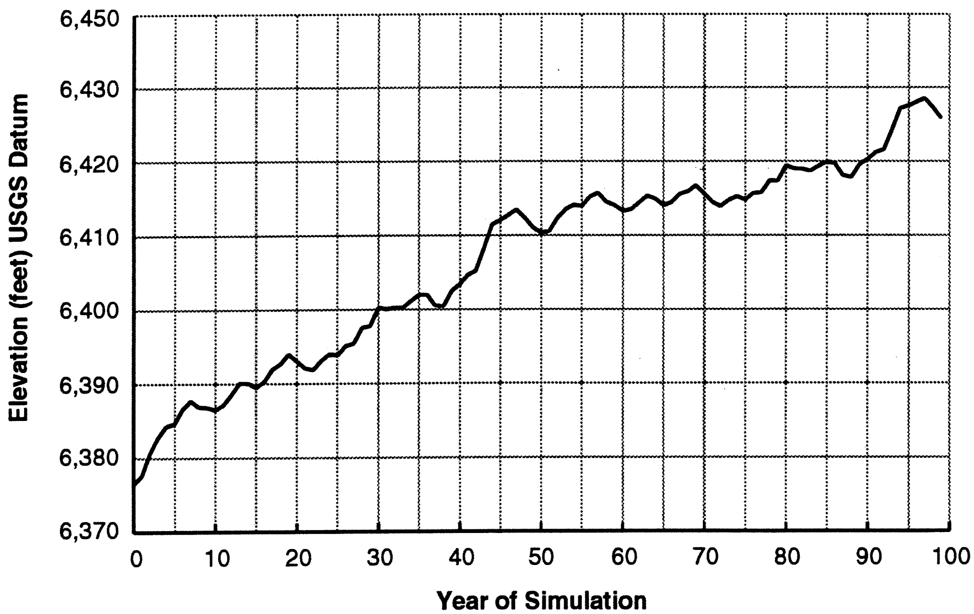
Note: Simulation is based on 1940-1989 historical hydrology, beginning at the point-of-reference lake surface elevation.

Figure 2-14.
Lake Configuration at the Protected Lake Level - 6,410-Ft Alternative



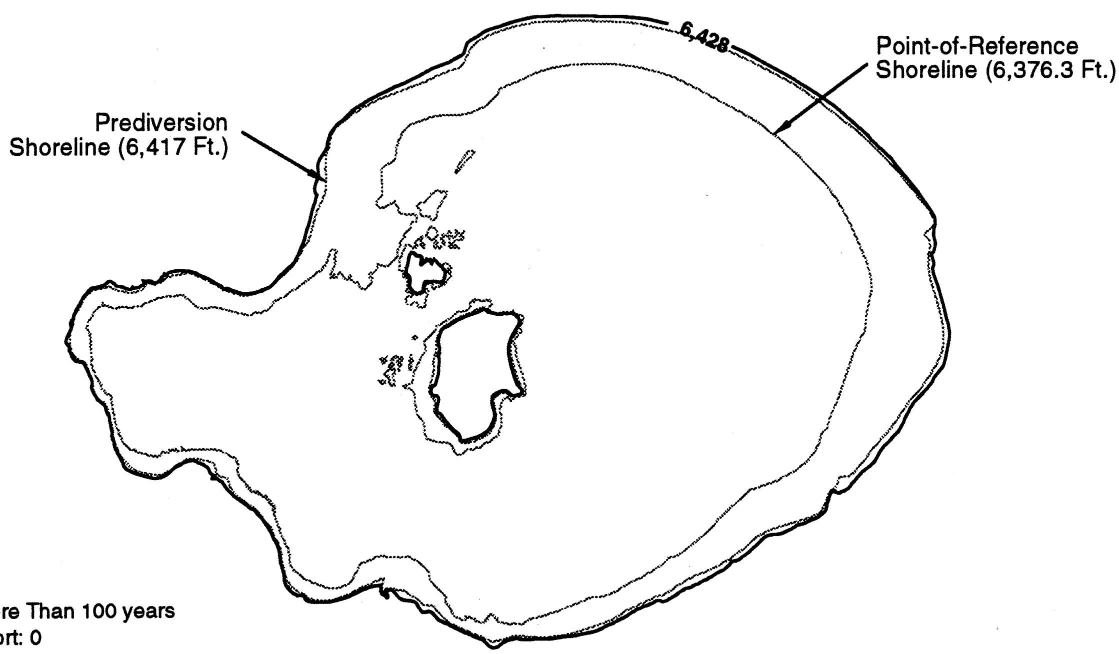
Transition Period: 80 years
Annual Average Export: 22 TAF
Annual Average Release: 104 TAF

Figure 2-15.
Simulated Lake Surface Elevation - No-Diversion Alternative



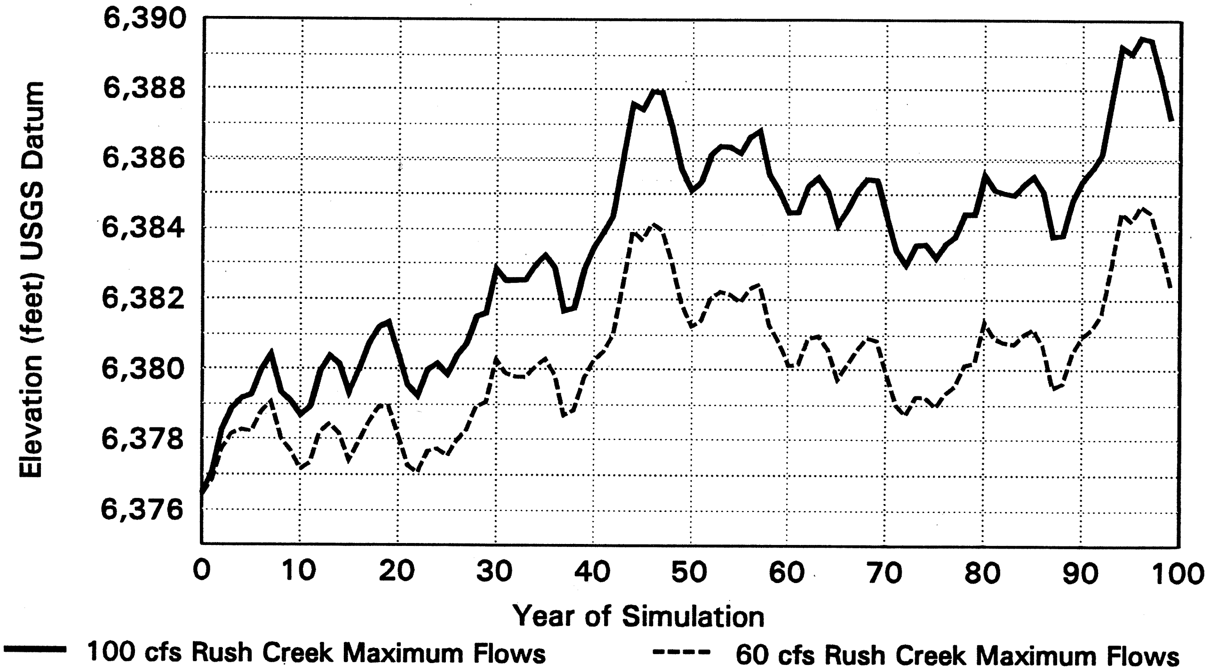
Note: Simulation is based on 1940-1989 historical hydrology, beginning at the point-of-reference lake surface elevation.

Figure 2-16.
Lake Configuration at the Equilibrium Lake Level - No-Diversion Alternative



Transition Period: More Than 100 years
Annual Average Export: 0
Annual Average Release: 124 TAF

Figure 2-17.
Simulated Lake Surface Elevation with Preliminary Minimum Monthly Streamflows from DFG Stream Evaluation Reports



Note: Simulation is based on 1940-1989 historical hydrology, beginning at the point-of-reference lake surface elevation.

Table 2-6.
Preliminary Minimum Monthly Streamflows (cfs) for Lee Vining, Walker, Parker, and Rush Creeks from DFG Stream Evaluation Reports

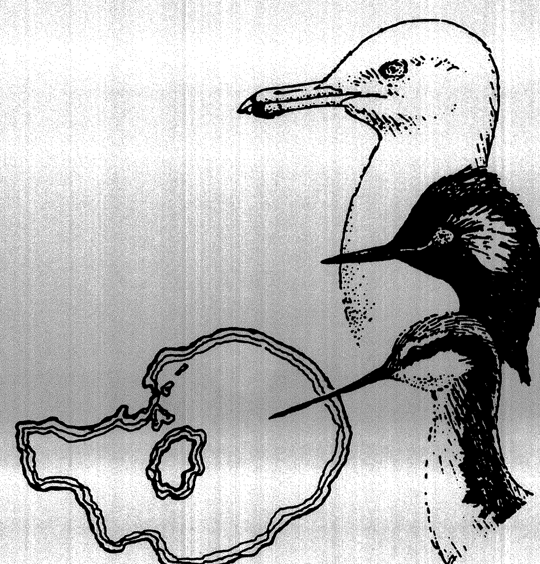
Month	Lee Vining Creek All Years	Walker Creek All Years	Parker Creek All Years	Rush Creek – 100 cfs			Rush Creek – 60 cfs		
				Dry Year	Normal Year	Wet Year	Dry Year	Normal Year	Wet Year
April	45	6	9	35	59	84	35	59	60
May	45	6	9	75	100	100	60	60	60
June	61 [a]	7 [b]	10.5 [c]	72	100	100	60	60	60
July	45	6	9	45	100	100	45	60	60
August	45	6	9	42	93	100	42	60	60
September	45	6	9	40	63	100	40	60	60
October	40	4.5	6	36	58	93	36	58	60
November	40	4.5	6	30	40	71	30	40	56
December	40	4.5	6	30	40	71	30	40	56
January	40	4.5	6	31	44	57	31	44	57
February	40	4.5	6	32	48	54	32	48	54
March	40	4.5	6	34	52	54	34	52	54

Notes:

[a] Dry and normal year flushing flow of 160 cfs for 3 days, wet year June flushing flow of 160 cfs for 30 days.
[b] Dry and normal year flushing flow of 15 cfs for 3 days, wet year June flushing flow of 15 cfs for 30 days.
[c] Dry and normal year flushing flow of 23 cfs for 3 days, wet year June flushing flow of 23 cfs for 30 days.

Sources: Beak Consultants (1991), Ebasco Environmental and Water Engineering and Technology (1991b and 1991c), Aquatic Systems Research (1992), and Gibbons pers. comm.

Chapter 3A. Environmental Setting, Impacts, and Mitigation Measures - Hydrology



MONO BASIN EIR

Prepared by Jones & Stokes Associates

Chapter 3A. Environmental Setting, Impacts, and Mitigation Measures - Hydrology

INTRODUCTION

As described in Chapter 2, alternative amendments to the City of Los Angeles appropriative water rights for diversion of four tributary streams in Mono Basin will have direct hydrologic effects on the four streams downstream of the diversions, the water balance and surface elevations of Mono Lake, and the amount of water exported to the Upper Owens River. The allowable exports from Mono Basin will also have indirect effects on Owens River flows, Lake Crowley reservoir storage, and exports from the Owens Valley to Los Angeles. The relationships between these variables were used to define a set of water rights alternatives using a monthly hydrologic model described in Chapter 2.

Many of the hydrologic conditions in Mono Basin and the Owens River basin will not be altered by the proposed amendments to the city's water rights. The available runoff from the four Mono Lake tributary streams that are diverted by LADWP will not change. The other sources of water flowing into Mono Lake (e.g., rainfall, most groundwater, and other surface streamflow) will not change. The runoff and spring discharges in the Owens Valley will not be affected. As described in Chapter 2, the assumption has been made for this EIR that groundwater pumping in the Owens Valley will not change with amendment of Mono Basin water rights.

The hydrologic records used to analyze the alternative water rights amendments for the four diverted Mono Lake tributaries are for 1940-1989. The LADWP diversions began in 1941 and continued until 1989. Because of large year-to-year variations in the natural hydrology of Sierra Nevada streams, data from a large sequence of years are required to characterize hydrologic patterns accurately. Hydrologic effects caused by each alternative result from different diversions of streamflow for irrigation use or export from Mono Basin, but not from altered runoff patterns. Therefore, these hydrologic records are considered to characterize the prediversion period (before 1941), the historical diversion period (1941-1989), the point-of-reference conditions, and the probable future conditions for this EIR.

The "Prediversion Conditions" section in this chapter describes the basic hydrology of Mono Basin and the Owens River basin. The streamflows in the four diverted Mono Lake tributary streams and the Upper Owens River are described in greatest detail because these are the primary resources being evaluated for amended water rights. The water balance of Mono Lake (Appendix A) is described further because this is the primary tool for determining the relationship between stream releases to Mono Lake and the expected fluctuations of lake surface elevation.

The effects of alternative water rights amendments on Owens River flows and exports to Los Angeles are analyzed with the Los Angeles Aqueduct Monthly Program (LAAMP) operations model. This model is described in Chapter 2, as well as Auxiliary Report 5; model results are given in Auxiliary Report 18.

Results from the aqueduct simulations are used to assess impacts in several topic areas. The hydrologic effects described in this chapter are not themselves classified as environmental impacts, but they may cause impacts as identified in the various resource chapters of this report.

PREDIVERSION CONDITIONS

The general hydrology of Mono Basin and the Owens River basin is described below for the prediversion period, which included LADWP aqueduct facilities in the Owens River basin but none in Mono Basin.

Sources of Information

General Hydrology

Most of the historical hydrologic data was obtained from the LADWP "Totals and Means" database, which contains monthly totals for rainfall stations, streamflow gauges, reservoir storage, and various diversions. Daily records are available in separate LADWP databases for several of these stations. These hydrologic data provide an accurate description of basic hydrologic patterns.

Several detailed investigations of the hydrology of Mono Basin have been made, the most complete being those by Vorster (1985) and LADWP (1987). The U.S. Geological Survey (USGS) has conducted several investigations of the area's surface water and groundwater resources (Hollett et al. 1989, Lee 1912). The extensive measurements by LADWP have contributed to an increasingly accurate understanding of the hydrology of the Owens Valley. Several recent studies have been directly associated with the development of the Inyo County-Los Angeles groundwater management plan (LADWP 1990).

Hydrologic monitoring reports of groundwater and surface water have been prepared by USGS for the Long Valley caldera (Farrar et al. 1989). Streamflow records have been maintained by USGS and LADWP for these streams since before 1940.

Snowpack Measurements

The hydrology of Mono Basin and the Owens River basin is dominated by winter accumulation of snowpack in the upper elevations of the Sierra Nevada and White Mountains, and subsequent snowmelt runoff in the May-July period. Several snowpack depth measurement stations have been maintained by LADWP, the California Department of Water Resources (DWR), and Southern California Edison (SCE) high in the Owens River basin, in Mono Basin, and in adjacent basins on the western crest of the Sierra Nevada.

Use of "Runoff Year"

Because snowpack accumulation is usually complete by early April, the "runoff year" has been used by LADWP for its standard hydrologic record keeping and aqueduct management planning. The runoff year begins on April 1 and ends on March 31. When annual values are reported or discussed in this EIR, the runoff year is the annual period being used, rather than the calendar year.

Rainfall Records

Rainfall is important at low elevations for replenishing soil moisture for vegetation but does not provide a significant portion of the basin runoff. Some rainfall and snowmelt infiltrates into the soil and is lost to evapotranspiration or percolates to groundwater. Several reliable records of monthly rainfall are available from stations within Mono Basin and the Owens River basin, but the amount of evapotranspiration and groundwater recharge can only be estimated.

Streamflow

Several stream gauge stations that have been maintained by USGS and LADWP provide accurate records of streamflow in Mono Basin and the Owens River basin. Monthly runoff volumes have been converted to monthly average flows in cubic feet per second (cfs) for easier interpretation in the assessment of riparian and fisheries impacts. The general conversion factor is 1 cfs per day equals 2 acre-feet (af). Daily flows can be higher than the monthly average values, but only average monthly flows are estimated for this EIR.

During runoff, the stream channels allow a portion of the streamflow to infiltrate into the alluvial aquifers. Simultaneous (or synoptic) flow measurements have been used to evaluate these losses along all four diverted tributary streams (Beak Consultants 1991, 1992; EBASCO Environmental and Water Engineering and Technology 1991b, 1991c). These losses are also described in Chapter 3C, "Vegetation", as they relate directly to riparian habitat conditions.

Mono Basin Hydrology

Mono Basin has a mapped surface drainage area of 695 square miles (Vorster 1985). Mono Basin drains the eastern slope of the Sierra Nevada but is located at the western edge of the Great Basin desert region. Mono Basin is a closed hydrographic basin, so all surface runoff and groundwater flows toward Mono Lake. Water leaves the basin naturally only by evaporation from the surface of Mono Lake and evapotranspiration from the riparian corridors and from vegetation and soils on the remainder of the watershed.

Geology

Mono Basin geology is generally described as a sediment-filled structural depression that was created by faulting and tectonic downwarping (Stine 1987). Mono Basin is surrounded by the granite and metamorphic rocks of the eastern Sierra Nevada escarpment on the west, and highly fractured volcanic rocks and deposits of the Bodie Hills, Anchorite Hills, Cowtrack and Glass Mountains, and Mono Craters on the north, east, and south (Figure 1-1). Glacial debris from multiple periods of glaciation has formed many moraines, ridges, and alluvial cobble deposits that cover a broad piedmont slope at the base of the Sierra Nevada. The major surface streams drain from the melting snowpack and alpine lakes high in the Sierra Nevada down across the glacial deposits to the sedimentary and volcanic layers of material that fill Mono Basin. The geologic history of Mono Basin is reviewed by LaJoie (1968), LADWP (1987), and Stine (1987).

Tributary Streams

Three major streams enter Mono Lake: Mill Creek, Lee Vining Creek, and Rush Creek (Figure 1-2). Mill Creek enters in the northwestern corner of the western embayment of Mono Lake and has not been diverted by LADWP. Lee Vining Creek enters the western embayment of Mono Lake from the southwest. Rush Creek enters Mono Lake from the south. Walker Creek and Parker Creek are tributaries to Rush Creek, but they can be diverted directly into the Lee Vining conduit of the LA Aqueduct system.

Three other small, perennial tributary streams (Wilson, Post Office, and DeChambeau Creeks) enter Mono Lake from the Sierra Nevada. Springs and intermittent streams drain the volcanic and alkaline hills that surround the rest of Mono Lake; their water contributions to Mono Lake are considered as part of the unmeasured local runoff and groundwater inflows. Several geothermal springs exist within Mono Basin, including some within Mono Lake itself; however, flows from these geothermal sources are not considered important relative to the other surface water and groundwater sources (LADWP 1987).

Lee Vining Creek Watershed

Lee Vining Creek has a watershed area of 47 square miles, most of which (40 square miles) is upstream of the LADWP diversion into Lee Vining conduit (Table 3A-1).

Watershed Character. Lee Vining Creek drains the eastern Sierra Nevada crest. Mount Dana, with an elevation of 13,053 feet, is the highest peak in Mono Basin, and several other peaks above 12,000 feet rim the watershed boundary (Figure 1-1). Several small glaciers are present, and a series of alpine lakes provides storage for snowmelt and dampens the peak runoff. Three of these lakes (Saddlebag, Tioga, and Ellery) were enlarged for hydropower storage and regulation in the 1920s.

Lee Vining Creek drops precipitously down the eastern Sierra escarpment from Ellery Lake at elevation 9,500 feet to the Poole Power Plant at elevation 7,825 feet. Warren Fork enters Lee Vining Creek from the north upstream of the Poole Power Plant. Gibbs Creek is a major tributary that joins Lee Vining Creek upstream of the LADWP diversion.

Below the LADWP diversion, Lee Vining Creek flows past the USFS Lee Vining Ranger Station to the mouth of a glacial canyon, above U.S. Highway 395 (U.S. 395) and the town of Lee Vining. Water supply and hydropower diversions were historically located at this point in the stream. The hydropower plant was located downstream in the town of Lee Vining. The creek then flows over alluvial deposits to its delta in Mono Lake.

Precipitation, Runoff, and Diversions. Four snow courses are maintained in and adjacent to the Lee Vining Creek watershed by DWR and SCE. These provide an excellent record of snowpack in the watershed at the 9,600 to 9,900-foot elevation. The average April 1 water depth at the four stations is about 29 inches (Table 3A-2).

Average precipitation is 25.5 inches at Ellery Lake (9,645 feet elevation) and 27.5 inches at Poole Power Plant (7,850 feet), but only 12.8 inches at the Lee Vining Ranger Station (7,175 feet). The rain shadow of the eastern Sierra Nevada is evident in the rain gauges east of the Sierra Nevada crest.

Streamflow has been measured on Lee Vining Creek above Gibbs Creek since 1934 and on Gibbs Creek from 1948 until 1977. The long-term runoff from Gibbs Creek is approximately 2 thousand acre-feet per year (TAF/yr). Irrigation diversions of approximately 1 TAF/yr from Gibbs Creek to Horse Meadow and Farrington Ranch lands were made in the period before LADWP diversion began. Another irrigation diversion (at O-Ditch) of approximately 0.75 TAF/yr was made from Lee Vining Creek onto National Forest meadows above the Lee Vining Ranger Station.

The annual average runoff from Lee Vining Creek has been estimated from the LADWP records to be 49.2 TAF/yr. Annual flow variations of Lee Vining Creek have generally followed the pattern of other diverted streams in the area (Figure 3A-1). Figure 3A-2 shows the monthly cumulative distribution of runoff for Lee Vining Creek, as estimated by LADWP and adjusted to include Gibbs and O-Ditch diversions. The seasonal distribution of flow in Lee Vining Creek is strongly affected by the upstream SCE storage and hydropower operations.

The monthly flows during dry years (lowest 20% of years) are remarkably constant throughout the year (Table 3A-3). In near-normal runoff years, the base flow during the entire year is slightly higher and the peak runoff during the snowmelt period is increased. During wet years (highest 20% of years), most of the additional runoff occurs during the snowmelt period, although elevated summer and fall flows sometimes have occurred.

Above the Poole Power Plant, an average of approximately 6.3 TAF of the annual runoff is stored during the May-July peak period and released during the fall and winter period (Vorster 1985). Following snowmelt, SCE normally releases a fairly constant flow from the upper basin. Observed streamflows as regulated by SCE are used as the undiverted streamflows for determining the effects of alternative LADWP water rights on Lee Vining Creek.

Channel Losses. Infiltration, evapotranspiration, and unknown diversion losses along Lee Vining Creek can be estimated from the 1941-1969 period of record when a streamflow gauge was located near Mono Lake. The apparent losses were about 1-2 TAF per month (17-33 cfs), regardless of the flow rate or month of the year. Recent synoptic streamflow measurements on this portion of Lee Vining Creek have indicated that the actual loss is much less, however, being about 3-8 cfs (Trihey & Associates 1992).

Walker Creek Watershed

Walker Creek is south of Lee Vining Creek and has a watershed of 7.8 square miles (Table 3A-1).

Watershed Character. The watershed extends to the Sierra Nevada crest, with a maximum elevation of 12,800 feet (Mount Gibbs). Walker Creek above Walker Lake (elevation 7,935 feet) drains steep, mountainous terrain mostly above treeline where a soil profile is not well developed. Walker Lake is an alpine lake that was enlarged for irrigation storage and recreation use, with a surface area of about 85 acres and a usable storage of 550 af (Vorster 1985). Below Walker Lake, the creek flows through a narrow moraine-bound canyon and crosses the Lee Vining conduit where it may now be diverted at an elevation of 7,150 feet. Downstream of the conduit, the stream meanders through the Cain Ranch irrigated pasturelands on the alluvial piedmont east of the mountains and then descends in a canyon eroded into former lakebeds to join Rush Creek at an elevation of 6,610 feet. (EBASCO Environmental and Water Engineering and Technology 1991c.)

Streamflow. Streamflow has been measured by LADWP on Walker Creek above the Lee Vining conduit since 1942. The annual average runoff from Walker Creek has been estimated at 5.4 TAF/yr. The annual variations of Walker Creek have generally followed the pattern of other diverted streams in the area (Figure 3A-1). The seasonal distribution of flow in Walker Creek is modified only slightly by storage in Walker Lake. In particular, the flashboards on the dam have normally been removed in November, allowing a pulse of flow that raises the average November streamflows compared to those for October and December. Otherwise, the monthly cumulative distribution of runoff for Walker Creek is very close to runoff patterns typical of eastern Sierra streams (Figure 3A-3, Table 3A-3).

Diversions. Before LADWP diversions began, an unknown fraction of Walker Creek runoff was diverted to irrigate Cain Ranch lands downstream of the Lee Vining conduit. The total irrigated acreage at Cain Ranch is approximately 2,000 acres. LADWP has estimated the average irrigation diversion from Walker Creek during the diversion period to be approximately 2.4 TAF/yr, occurring from April to September, based on Walker Creek flow crossing the conduit and Sand Trap 3, which releases water from the conduit into Walker Creek. (The variability of these monthly releases from year to year suggests that some of the higher flows were spills from the conduit to Walker Creek rather than irrigation diversions.) A streamflow gauge was never established at the mouth of Walker Creek, so an accurate estimate of the irrigation uses along the Walker Creek corridor is not possible.

Parker Creek Watershed

Parker Creek is south of Walker Creek and has a watershed of approximately 12.2 square miles (Table 3A-1).

Watershed Character. The watershed extends to the Sierra Nevada crest, with a maximum elevation of 13,000 feet (Kuna Peak). Parker Creek above Parker Lake (elevation 8,300 feet) is formed by several branches that drain steep, mountainous terrain with permanent snowfields on the north sides of the peaks. Parker Lake is a natural alpine lake. Downstream, the creek flows through a narrow, moraine-bound canyon that broadens in the alluvial deposits just upstream of the conduit at an elevation of about 7,600 feet. Parker Creek crosses the conduit at elevation 7,150 feet, crosses the piedmont pasturelands, and descends in a canyon to Rush Creek at elevation 6,670 feet, just upstream of Walker Creek. (EBASCO Environmental and Water Engineering and Technology 1991b).

Runoff. Streamflow has been measured by LADWP on Parker Creek above the conduit since 1963 and upstream of irrigation diversions above the conduit from 1938 to 1978. The annual average runoff from Parker Creek has been estimated at 9.1 TAF/yr. The annual flow variations of Parker Creek have generally followed the pattern of other diverted streams in the area (Figure 3A-1). The monthly cumulative distribution of runoff for Parker Creek is typical of natural runoff for eastern Sierra streams (Figure 3A-4, Table 3A-3).

Diversions. Before LADWP diversions began, an unknown portion of the Parker Creek runoff was diverted to irrigate Cain Ranch lands both upstream and downstream of the Lee Vining conduit. The total irrigated acreage at Cain Ranch is approximately 2,000 acres. The upstream irrigation diversions have been estimated from the difference between the two streamflow gauges until 1978, and the three separate upstream diversions have been measured by LADWP since 1979. LADWP has estimated its average irrigation diversion from Parker Creek above the conduit to be approximately 1.5 TAF/yr during April-September.

LADWP's total releases downstream of the conduit have been estimated at 2.5 TAF/yr, based on Parker Creek flow crossing the conduit and Sand Trap 4, which releases water from the conduit into Parker Creek. (The variability of these monthly releases from year to year suggests that some of the higher flows were conduit spills to Parker Creek rather than irrigation diversions.) Between 1948 and 1962, many years of no flow were recorded at a streamflow gauge near the Cain Ranch buildings, showing that most of the flow released downstream of the conduit was in fact diverted for irrigation. Measurements of flow crossing the conduit or Sand Trap 4 releases were not made during this period, however. An accurate estimate of the irrigation uses along the Parker Creek corridor is therefore not possible.

Channel Losses. Average channel loss of water during fall and winter was determined by synoptic flow measurements in 1990 and by flow differences between two streamflow gauges at the conduit crossing and near Cain Ranch buildings. A loss of less than 1 cfs was generally measured for this 3.5-mile reach at a flow of approximately 5 cfs.

South and East Parker Creek Watershed

South Parker Creek drains a watershed of approximately 3.8 square miles just south of Parker Creek (Table 3A-1). The larger southern branch extends to near the Sierra Nevada crest at the 12,600-foot elevation (Mount Wood); the smaller branch extends to an elevation of 9,400 feet. The two branches join upstream of the conduit at an elevation of approximately 7,320 feet. The creek descends on the alluvial fan complex, crosses the present conduit location at an elevation of 7,135 feet, and enters Rush Creek at elevation 6,850 feet, just upstream of the U.S. 395 bridge (EBASCO Environmental and Water Engineering and Technology 1991a).

Streamflow has been measured by LADWP for the two branches above the irrigation diversions since 1935, and the combined flow at the conduit has been measured since 1964. LADWP has estimated runoff for South and East Parker Creeks at approximately 1.2 TAF/yr.

Upstream of the conduit, streamflow records indicate that approximately 0.5 TAF/yr of the South and East Parker Creek flow has been diverted for irrigation purposes or infiltrated above the conduit during April-September. LADWP does not have appropriative water rights to divert South and East Parker Creeks for export, although a diversion into the conduit was operated until recently.

Rush Creek Watershed

Rush Creek has a total watershed area of approximately 141 square miles (Table 3A-1).

Watershed Character. Rush Creek flows into Mono Lake from the south and drains a rugged watershed in the eastern Sierra Nevada, with several peaks above 12,000 feet, and the June Lake Loop at the foot of the mountains (Figure 1-1). Grant Lake reservoir is an enlarged natural lake used by LADWP to store water for export through the Mono Craters Tunnel. Before exports began in 1941, a smaller Grant Lake reservoir was used to store water for irrigating approximately 1,000 acres in the Pumice Valley along lower Rush Creek (Vorster 1985). Grant Lake reservoir now has a maximum storage capacity of approximately 47,500 af. Average monthly evaporation from the reservoir is shown in Table 3A-4.

Rush Creek above Grant Lake reservoir has a watershed area of approximately 62 square miles, with 52 square miles upstream of the streamflow gauge. A major portion of the watershed (23.2 square miles) is located upstream of Lake Agnew (elevation 8,508 feet) in the Ansel Adams Wilderness area. The other main branch of the Rush Creek watershed includes Gull Lake (elevation 7,602 feet) and June Lake (elevation 7,620 feet) and is drained by Reversed Creek, which joins Rush Creek just downstream of the Rush Creek Power Plant. This portion of the watershed has a maximum elevation of about 9,000 feet.

SCE Hydropower Operations. The upper portion of the watershed includes several alpine lakes, three of which were enlarged during 1916-1925 for hydropower storage. Agnew, Gem (elevation 9,058 feet), and Waugh (elevation 9,442 feet) Lakes provide usable storage of approximately 23,000 af. Waugh Lake is filled (5,000 af) in May and June and remains full until Labor Day. The water is then transferred to Gem Lake in September and October, and Waugh Lake remains nearly empty during the winter (Federal Energy Regulatory Commission 1992). Gem Lake provides the major storage (17,000 af) and is filled with snowmelt runoff between April and July. Agnew Lake provides less than 1,000 af storage.

The Rush Creek Power Plant (operated by SCE) is located just upstream from the mouth of Reversed Creek at an elevation of about 7,300 feet; the plant has penstocks with intakes in Agnew and Gem Lakes. Frequent releases are made from Gem Lake, and the Agnew Lake intake is used only in October. The Rush Creek Power Plant is operated at full capacity during periods of high runoff, and flows are regulated to provide a constant power output for the rest of the year, consistent with available runoff and storage. Releases from Rush Creek Power Plant and streamflow in Rush and Reversed Creeks flow into Silver Lake. Alger Creek flows into Silver Lake from the west. Releases from Silver Lake flow approximately 3 miles to Grant Lake reservoir.

Runoff. Three snow courses are maintained in and adjacent to the Rush Creek watershed by DWR and SCE at elevations of 9,150-10,400 feet (Table 3A-2). The average April 1 water depth is 31 inches. Average precipitation is only 21.8 inches at Gem Lake at

8,790 feet, however (although water depth at a snow course at 7,300 feet averages more than 25.3 inches). At Cain Ranch (6,850 feet), precipitation is only 11.5 inches. Rain shadow effects are again evident.

Streamflow has been measured at the inflow to Grant Lake reservoir since 1934. The annual average runoff from Rush Creek is estimated from the available LADWP records to be 59 TAF/yr. The annual flow variations of Rush Creek have generally followed the pattern of other diverted streams in the area (Figure 3A-1). The seasonal distribution of flow in Rush Creek is strongly affected by the upstream SCE storage and hydropower operations, and resulting streamflows are used as the undiverted streamflows for determining the effects of the alternative LADWP diversions (Figure 3A-5, Table 3A-3).

Diversions. Historically, diversions were made from Rush Creek to irrigate the Pumice Valley area. Diversions were recorded at A-Ditch for 1919-1973 and at B-Ditch for 1919-1968. Because these ditches were also used to spread excess water during high runoff years, irrigation use cannot be estimated accurately. A streamflow gauge was maintained near the mouth of Rush Creek from 1935 to 1939 and from 1952 to 1967. Accurate irrigation losses cannot be determined from these records, however. Springflow in the Rush Creek bottomlands was enhanced by the A-Ditch and B-Ditch irrigation during the prediversion period.

Channel Losses. Infiltration losses from Rush Creek between Grant Lake reservoir and Mono Lake were measured in 1987 (EA Engineering Science and Technology Inc. 1989), with streamflows varying from 15 cfs to 100 cfs, to be approximately 5 cfs in winter and 10 cfs in summer. The 5-cfs difference was assumed to be evapotranspiration from the riparian vegetation.

Mill Creek Watershed and Relationships with Adjacent Watersheds

Mill Creek drains approximately 18 square miles of the eastern Sierra Nevada escarpment. The waters of Mill Creek were diverted before 1941 for hydropower and irrigation of the Conway and DeChambeau Ranches northwest of Mono Lake. The period of record for Mill Creek extends from runoff year 1895 to the present. The average runoff for the 1940-1989 period is about 21 TAF/yr (Table 3A-1).

In the upper watershed of Mill Creek is a series of connected alpine lakes. The lakes store snowmelt and dampen the peak runoff from the upstream portion of the watershed. Lundy Lake, at 7,808 feet in the mouth of Lundy Canyon, was enlarged with a dam constructed by Southern Sierra Power Company in 1911. It has a surface area of 130 acres and provides a seasonal storage volume of about 3,800 af (Vorster 1985).

SCE's Mill Creek Power Plant is located across a ridge north of Lundy Lake at the head of the Wilson Creek drainage. The hydropower diversions from Mill Creek at Lundy Lake are returned to Wilson Creek and then diverted into a series of irrigation ditches in the Conway and DeChambeau Ranch area. Wilson Creek does not have a large watershed area at high elevations and has much smaller natural runoff. Average annual precipitation is only 17-18 inches, as measured at a gauge at Conway Summit (8,150 feet elevation).

Virginia Creek, an adjacent stream north of Wilson Creek in the Walker River watershed, has been diverted to supply irrigation water for the Conway Ranch for many years. Because Conway Ranch also has rights to 13 TAF/yr of Mill Creek water, and less than half of the 6 cfs permitted at the Virginia Creek diversion between March and October has usually been observed, an average annual diversion of less than 1.5 TAF/yr seems likely (Vorster 1985). An unknown portion of this applied irrigation water infiltrates into groundwater and drains toward Mono Lake.

DeChambeau Creek, located just south of Mill Creek, drains a small (2.5-square-mile) but steep watershed. It was historically diverted for irrigation and a small hydropower plant. The average annual runoff is about 900 af/yr. The Mono Lake rainfall gauge (6,450-feet elevation) located in the DeChambeau Creek watershed shows average annual precipitation of 14.2 inches.

The consumptive use of water in the irrigated ranch areas supplied from Mill, Wilson, Virginia, and DeChambeau Creeks can only be estimated from the irrigated acreage on these ranch lands. Although much more water may be diverted from the streams into the irrigation ditches, all but the evapotranspired water will eventually flow to Mono Lake. Vorster (1985) estimated this use of water to be about 2 TAF/yr for the approximately 1,000 acres of irrigated pasture on the Conway and DeChambeau Ranch lands. Net runoff of approximately 21.5 TAF/yr from these northern creeks flows into Mono Lake. The hydropower diversions and irrigation uses have been relatively similar in the prediversion and point-of-reference conditions and would not be changed by amendment of the city's water rights.

Other Mono Basin Streams and Springs

Runoff from about 125 square miles of the Sierra Nevada portion of the Mono Lake watershed is gauged. The 60-square-mile ungauged portion is located below streamflow gauges or is drained by small creeks that are not gauged. Another 440 square miles of the more arid valley floor and hills of Mono Basin are ungauged. Bridgeport and Cottonwood Creeks, draining the Bodie Hills to the north, have been gauged intermittently (Vorster 1985), but Dry Creek and other intermittent creeks to the south and east have not been gauged.

Most of the rainfall on this portion of the watershed is stored in the soils and lost to evapotranspiration. An unknown fraction infiltrates and recharges Mono Lake as groundwater. Vorster (1985) estimated the average net inflow from these ungauged areas at about 35 TAF/yr. A Mono Lake water budget can be used to estimate these unmeasured inflow terms more accurately because a large portion of the inflow infiltrates along the stream corridors and cannot be measured at streamflow gauges.

Mono Lake Hydrology

The hydrology of Mono Lake is described and analyzed by constructing a general water budget that includes inflow, storage, and outflow (Appendix A). Inflows are streamflows and direct rainfall onto the lake surface. Storage is simply the volume of the lake at a particular surface elevation and is determined by Mono Lake bathymetry data. Outflow is the unmeasured evaporation from the lake surface, which is estimated from assumed monthly evaporation rates and monthly lake surface area.

Historical Lake Levels. The hydrology of Mono Lake can be characterized by the historical pattern of lake-level fluctuation, as shown in Figure 1-7 for the period 1912-1991. Fluctuations in Mono Lake surface elevation were caused by the variability in annual snowpack and runoff that occurs in the eastern Sierra Nevada. Since LADWP diversions and exports began in 1941, the downward trend is explained by the reduced inflows to Mono Lake. High runoff years resulted in periods of rising lake level because LADWP did not divert Mono Basin runoff when Owens Valley runoff was sufficient to meet water demands or fill the aqueduct.

The surface area of Mono Lake has fluctuated between about 57,000 acres in 1919 and 37,000 acres in 1981 (Figure 3A-6). The lake volume has fluctuated between about 4.9 million acre-feet (MAF) in 1919 and about 2.1 MAF in 1981 (Figure 3A-7).

Simulated Lake Levels without LADWP Diversions. The natural behavior of Mono Lake in the 1940-1989 period without any LADWP diversions for irrigation or exports has been simulated with the water balance model (Appendix A) to help characterize prediversion Mono Lake hydrology (Figure 3A-8). Beginning at about 6,418 feet, the lake elevation would have remained relatively constant between 6,419 and 6,425 feet until the high runoff period of 1983-1986, when the simulated natural lake level would have risen to 6,433 feet. The subsequent drought period of 1987-1989 would have lowered the lake elevation to about 6,428 feet. The annual and average terms of the simulated natural water budget are given in Table 3A-5.

Owens River Basin Hydrology

The Owens River basin drains the eastern Sierra Nevada from just north of Mammoth Mountain and the Minarets to south of Mount Whitney. Before diversions for irrigation and export to Los Angeles began, all the runoff from the Owens River basin flowed into Owens Lake. The first barrel of the LA Aqueduct was completed in 1913, and the Owens River intake and other LA Aqueduct facilities were constructed and operated until 1941, when Mono Basin exports began. Long Valley Dam, forming Lake Crowley reservoir, was not constructed until the Mono Craters Tunnel was added to the LA Aqueduct system to allow exports from Mono Basin in 1941. The Owens Gorge hydropower plant were added in the early 1950s, and Pleasant Valley reservoir was constructed to re-regulate the peaking hydropower flows from the gorge (Figure 1-5).

Long Valley Dam separates the Upper Owens River from the Owens River gorge, which has cut through the volcanic tuff tablelands that mark the boundary of the Long Valley caldera. Tinemaha Dam is located on a bedrock outcropping that constricts the Owens Valley groundwater basin just south of Big Pine. The intake to the LA Aqueduct is located downstream of Tinemaha Dam. The lower portion of the Owens River basin contains several creeks that originally flowed directly into Owens Lake but were diverted into the LA Aqueduct between Tinemaha and Haiwee reservoirs.

Estimated runoff for the Owens River basin is shown in Figure 3A-9. (Runoff for Round Valley, located between Long Valley and Bishop, is included with Long Valley runoff.) The average Mono Basin runoff (from the four diverted creeks) is 124 TAF/yr; the average Long Valley and Round Valley runoff is 177 TAF/yr; and the remainder of the Owens River basin runoff is 239 TAF/yr. The total average Mono-Owens runoff is about 540 TAF/yr.

Upper Owens River

The Owens River originates at Big Springs, located downstream of the confluence of Glass and Deadman Creeks and upstream of the East Portal of Mono Craters Tunnel. Below East Portal, the river meanders for several miles across valley-bottom alluvial pasturelands and enters Lake Crowley reservoir. Prediversion streamflows are addressed in detail in Chapter 3C, "Vegetation".

Because of significant geothermal activity, several large hot springs are located in the basin. The largest is Hot Springs, located along Hot Creek. The average annual discharge from Hot Springs (and the cool springs at Hot Creek Hatchery located upstream) of about 30 TAF/yr (41.5 cfs) flows directly into the Owens River just above Lake Crowley reservoir.

Significant diversions are made from the Owens River and Hot Creek for irrigation of LADWP and private grazing pasturelands. LADWP records indicate that an average of 20 TAF/yr are diverted for irrigation of its lands. This represents significantly more than the actual evapotranspiration losses, however. Excess diverted water returns to the Owens River or recharges the groundwater flowing to Lake Crowley reservoir. In the prediversion period, these irrigation withdrawals probably caused virtual dewatering of some reaches of the Upper Owens River during the driest years unless irrigated acreages were reduced, based on an assessment of current irrigation demands. (See "Summary Comparison of Hydrologic Effects of the Alternatives".)

Watersheds Downstream of the Upper Owens River

From Lake Crowley reservoir to the aqueduct intake at Haiwee Reservoir, many watersheds and groundwater withdrawals contribute water to the Owens River and the water export system. Runoff from these watersheds, sustainable groundwater withdrawals in the Bishop area, and basin uses are described in Appendix T.

ENVIRONMENTAL SETTING

The status of the hydrology during the historical Mono Lake tributary diversion period (1941-1989), up to the point of reference for this EIR, is described in the following sections. The additional LA Aqueduct facilities that became operational in both Mono Basin and the Owens River basin during this period are described.

Mono Basin Diversions and Uses during the Diversion Period

Although the Mono Basin runoff hydrology for both the prediversion and point-of-reference conditions are considered to be characterized by the historical 1940-1989 streamflow records, the prediversion and the point-of-reference conditions differ in the amount of diversions for irrigation and export, and the corresponding releases of undiverted water to Mono Lake. The Mono Lake surface elevation also differed because of the effects of the historical diversions between 1941 and 1989 (Figure 1-6). Mono Lake surface elevation was approximately 6,417 feet in 1941, before Mono Basin exports began, and had declined to approximately 6,376 feet by August 1989 (Figure 1-7).

For the 50-year historical period from April 1940 to March 1989, a cumulative total of 3.3 MAF (annual average of 65.4 TAF) of water was exported from Mono Basin, according to LADWP records. This represents an average of 53% of the runoff from the four diverted tributaries. These changes were the direct result of LADWP diversion operations in Mono Basin to supplement Owens River diversions and Owens River groundwater pumping to supply water for the city.

LA Aqueduct Diversion and Storage Facilities in Mono Basin

Mono Craters Tunnel

The Mono Craters Tunnel was constructed near the end of the prediversion period to allow water from Mono Lake tributaries to be exported to the Owens River (Figures 1-1, 1-3, 1-4, and 1-5). The Mono Basin end of the tunnel is called the West Portal, and the Owens River end is called the East Portal. The tunnel has a capacity of approximately 300 cfs, but the amount of water exported is about 285 cfs because of the groundwater inflow along the tunnel (called "tunnel make") that provides a constant flow of about 15 cfs at East Portal. When the East Portal was opened, just before LADWP diversions of the tributary streams began, nearly 11 TAF/yr of groundwater began draining through the tunnel from volcanic uplands making up the divide between Mono Basin and the Owens River basin.

Grant Lake Reservoir and Outlet Facilities

Grant Lake reservoir had been enlarged to provide maximum storage of about 48 TAF as part of the LA Aqueduct extension to Mono Basin. The outlet from the Grant Lake reservoir is a conduit with a capacity of approximately 395 cfs. This outlet supplies the West Portal of the Mono Craters Tunnel and is used to release water through Mono Gate #1 to Rush Creek below Grant Lake reservoir. A canal conveys water from Mono Gate #1 to the original Rush Creek channel. The A-Ditch and B-Ditch irrigation and spreading diversion points are located on the canal just upstream from Rush Creek.

During high runoff periods, excess runoff has been released over the Grant Lake reservoir spillway directly into Rush Creek. A spill ditch near the West Portal has also been used occasionally to release excess water into Pumice Valley. During high runoff periods (e.g., 1967), diversions from Lee Vining Creek to Grant Lake reservoir sometimes continued, causing large spills over the Grant Lake reservoir spillway.

Lee Vining Conduit

The Lee Vining conduit connects the Lee Vining Creek diversion dam to the Grant Lake reservoir. The conduit crosses Walker and Parker Creeks, with diversion structures located on these creeks. Walker and Parker Creek flows are diverted into the conduit, released for irrigation diversions downstream of the conduit, or spilled down their channels during heavy runoff periods.

A small diversion structure was operated at south Parker Creek for many years during the diversion period but was closed recently because LADWP does not have appropriative water rights for this creek. The Lee Vining conduit has a capacity of approximately 300 cfs at Lee Vining Creek, with slightly higher capacity below Walker Creek (325 cfs) and Parker Creek (350 cfs). The Lee Vining conduit ends in Grant Lake reservoir, across from the outlet facility near the dam.

Owens Valley Diversions and Uses during the Diversion Period

Although the Owens River basin runoff hydrology for both the prediversion and point-of-reference conditions are considered to be characterized by the historical 1940-1989 streamflow records, the two reference conditions differ in the amount of diversions for local uses and export to Los Angeles, and in the amount of groundwater pumping. These historical use and export patterns were caused by variable hydrologic conditions and the increasing demands for water supply to the city, as well as modifications to the LA Aqueduct facilities during the period, including the extension of the aqueduct to Mono Basin.

For the 50-year historical period from April 1940 to March 1989, a cumulative total of 18.2 MAF (annual average of 364 TAF) of water was exported from the Owens River basin to Los Angeles, according to LADWP records (Table 3A-6). Pumping was greatly increased following the completion of the second LA Aqueduct barrel from Haiwee to Los Angeles in 1971.

These changes were the direct result of several changes to LA Aqueduct facilities and operations to meet an increasing demand for water in Los Angeles. Determining the portion of these hydrologic changes attributable to the effects of the Mono Basin extension and tributary diversions is difficult.

Modification of LA Aqueduct Facilities in Owens River Basin during the Diversion Period

Lake Crowley Reservoir

Long Valley Dam had been constructed to form Lake Crowley reservoir as part of the LA Aqueduct extension to Mono Basin in 1940. Lake Crowley reservoir has a maximum storage capacity of approximately 183.5 TAF, and the minimum storage for power production is about 40 TAF. Once the Mono Basin diversions began, Lake Crowley reservoir provided storage of Long Valley runoff and Mono Basin exports for later release down the Owens River to Tinemaha Reservoir and the LA Aqueduct intake near Aberdeen. Lake Crowley reservoir is a major LA Aqueduct storage facility that allows upstream runoff to be stored for several months while runoff from Bishop to Haiwee Reservoir is exported to Los Angeles.

Owens River Gorge Hydropower Plants

The Owens River gorge hydropower plants were constructed during the diversion period in 1952-1954. The penstock intake is located just upstream of Long Valley Dam. The power plants are located in the gorge along the Owens River. The penstocks connecting the three hydropower plants have a capacity of approximately 690 cfs. The hydropower plants are usually operated for peaking power generation several hours each day. The downstream plant is located just above the confluence of the Owens River and Rock Creek, at the upstream end of Pleasant Valley Reservoir.

Pleasant Valley Reservoir was constructed when the hydropower plants were built. It serves as a re-regulation reservoir to provide a relatively constant outflow to the Middle Owens River. Releases from Lake Crowley reservoir via the hydropower plants and natural flow from the Owens River gorge, Rock Creek, and Birchim Canyon springs flow into Pleasant Valley Reservoir. A small hydropower plant is located at Pleasant Valley Reservoir Dam.

Rock Creek Diversion Structure

LADWP constructed a diversion from Rock Creek at Toms Place to Crooked Creek and Lake Crowley reservoir in 1964. This allows some of the Rock Creek runoff to be stored in Lake Crowley reservoir and allows hydropower to be generated from the diverted portion of Rock Creek.

Monthly minimum release flow requirements were established below the diversion by California Department of Fish and Game. The average runoff of Rock Creek at the diversion is about 21 TAF. The average annual diversion from Rock Creek into Lake Crowley reservoir has been 7 TAF/yr, with annual values ranging from almost nothing in dry years to almost 25 TAF in 1983.

Second LA Aqueduct Barrel

A major change in LA Aqueduct facilities occurred in 1970, when the second barrel of the LA Aqueduct between Haiwee Reservoir and Los Angeles began operating. The first barrel of the LA Aqueduct had a capacity of 500 cfs, with an annual export capacity of about 360 TAF. The second barrel had a capacity of 300 cfs, increasing the annual export capacity to about 585 TAF (LADWP 1990). This expansion of the LA Aqueduct was planned by LADWP to be supplied with water from three sources: increased surface water diversions from Mono Basin and the Owens River basin, reduced irrigation uses on LADWP-leased lands, and increased groundwater pumping.

As Table 3A-6 indicates, exports to Los Angeles increased after 1970, with corresponding increases in Mono Basin exports and groundwater pumping. The reduction in irrigation use cannot be documented easily.

The increased yield of water from groundwater pumping also is not identified easily, because pumping reduces natural spring flows and reduces the natural groundwater discharges to the Owens River. The effect of groundwater pumping on the Owens Valley is the subject of a separate document (LADWP 1990) and is not analyzed in this EIR. The full capacity of the two LA Aqueduct barrels, as well as a groundwater pumping pattern consistent with the LA-Inyo pumping agreement, is assumed in the analyses of this EIR.

IMPACT ASSESSMENT METHODOLOGY

The basic assessment methodology for hydrologic effects was the LAAMP model of monthly LA Aqueduct system operations, using the 50-year sequence of historical 1940-1989 runoff hydrologic data, and various assumptions and constraints for each alternative. Most of these have already been described in Chapter 2. The details of the model development and testing for application to the EIR alternatives assessment is described in Auxiliary

Report 5, "LAAMP Model Documentation" (Luhdorff and Scalmanini 1992). Some additional modeling assumptions are presented here.

Runoff Year-Types

To allow the development of diversion and lake level rules that may vary with runoff, as described in Chapter 2, annual runoff was classified into "wet", "normal", and "dry" categories. Wet and dry year categories were defined as 20% of the runoff years with the lowest and highest runoff, respectively (Table 2-2).

For the diverted Mono Lake tributary creeks, the dry year category represents years with less than 69% of "normal" (average) runoff, and the wet year category represents years with more than 132% of the normal runoff level of about 123,500 af. The dry and wet runoff year categories for the combined Mono Basin and Owens Valley scenario represent years with less than 65% and greater than 125% of the normal runoff of 595,000 af, respectively. Average runoff excluding Mono Basin is approximately 470,000 af.

Use of Measured Runoff as Forecasts from Snowpack Measurements

The LAAMP model assumes that April 1 forecasts of annual runoff are accurate, so that necessary lake level releases, LA Aqueduct export targets, and other aqueduct operating criteria that depend on runoff year classification can be estimated. The LAAMP model uses the cumulative *measured* runoff for each runoff year, whereas future operations must rely on the snowpack accumulation *forecasts* of runoff.

LADWP has developed procedures for forecasting runoff, that are similar to those used by DWR for other river-basin runoff forecasts. These forecasts correlate measured runoff with measured snowpack, base flow, and precipitation. The primary measurements used by LADWP to forecast runoff are snowpack water depth, antecedent (previous) runoff, and precipitation at selected stations.

LADWP forecasts of expected runoff are used to plan aqueduct operations, negotiate allowable groundwater pumping, and estimate supplemental water purchases from the Metropolitan Water District (MWD) that will be necessary. The forecasting generally begins in December and is updated monthly during spring.

Regression equations relating snowpack and precipitation to runoff have been estimated with historical data from 1950 to 1990. All the snow courses have been surveyed consistently since 1971, but data from the early part of that period have additional measurement errors. Estimated runoff values can be compared to the historical runoff measurements to evaluate the accuracy of these runoff forecast equations. This comparison for the combined Mono Basin and Owens River basin indicates that the annual forecasts average within 7% of the actual values (Hasencamp pers. comm.).

This comparison indicates that the April 1 runoff forecasts are sufficiently accurate to allow the historical runoff measurements to be used as though they were forecasts in the LAAMP model. Even with a 7% error in the forecasted runoff volume, the runoff year classification based on the forecasted runoff will almost always be correct.

Use of the Historical Hydrologic Sequence

The use of the historical sequence of hydrologic data for the LAAMP simulation of the alternatives provides a reasonable characterization of the range of aqueduct conditions that are likely to occur under each amended water rights alternative. Although other possible sequences might be generated by rearranging the historical sequence, the historical sequence represents hydrologic conditions adequately. Thus, it is used in the LAAMP aqueduct operations model to simulate lake level fluctuations; diverted creek streamflows; and streamflow, reservoir storage, water supply, and power generation conditions along the aqueduct to Los Angeles.

SUMMARY COMPARISON OF HYDROLOGIC EFFECTS OF THE ALTERNATIVES

Complete results of the LAAMP modeling for each alternative are contained in Auxiliary Report 18, "Summary of Hydrologic Simulation of Mono Basin EIR Alternatives with the LAAMP Aqueduct Operating Model".

Hydrologic effects of the alternatives include direct effects on Mono Lake tributary streamflows, Mono Lake water balance, and exports from Mono Basin and indirect effects on the East Portal flows and delivery to the LA Aqueduct.

Table 3A-7 provides a summary comparison of the LAAMP model simulations of the alternatives. Annual average values are given for most variables. The actual sequence of simulated flows resulted from using the historical 1940-1989 hydrologic patterns in the LAAMP simulations. Future conditions will continue the natural variability of the historical record, but of course will not repeat the historical hydrologic sequence. The normal range of conditions will be similar to that shown in the simulations, but the exact sequence of lake fluctuations, streamflows, or exports will undoubtedly not occur. Effects of extreme drought on Mono Lake level has been characterized separately, as described in Chapter 2 and Appendix H.

Table 3A-8 provides a summary comparison of monthly median flows in the Owens River and indicates the indirect effects of the alternative water rights amendments for the Mono Lake tributaries.

Table 3A-9 provides a summary comparison of simulated monthly flows, estimated irrigation diversions, and the resulting instream flows in the Upper Owens River during normal minimum runoff years. This table indicates that during the lowest runoff years, current irrigation diversions must be limited to provide minimum flow in the Upper Owens River under all alternatives except the No-Restriction Alternative.

HYDROLOGIC EFFECTS OF THE POINT-OF-REFERENCE SCENARIO

As described in Chapter 2, a point-of-reference scenario has been developed for impact assessments that requires minimum streamflows for Rush and Lee Vining Creeks, as imposed by court order by the August 1989 point-of-reference date. For this scenario, minimum flows of 19 cfs for Rush Creek and 5 cfs for Lee Vining Creek are the only requirements placed on Mono Basin export operations. The initial lake elevation for this and all alternative simulations is the August 1989 level of 6,376.3 feet. The simulation shows that the lake surface at that time could not be sustained by continuing those minimum flow requirements.

Effects on Diverted Tributary Streamflows

The simulated effects on the tributary streamflows are summarized as monthly cumulative flow occurrence, with 10% occurrence intervals, for each tributary (Table 3A-10). Because diversions from Walker and Parker Creeks are not restricted for the point-of-reference case, streamflows are reduced to zero all of the time and flows are always diverted to Grant Lake reservoir. Table 3A-10 indicates that flows in Lee Vining and Rush Creeks are usually held at the specified minimum flows of 5 cfs and 19 cfs, respectively, but that during periods of excess runoff when water is not required for LA Aqueduct operations or cannot be exported from Mono Basin because of physical capacity constraints, water is released down Lee Vining and Rush Creeks to Mono Lake.

Effects on Mono Basin Exports and Releases to Mono Lake

In the point-of-reference scenario, an average of 44.6 TAF/yr would be released to Mono Lake (Table 3A-7). The average export would be 72.7 TAF/yr. An additional

8.9 TAF/yr is assumed to be used for irrigation in Mono Basin under the point-of-reference scenario, reflecting historical practices at Cain Ranch.

Figure 3A-11 shows the expected variation in annual exports, arranged from driest to wettest years. The fraction of the total runoff that is exported is indicated by comparing export to runoff, which is also indicated for the full range of driest to wettest years. Variations from the general trend of the export curve result for carry-over of water in Grant Lake reservoir from one year to the next.

The minimum required streamflows under the point-of-reference scenario would provide a minimum lake release of about 17 TAF/yr. Exports would be less than under the No-Restriction Alternative by an average of only about 12.3 TAF/yr because the minimum flows are often satisfied by excess runoff that is not needed to meet LA Aqueduct export targets.

Effects on Mono Lake Surface Elevations

Under the point-of-reference scenario the lake surface, fluctuating in response to annual variations in runoff, would tend to fall until evaporation losses from the diminishing surface of the lake were balanced by inflows. The transition period would be more than 50 years. Thereafter, a dynamic equilibrium would prevail with a mean lake elevation of about 6,365 feet and normal fluctuations of about 16 feet. The frequency with which the lake surface would be above or below each elevation after the transition period is shown in Figure 3A-10.

Effects on Upper and Middle Owens River Flows

Mono Basin exports increase the Upper Owens River flows between East Portal and Lake Crowley reservoir and increase the releases from Lake Crowley reservoir into the Middle Owens River between Pleasant Valley Reservoir and Tinemaha Reservoir. These effects are summarized in Auxiliary Report 18 (Jones & Stokes Associates 1993).

Effects of the point-of-reference scenario on Owens River flows are given in Table 3A-8 by the median monthly flows (exceeded 50% of the time) at two locations. For dry years, when most Mono Basin runoff is exported under the No-Restriction Alternative, monthly flows are simply reduced by approximately 25 cfs because this is the minimum streamflow required for the Mono Lake tributaries. During years when excess water is already being released to Mono Lake, however, maintaining the minimum streamflows in Rush and Lee Vining Creeks would not require any reduction in Owens River flows.

Monthly flows below East Portal are influenced by the Upper Owens River runoff and Mono Basin exports, which are greatest in early spring and relatively constant the rest of the year. Monthly flows in the Middle Owens River are influenced by Lake Crowley reservoir operations, minimum and maximum flow constraints, canal diversions for irrigation and spreading, and groundwater pumping, in addition to the direct effects of tributary runoff and indirect effects of Mono Basin exports. Owens River flows are also influenced indirectly by the simulated Haiwee Reservoir export targets, which are set at LA Aqueduct capacity for the first 6 months and reduced in the October-to-March period, depending on runoff year category as described in Chapter 2.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the point-of-reference scenario, exports to Los Angeles would average 438 TAF/yr. This is 8 TAF/yr less than the average export under the No-Restriction Alternative. The Mono Basin export deficit of 12 TAF/yr from the No-Restriction Alternative of maximum export would be reduced by an average 4 TAF/yr decrease in Owens River basin irrigation uses.

HYDROLOGIC EFFECTS OF THE NO-RESTRICTION ALTERNATIVE

Effects on Diverted Tributary Streamflows

Because diversions are not restricted for this alternative, streamflows below the diversion locations are reduced to zero most of the time (Table 3A-11). Only during periods of excess runoff, when water is not required for LA Aqueduct operations or cannot be exported from Mono Basin because of physical capacity constraints, is water released down the tributary channels to Mono Lake. Flows in Walker and Parker Creeks are always diverted to Grant Lake reservoir in Lee Vining Conduit. Only during the highest runoff periods are flows released down Lee Vining Creek or spilled from Grant Lake reservoir to Rush Creek. On average, Rush Creek would experience a spilling flow above 350 cfs once per decade, and Lee Vining Creek would experience a spilling flow above 280 cfs once per decade.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-13 shows the expected variation in annual exports under this alternative, which results in an average of 32.2 TAF/yr released to Mono Lake. Releases are made only in wet years, when Mono Basin runoff is not needed to meet LA Aqueduct export targets at Haiwee Reservoir. An estimated 8.9 TAF/yr is used for irrigation in Mono Basin under this alternative, reflecting historical practices at Cain Ranch.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations is shown in Figure 3A-12.

Effects on Upper and Middle Owens River Flows

Effects of the No-Diversion Alternative on Owens River flows are summarized in Table 3A-8.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the No-Restriction Alternative, exports to Los Angeles would average 446 TAF/yr. This is less than the specified average export target of 475 TAF/yr. The physical aqueduct capacity is approximately 585 TAF/yr, but it is difficult to completely fill the aqueduct throughout the entire year. The No-Restriction Alternative, however, provides the largest export from Mono Basin and the largest export to Los Angeles. The Owens Valley groundwater pumping simulated for the No-Restriction Alternative was used for all other Mono EIR simulations, as described in Chapter 2 and Auxiliary Report 18.

HYDROLOGIC EFFECTS OF THE 6,372-FT ALTERNATIVE

Effects on Diverted Tributary Streamflows

Table 3A-12 indicates that flows in Lee Vining and Rush Creeks would be above the minimum specified values only during the peak runoff months of wet years. On the average, both streams would experience a spilling flow above 120 cfs once per decade. Flows in Walker and Parker Creeks would always be at or above the minimum specified values. During only a few years would the lake level be low enough that additional releases would be required above those resulting from the minimum specified streamflows.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-15 shows the frequency pattern of runoff and corresponding exports under this alternative, which results in an average of 61.2 TAF/yr released to Mono Lake. Only a small non-LADWP diversion (O-Ditch) of less than 1 TAF/yr from Lee Vining Creek was assumed for the 6,372-Ft Alternative; all Cain Ranch irrigation by LADWP was assumed to be stopped.

The specified minimum monthly streamflows provide a minimum lake release of about 58 TAF/yr, but the average lake release would be 61.2 TAF/yr. The lake release for this alternative is 16.6 TAF/yr more than for the point-of-reference scenario, yet the average export is only 8.4 TAF/yr less than for the point-of-reference scenario because of the gain of 8.2 TAF/yr from reduced use for Cain Ranch irrigation.

Effects on Mono Lake Surface Elevations

The lake level under this alternative would fluctuate much less than under the point-of-reference scenario. The flow target of 300 cfs for the Upper Owens River below East Portal reduces lake level fluctuations during wet years by forcing the export of available Mono Basin runoff in excess of specified streamflows or lake releases. The frequency with which the lake surface would be above or below certain elevations is shown in Figure 3A-14.

Effects on Upper and Middle Owens River Flows

The effects of the 6,372-Ft Alternative on Owens River flows are given in Table 3A-8. During wet years, the minimum specified flow of 300 cfs for the Upper Owens River below East Portal would increase the monthly exports slightly over those under the point-of-reference scenario, shifting the period of greatest median flow from April-June to June-July.

This seasonal effect would be much less apparent in the Middle Owens River at Pleasant Valley because of the regulating operation of Lake Crowley reservoir. Most months would have reduced median flows compared with the point-of-reference scenario.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the 6,372-Ft Alternative, exports to Los Angeles would average 421 TAF/yr. This is 17 TAF/yr less than the average export under the point-of-reference scenario. The Mono Basin export deficit of 8.4 TAF/yr from the point-of-reference scenario would be increased by 8.2 TAF/yr because of increased spreading and spilling in the Owens Valley. The target Upper Owens River flow of 300 cfs would force almost all available water to be exported from Mono Basin, but this water could not always be captured and exported to Los Angeles by the aqueduct system.

HYDROLOGIC EFFECTS OF THE 6,377-FT ALTERNATIVE

Effects on Diverted Tributary Streamflows

Specified minimum streamflows would almost always be available except in June. Because the specified minimum June values are median flows, they would be available only 50% of the time. Table 3A-13 indicates that flows in Lee Vining and Rush Creeks would be above the minimum specified values only during the peak runoff months of wet years. Flows in Walker and Parker Creeks would remain at the minimum specified values except during June. Additional lake releases would be required for only a few years.

Under this alternative, Rush and Lee Vining Creeks would experience spilling flows above 230 cfs once per decade on the average.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-17 shows the expected variation in annual exports under this alternative, which results in an average of 73.8 TAF/yr released to Mono Lake. The simulated average export for the 6,377-Ft Alternative was 51.8 TAF/yr. During many years, the specified minimum flows for June would not be available, so required lake releases would be less than the 70 TAF/yr of specified monthly releases. Only if the operation rules to maintain lake levels required more lake releases would deficits in monthly specified streamflows be released in later months.

The specified minimum monthly streamflows provide a minimum lake release of about 70 TAF/yr, and the average lake release would be slightly higher at 73.8 TAF/yr. The average lake release for this alternative would be 29.2 TAF/yr more than for the point-of-reference scenario, and the average export would be 20.9 TAF/yr less than for the point-of-reference case because of the gain of 8.3 TAF/yr from reduced use of irrigation for Cain Ranch.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations is shown in Figure 3A-16.

Effects on Upper and Middle Owens River Flows

The effects of the 6,377-Ft Alternative on Owens River flows are given in Table 3A-8. The median monthly flows of the Upper Owens River below East Portal would generally be less than those under the point-of-reference scenario, although the July flow would be greater.

Seasonal effects are much less apparent in the Middle Owens River at Pleasant Valley because of the regulating operation of Lake Crowley reservoir. All months would have reduced median flows compared with the point-of-reference scenario.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the 6,377-Ft Alternative, exports to Los Angeles would average 412 TAF/yr. This is 26 TAF/yr less than the simulated average export under the point-of-reference scenario. The Mono Basin export deficit of 21 TAF/yr from the point-of-reference scenario would be increased by about 5 TAF/yr because of increased spreading and spilling in the Owens Valley.

HYDROLOGIC EFFECTS OF THE 6,383.5-FT ALTERNATIVE

Effects on Diverted Tributary Streamflows

Table 3A-14 indicates that flows in Lee Vining and Rush Creeks would be above the minimum specified values during the peak runoff months of many years because of the increased lake releases required to achieve and maintain the 6,383.5-foot target minimum lake level. Flows in Walker and Parker Creeks would always remain at or above the minimum specified values except during June, when the median flow would be available only 50% of the time.

Under this alternative, Rush Creek would experience a spilling flow above 290 cfs, and Lee Vining Creek would experience a spilling flow above 260 cfs once per decade, on average.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-19 shows the expected variation in annual exports under this alternative, which results in an average of 88 TAF/yr released to Mono Lake during the first 50 years of implementation. Once the lake level reached the target minimum level of 6,383.5 feet, less water would be required to maintain that level, and 82.2 TAF/yr would be released during the next 50 years. The average export for the first 50 years would be 37.7 TAF/yr and for the second 50 years would be 43.5 TAF/yr.

Greater releases would be required during the first 20 years to raise the lake elevation to the target level. The average for the first 50 years reflect this increased initial water requirement. The average for the second 50-year period is more indicative of the long-term split of available water between lake releases and exports.

The average lake release for the first 50 years of the 6,383.5-Ft Alternative would be 43.3 TAF/yr more than for the point-of-reference scenario; for the second 50 years, releases would be 37.6 TAF/yr more. The average export during the first 50 years would be 35.0 TAF/yr less than for the point-of-reference case; for the second 50 years, export would be 29.2 TAF/yr less.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations after dynamic equilibrium was reached is shown in Figure 3A-18.

Effects on Upper and Middle Owens River Flows

The effects of the 6,383.5-Ft Alternative on Owens River flows are given in Table 3A-8 for the first 50 years of implementation. Values for the second 50 years would be slightly higher because Mono Basin exports would be increased by an average of

6 TAF/yr. Median monthly flows of the Upper Owens River below East Portal would be less than those of the point-of-reference scenario, especially during the peak runoff period.

Effects of reduced Mono Basin exports for this alternative would be evident in the Middle Owens River at Pleasant Valley, especially during the peak runoff months. All months would have reduced median flows compared with the point-of-reference scenario.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the 6,383.5-Ft Alternative, exports to Los Angeles would average 403 TAF/yr for the first 50 years of simulation and 408 TAF/yr for the second 50 years. This is 35 TAF/yr less than the average export under the point-of-reference scenario for the first 50 years and 30 TAF/yr less for the second 50 years. These figures are identical to the Mono Basin export deficits compared with the point-of-reference scenario. No additional water would be lost to spilling or spreading in the Owens Valley.

HYDROLOGIC EFFECTS OF THE 6,390-FT ALTERNATIVE

Effects on Diverted Tributary Streamflows

Table 3A-15 indicates that flows in Lee Vining and Rush Creeks would be above the minimum specified values during the peak runoff months of most years because of the greatly increased lake releases required to achieve and maintain the 6,390-foot target minimum lake level.

Under this alternative, Rush Creek would experience a spilling flow above 360 cfs, and Lee Vining Creek would experience a spilling flow above 280 cfs once per decade, on average.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-21 shows the expected variation in annual exports under this alternative, which results in an average of 95.9 TAF/yr released to Mono Lake during the first 50 years of implementation. Once the lake level reached the target minimum level of 6,390 feet, less water would be required to maintain that level, and 88.7 TAF/yr would be released during the next 50 years. The average export would be 29.8 TAF/yr for the first 50 years and 37 TAF/yr for the second 50 years.

Greater releases would be required during the first 40 years to raise the lake elevation above the target level. The average for the first 50 years reflects this increased initial water requirement. The average for the second 50-year period is more indicative of the long-term split of available water between lake releases and exports.

The average lake release for the first 50 years of the 6,390-Ft Alternative would be 51.3 TAF/yr more than for the point-of-reference scenario; for the second 50 years, releases would be 44.1 TAF/yr more. The average export during the first 50 years would be 42.9 TAF/yr less than for the point-of-reference scenario; for the second 50 years, exports would be 35.7 TAF/yr less.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations after dynamic equilibrium was reached is shown in Figure 3A-20.

Effects on Upper and Middle Owens River Flows

The effects of the 6,390-Ft Alternative on Owens River flows are given in Table 3A-8 for the first 50 years of implementation. Values for the second 50 years would be slightly higher because Mono Basin exports would be increased by an average of 7 TAF/yr. Median monthly flows of the Upper Owens River below East Portal would be much less than for the point-of-reference case, especially during the peak runoff period.

Effects of reduced Mono Basin exports for this alternative would be evident in the Middle Owens River at Pleasant Valley, especially during the peak runoff months. All months would have less median flow than with the point-of-reference scenario.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the 6,390-Ft Alternative, exports to Los Angeles would average 398.6 TAF/yr for the first 50 years of implementation and 404.3 TAF/yr for the second 50 years. This is 39.2 TAF/yr less than the average export under the point-of-reference scenario for the first 50 years and 33.5 TAF/yr less for the second 50 years. These figures are slightly less than the Mono Basin export deficits of the point-of-reference scenario because of reduced Owens

Valley uses when target levels of the Haiwee Reservoir export cannot be satisfied in dry runoff years.

HYDROLOGIC EFFECTS OF THE 6,410-FT ALTERNATIVE

Effects on Diverted Tributary Streamflows

Table 3A-16 indicates that flows in Lee Vining and Rush Creeks would be above the minimum specified values during the peak runoff months of most years because of the greatly increased lake releases required to achieve and maintain the 6,410-foot target minimum lake level.

Under this alternative, Rush Creek would experience a spilling flow above 400 cfs, and Lee Vining Creek would experience a spilling flow above 280 cfs once per decade, on average.

Effects on Mono Basin Exports and Releases to Mono Lake

Figured 3A-23 shows the expected variation in annual exports under this alternative, which results in an average of 114.8 TAF/yr released to Mono Lake during the first 50 years of implementation. Because the lake level would not yet be above the target minimum level of 6,410 feet after 50 years, increased lake releases of 108 TAF/yr would be required during the second 50 years of implementation, and 104 TAF/yr would be released during the third 50 years of implementation. The average export would be 11 TAF/yr for the first 50 years, 17.7 TAF/yr for the second 50 years, and 21.7 TAF/yr for the third 50 years of implementation.

Greater releases would be required during the first 80 years to raise the lake elevation above the target minimum level. The averages for the first and second 50-year periods reflect this increased water requirement. The averages for the third 50-year period are more indicative of the long-term split of available water between lake releases and exports.

The average lake release for the first 50 years of the 6,410-Ft Alternative would be 70.2 TAF/yr more than for the point-of-reference scenario; for the second 50 years, releases would be 63.4 TAF/yr more; and for the third 50 years, they would be 59.4 TAF/yr more. The average export during the first 50 years would be 61.7 TAF/yr less than for the point-of-reference scenario; for the second 50 years, exports would be 55 TAF/yr less; and for the third 50 years, they would be 51 TAF/yr less.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations after dynamic equilibrium was reached is shown in Figure 3A-22.

Effects on Upper and Middle Owens River Flows

The effects of the 6,410-Ft Alternative on Owens River flows are given in Table 3A-8.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the 6,410-Ft Alternative, exports to Los Angeles would average 385.8 TAF/yr for the first 50 years of implementation, 389.5 TAF/yr for the second 50 years, and 393.5 TAF/yr for the third 50 years. This is 52 TAF/yr less than the average export under the point-of-reference scenario for the first 50 years, 48.3 TAF/yr less for the second 50 years, and 44.5 TAF/yr less for the third 50 years. These figures are slightly less than the Mono Basin export deficits of the point-of-reference scenario because of reduced Owens Valley water use, reduced spreading, and reduced aqueduct spilling.

HYDROLOGIC EFFECTS OF THE NO-DIVERSION ALTERNATIVE

The No-Diversion Alternative represents no diversion and export of Mono Basin streamflow, but groundwater inflow would continue to be relatively constant into the Mono Craters Tunnel draining from East Portal into the Upper Owens River.

Effects on Diverted Tributary Streamflows

For each diverted creek, Table 3A-17 shows runoff flows modified by SCE storage and hydropower operations. No hydrologic effects on the diverted creeks were assumed in this alternative. Spilling flows would be similar to those described for the 6,410-Ft Alternative.

Effects on Mono Basin Exports and Releases to Mono Lake

Figure 3A-25 shows no exports for this alternative, with results in all runoff (124.2 TAF/yr on average) being released to Mono Lake. For this alternative, Grant Lake reservoir is assumed to remain full, so evaporative losses are slightly greater than for the point-of-reference scenario. No exports are allowed, implying 72.7 TAF/yr less export than under the point-of-reference scenario.

Effects on Mono Lake Surface Elevations

The frequency with which the lake surface would be above or below certain elevations after dynamic equilibrium was reached is shown in Figure 3A-24.

Effects on Upper and Middle Owens River Flows

The effects of the No-Diversion Alternative on Owens River flows are given in Table 3A-8. Flows in the Upper Owens River below East Portal would be the natural runoff values, supplemented with a nearly constant 17 cfs from "tunnel make".

The effects of eliminating Mono Basin exports would be strongly evident in the Middle Owens River at Pleasant Valley, especially during the peak runoff months. All months would have reduced median flows compared with the point-of-reference scenario. The flows at Pleasant Valley would generally be uniform, with median monthly flows between 200 and 300 cfs, except for July with a median flow of 433 cfs.

Effects on LA Aqueduct Exports from Haiwee Reservoir to Los Angeles

Under the No-Diversion Alternative, exports to Los Angeles would average 373.6 TAF/yr. This is 64.2 TAF/yr less than the average export under the point-of-reference scenario. This figure is slightly less than the Mono Basin export deficit of 72.7 TAF/yr compared to the point-of-reference scenario because of reduced Owens Valley water use, reduced spreading, and reduced aqueduct spilling.

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Table 3A–1. Mono Lake Tributary Watershed Area and Average Runoff

Mono Lake Tributary	Location	Watershed Area (mi^2)	1940–1989 Average Runoff (AF/yr)
Mill Creek		18	21,500
Wilson Creek			
DeChambeau Creek		2.5	900
Lee Vining Creek	Total	47	
	At Diversion	35	49,200
Walker Creek	Total	15	
	At Diversion	7.8	5,400
Parker Creek	Total	12.2	
	At Diversion	6.3	9,125
South and East Parker Creeks	Total	3.8	
	At Diversion	2.9	1,220
Rush Creek	Total	141	
	At Inflow Gage	52	59,800
Ungaged Sierra Creeks		68	
Hill and Basin Floor Area		438	
Mono Lake (At 6,376–Ft Elevation)		65	
Total Mono Lake Watershed		695	

Notes: Watershed areas from Vorster (1985).
Runoff from LADWP records.

Table 3A–2. Average Snowpack and Rainfall Records

Basin	Station	Elevation (Feet)	Precipitation Type Measured	Average Depth (Inches)
Mono Lake Basin				
Mill Creek	Virginia Lake	9,500	Snow	18.4
	Virginia Lake Ridge	9,200	Snow	17.6
	Lundy Lake	7,760	Rain	17.0
Wilson Creek	Conway Summit	8,150	Rain	17.5
DeChambeau Creek	Mono Lake	6,450	Rain	14.2
Lee Vining Creek	Dana Meadows	9,850	Snow	30.0
	Tioga Pass	9,750	Snow	26.1
	Saddlebag Lake	9,750	Snow	32.2
	Ellery Lake	9,645	Rain	24.5
	Ellery Lake	9,600	Snow	28.7
	Poole Powerhouse	7,850	Rain	27.5
	Lee Vining Ranger Station	6,797	Rain	13.3
Rush Creek	Gem Pass	10,400	Snow	31.7
	Agnew Pass	9,450	Snow	31.4
	Gem Lake	9,150	Snow	30.7
	Gem Lake	8,790	Rain	20.7
	Rush Creek Powerhouse	7,300	Rain	25.3
	Cain Ranch	6,850	Rain	11.5
	Simis Ranch		Rain	5.5
Long Valley Basin				
	Mammoth Pass	9,500	Snow	42.1
	Minarets 2	9,000	Snow	29.2
	Mammoth	8,300	Snow	20.2
	Lake Mary		Rain	28.8
	Long Valley Dam	6,700	Rain	10.0
Round Valley Basin				
	Rock Creek Store		Rain	17.1
	Rock Creek 3	10,000	Snow	15.0
	Rock Creek 2	9,050	Snow	10.4
	Rock Creek 1	8,700	Snow	7.4
Owens River Basin				
	Bishop Pass	11,200	Snow	33.2
	Lake Sabrina	9,065	Rain	16.8
	Bishop	4,108	Rain	5.7
	Tinemaha Reservoir		Rain	6.6
	Big Pine Powerhouse	4,680	Rain	9.0
	Independence	3,950	Rain	5.1
	South Haiwee Reservoir	3,825	Rain	6.5
	Lone Pine		Rain	4.2
	Cottonwood Lakes 2	11,100	Snow	14.4
	Cottonwood Lakes 1	10,200	Snow	12.5
	Bishop Lake	11,300	Snow	21.5
	East Piute Pass	10,800	Snow	13.6
	Sawmill	10,300	Snow	19.0
	Big Pine Creek 1	10,000	Snow	22.7
	Big Pine Creek 3	9,808	Snow	17.5
	Big Pine Creek 2	9,700	Snow	15.2
	North Lake	9,300	Snow	9.3
	South Lake	9,580	Rain	18.3
	White Mountain 1		Rain	13.1
	White Mountain 2		Rain	18.8

Table 3A–3. Monthly Cumulative Flow Distribution of Diverted Streams

Percentiles	Monthly Streamflows in Cubic Feet Per Second											
	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Lee Vining Creek:												
0%	20.8	28.1	40.8	28.9	20.9	12.6	17.2	17.6	10.5	19.4	19.5	13.6
10%	30.5	76.4	98.2	52.0	31.3	24.1	28.2	23.8	21.7	23.3	22.6	19.2
20%	37.3	88.2	123.3	54.9	34.3	26.2	31.2	27.0	24.4	24.9	25.1	25.5
30%	40.2	96.0	133.9	73.4	42.0	32.6	33.2	29.5	26.3	28.2	26.7	28.6
40%	42.4	102.5	171.5	100.8	49.0	34.6	35.5	33.9	29.9	30.5	27.8	29.9
50%	45.5	115.6	192.8	117.4	57.4	39.9	37.7	35.0	32.7	32.3	29.1	31.8
60%	52.9	122.0	216.8	141.2	73.6	43.9	44.4	37.8	34.5	33.4	30.8	34.6
70%	59.1	139.9	242.3	183.2	101.0	55.8	47.0	39.2	35.8	35.1	32.9	36.7
80%	69.2	148.4	260.1	208.6	113.6	60.7	49.0	44.7	47.5	39.1	34.8	38.6
90%	78.0	181.8	286.7	246.3	125.2	73.3	58.3	55.8	58.1	46.8	43.1	45.9
100%	97.1	210.3	350.6	312.6	219.1	120.3	80.8	67.1	78.5	56.5	56.4	61.3
Walker Creek:												
0%	0.4	1.1	6.6	3.9	2.2	1.8	2.0	0.6	2.1	2.0	1.6	0.6
10%	1.2	2.6	10.5	4.9	3.2	2.2	2.4	2.6	2.5	2.3	2.3	2.2
20%	1.7	4.3	13.7	6.8	3.8	2.8	3.0	3.3	2.9	2.5	2.4	2.6
30%	2.1	5.9	14.4	7.6	4.4	3.5	4.0	4.1	3.3	2.8	2.6	2.7
40%	2.8	7.3	17.6	11.1	6.0	3.9	4.5	4.9	3.4	2.9	2.8	2.9
50%	3.1	8.0	21.2	14.4	7.2	4.4	5.3	5.4	3.6	3.1	3.0	3.0
60%	3.6	10.9	24.0	17.8	8.0	5.4	6.4	6.7	3.9	3.4	3.3	3.2
70%	3.9	14.3	26.1	22.4	11.5	6.5	7.6	7.8	4.1	3.8	3.8	3.4
80%	4.4	15.1	27.4	25.2	13.6	7.3	9.0	8.8	4.7	4.2	4.2	4.0
90%	6.1	18.1	30.5	29.6	17.2	9.5	9.6	10.2	6.2	5.0	4.8	4.3
100%	8.6	22.5	45.8	36.9	33.7	16.1	10.8	14.4	11.8	9.8	7.6	7.0
Parker Creek:												
0%	3.6	4.7	13.7	12.9	9.6	3.9	2.9	2.7	2.8	2.7	1.7	2.6
10%	4.5	8.6	21.3	19.4	11.5	6.1	3.9	3.2	3.4	3.2	3.0	3.3
20%	5.2	10.4	24.1	20.9	13.0	7.2	4.2	3.7	3.5	3.5	3.4	3.6
30%	5.5	11.9	27.1	23.8	14.1	7.7	4.4	4.1	4.3	3.8	3.7	4.0
40%	6.2	13.8	30.7	26.5	15.5	8.1	4.8	4.3	4.4	4.0	4.0	4.2
50%	6.5	15.7	31.9	33.0	17.8	9.7	5.4	4.7	4.7	4.2	4.1	4.5
60%	7.0	17.7	36.8	35.2	21.5	10.5	6.4	5.5	4.9	4.5	4.2	5.0
70%	8.0	20.9	38.7	42.2	24.8	11.9	6.7	5.8	5.2	5.2	4.6	5.3
80%	8.8	22.3	40.1	50.4	28.9	13.0	7.8	6.0	5.5	5.4	5.5	6.1
90%	10.6	24.6	43.2	54.4	34.7	17.0	8.6	7.1	7.3	6.2	6.2	7.1
100%	14.8	38.2	57.7	71.2	53.6	24.9	12.8	12.0	10.6	8.1	9.6	11.7
Rush Creek:												
0%	29.4	20.6	26.2	38.3	36.5	25.2	26.0	24.4	21.5	25.6	31.1	26.9
10%	47.5	70.6	76.0	55.6	43.7	37.0	34.1	35.0	31.0	33.1	37.9	39.0
20%	55.0	79.9	98.0	59.7	46.7	43.6	38.6	42.3	36.0	40.1	39.3	43.0
30%	60.1	98.2	121.6	81.6	54.7	49.2	44.1	45.8	45.5	42.8	41.1	45.5
40%	64.4	104.0	138.4	102.9	62.4	51.4	46.1	48.2	49.9	45.5	43.9	48.7
50%	68.9	114.6	163.8	124.3	71.5	54.0	51.0	53.0	52.1	48.5	46.3	52.3
60%	76.1	131.3	187.9	153.1	91.3	63.6	56.3	62.3	53.9	49.9	47.5	55.1
70%	80.6	141.6	215.0	197.1	113.4	72.1	66.7	67.2	59.4	56.8	49.2	58.5
80%	90.3	153.5	264.2	254.2	130.3	85.4	73.9	79.6	64.3	58.9	53.5	61.0
90%	97.0	178.9	317.7	307.2	148.4	108.7	83.8	94.7	87.6	64.7	65.4	67.0
100%	113.0	248.8	407.6	488.4	260.0	133.4	122.8	112.4	109.2	85.1	82.2	104.3

Table 3A-4. Monthly Evaporation Records for Mono Lake and Owens River Basins

Station	Pan Type	Average Pan Evaporation in Inches												Total Annual
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Grant Lake	Landpan	NR	NR	NR	NR	5.5	7.3	8.0	7.3	5.5	4.0	NR	NR	
	Floating Pan	NR	NR	NR	4.8	6.1	7.0	8.5	8.6	7.0	5.2	3.1	3.8	
Lake Crowley	Landpan	NR	NR	NR	3.7	5.8	7.1	7.6	6.8	4.9	3.2	1.5	NR	
	Floating Pan	NR	NR	NR	4.2	6.2	7.7	8.4	8.1	6.7	5.2	3.2	3.0	
Tinemaha Reservoir	Landpan	2.2	3.1	5.7	8.0	10.6	12.8	13.9	12.7	9.8	6.9	3.9	2.4	91.9
	% of Total	2.4	3.4	6.2	8.7	11.5	13.9	15.1	13.9	10.7	7.5	4.3	2.6	
South Haiwee Reservoir	Landpan	1.3	2.2	4.1	5.6	7.7	9.4	10.3	9.2	6.9	4.6	2.4	1.3	65.0
	% of Total	2.1	3.3	6.2	8.6	11.8	14.4	15.9	14.2	10.7	7.1	3.7	2.0	

Note: NR denotes that pan evaporation was not recorded for that month.

Table 3A-5. Simulated Annual Mono Lake Natural Water Budget Terms

Year	Mono Lake Elev (ft)	Mono Lake Area (acres)	Diverted Streams Runoff (AF)	Total Mono Releases (AF)	Cain Ranch Rain (in)	Modeled Rain Volume (AF)	Other Inflows (AF)	Mono Total Inflow (AF)	Lake Evap (AF)	Net Volume Change (AF)
1940	6,417.6	55,096	130,202	105,644	12.7	58,193	63,446	227,283	220,257	7027
1941	6,417.9	55,106	182,803	180,670	10.3	47,574	75,431	303,674	220,985	82690
1942	6,419.4	55,409	164,756	165,888	8.9	40,908	71,319	278,115	222,002	56113
1943	6,420.4	55,630	152,100	153,300	9.6	44,503	68,435	266,239	222,967	43272
1944	6,421.2	55,802	101,264	102,491	9.9	45,636	56,853	204,980	222,863	−17883
1945	6,420.9	55,731	155,759	157,227	12.5	58,005	69,269	284,501	223,327	61174
1946	6,422.0	55,972	130,830	132,303	12.5	58,471	63,589	254,364	224,048	30315
1947	6,422.5	56,096	82,850	83,507	3.7	17,077	52,658	153,242	223,910	−70669
1948	6,421.3	55,813	93,756	94,903	9.0	41,748	55,142	191,794	222,993	−31199
1949	6,420.7	55,690	90,091	91,011	6.6	30,324	54,307	175,642	222,493	−46851
1950	6,419.9	55,503	110,397	111,803	11.8	54,363	58,934	225,100	221,857	3243
1951	6,419.9	55,516	112,762	114,898	19.7	91,011	59,473	265,382	222,113	43269
1952	6,420.7	55,688	175,940	176,805	6.0	27,678	73,867	278,350	223,400	54950
1953	6,421.7	55,905	95,271	96,513	10.0	46,522	55,488	198,522	223,378	−24856
1954	6,421.2	55,807	83,420	84,338	6.5	30,140	52,787	167,266	222,811	−55546
1955	6,420.2	55,586	99,355	101,160	16.1	74,403	56,418	231,981	222,101	9880
1956	6,420.4	55,625	167,778	169,002	9.9	45,753	72,007	286,763	223,123	63639
1957	6,421.6	55,878	104,918	106,650	15.3	71,297	57,686	235,633	223,462	12171
1958	6,421.8	55,925	157,539	158,772	9.9	46,342	69,675	274,789	224,217	50571
1959	6,422.7	56,130	74,101	75,015	6.5	30,142	50,664	155,821	223,969	−68147
1960	6,421.5	55,856	70,919	71,919	7.4	34,160	49,939	156,018	222,824	−66806
1961	6,420.3	55,591	72,574	74,098	13.0	60,019	50,316	184,433	221,856	−37423
1962	6,419.6	55,444	132,278	133,949	14.7	67,852	63,919	265,720	221,983	43737
1963	6,420.4	55,616	137,599	138,791	9.5	44,061	65,131	247,983	222,765	25218
1964	6,420.8	55,716	85,120	86,464	11.1	51,467	53,175	191,106	222,479	−31373
1965	6,420.3	55,591	142,517	143,991	12.6	58,192	66,252	268,435	222,706	45729
1966	6,421.1	55,773	95,488	97,168	14.8	68,408	55,537	221,113	222,850	−1737
1967	6,421.1	55,766	198,453	199,524	8.2	38,226	78,996	316,747	223,966	92780
1968	6,422.7	56,137	82,126	83,964	16.5	76,669	52,493	213,126	224,051	−10926
1969	6,422.5	56,093	214,158	215,412	10.2	47,859	82,574	345,846	225,661	120185
1970	6,424.6	56,649	103,097	104,088	7.3	34,401	57,271	195,759	226,211	−30452
1971	6,424.1	56,482	114,855	116,035	9.4	43,892	59,950	219,876	225,776	−5899
1972	6,424.0	56,450	90,419	91,903	12.6	59,148	54,382	205,433	225,375	−19942
1973	6,423.6	56,363	133,142	134,671	13.1	61,656	64,116	260,443	225,639	34804
1974	6,424.3	56,531	132,271	133,577	10.7	50,525	63,918	248,020	226,256	21764
1975	6,424.6	56,650	120,053	121,093	7.9	37,077	61,134	219,304	226,645	−7341
1976	6,424.5	56,609	55,176	56,112	6.6	31,178	46,352	133,642	225,550	−91908
1977	6,422.9	56,178	52,918	55,198	21.2	98,568	45,838	199,604	224,055	−24451
1978	6,422.5	56,079	178,996	180,617	14.1	66,315	74,563	321,495	224,914	96581
1979	6,424.2	56,501	121,693	123,363	14.7	68,907	61,507	253,777	225,933	27845
1980	6,424.7	56,653	170,530	171,612	8.3	39,409	72,634	283,655	227,224	56431
1981	6,425.7	56,883	100,388	101,868	12.6	59,474	56,653	217,995	227,301	−9306
1982	6,425.5	56,852	212,339	214,799	23.2	110,491	82,160	407,450	228,672	178778
1983	6,428.6	57,665	238,944	240,360	11.9	58,193	88,222	386,775	233,645	153130
1984	6,431.3	58,916	147,798	148,747	6.9	33,742	67,455	249,944	235,842	14102
1985	6,431.5	58,964	109,183	111,102	17.3	84,906	58,657	254,665	235,582	19083
1986	6,431.8	59,029	170,067	170,895	5.6	27,437	72,529	270,861	236,592	34269
1987	6,432.4	59,146	67,917	68,977	8.0	39,133	49,255	157,365	236,033	−78667
1988	6,431.1	58,877	70,410	71,176	4.9	23,706	49,823	144,706	234,525	−89819
1989	6,429.5	58,254	87,382	88,391	7.5	36,176	53,690	178,257	232,106	−53849
Minimum:	6,417.6	55,096	52,918	55,198	4	17,077	45,838	133,642	220,257	−91908
Average:	6,423.1	56,344	123,494	124,235	11	51,427	61,918	237,580	225,426	12154
Maximum:	6,432.4	59,146	238,944	240,360	23	110,491	88,222	407,450	236,592	178778

Notes: Assumed constant 5060 AF Grant Lake gains and 748 AF irrigation diversion.
48" of annual precipitation assumed.

Table 3A–6. Annual Owens Valley Runoff, Ground Water Pumping, and Los Angeles Exports

Runoff Year	Owens Valley Runoff (AF)	Owens Valley Pumping (AF)	Laws Pumping (AF)	Bishop Pumping (AF)	Big Pine Pumping (AF)	Tinemaha to Haiwee Pumping (AF)	Haiwee Inflow (AF)	Flow to Los Angeles (AF)
1940	441,898	0						204,557
1941	648,446	0						243,452
1942	522,933	131						264,215
1943	499,464	52						271,987
1944	404,037	0						274,004
1945	590,626	11					310,497	290,725
1946	487,526	34					325,089	293,932
1947	366,550	52					339,890	314,136
1948	297,689	25					298,866	283,747
1949	338,077	27					335,934	300,838
1950	356,596	23					335,072	310,900
1951	368,859	27					340,545	317,243
1952	644,955	29					331,011	314,510
1953	361,655	24					333,911	313,629
1954	377,571	27					337,577	316,589
1955	380,713	28					343,548	320,243
1956	539,761	33					342,606	318,723
1957	423,291	27					341,111	328,048
1958	588,789	26					354,824	319,975
1959	310,706	38					339,034	323,403
1960	260,242	65,096					333,006	320,001
1961	253,608	109,985					355,070	333,030
1962	482,085	9,175					347,648	326,583
1963	504,072	899					367,491	334,340
1964	307,125	25,100					327,090	332,963
1965	462,845	6,732					359,177	319,839
1966	349,868	603					337,742	319,922
1967	684,936	1,425					375,308	340,069
1968	342,457	23,914					345,769	345,846
1969	973,729	4,023					385,447	343,767
1970	407,147	34,285	9,797	0	5,058	19,430	460,219	437,413
1971	363,032	149,562	28,420	20	45,780	75,342	495,172	471,525
1972	324,924	173,008	28,345	4,180	38,120	102,363	462,559	452,019
1973	519,584	86,751	15,979	7,272	8,943	54,557	478,670	455,347
1974	488,837	78,647	4,990	197	22,506	50,954	471,760	465,176
1975	404,157	116,924	11,202	3,454	30,998	71,270	506,116	478,066
1976	291,586	118,579	16,285	6,622	27,306	68,366	406,328	399,627
1977	255,417	153,024	15,038	11,048	38,001	88,937	299,576	288,640
1978	686,471	43,207	945	0	24,418	17,844	534,256	507,285
1979	445,747	96,871	17,933	7,771	27,639	43,528	504,079	482,781
1980	683,870	45,144	1,251	13	24,211	19,669	506,452	499,167
1981	403,773	108,400	25,313	9,687	28,462	44,938	485,677	464,125
1982	751,937	45,884	1,388	3,503	22,351	18,642	529,455	503,049
1983	881,746	44,922	1,113	11	28,119	15,679	544,871	534,113
1984	560,386	61,981	7,403	4,849	28,067	21,662	543,867	506,587
1985	480,287	107,718	17,369	10,485	25,911	53,953	527,404	498,574
1986	711,372	69,887	8,600	195	25,934	35,158	537,617	506,041
1987	328,682	209,394	38,241	10,978	48,663	111,512	450,017	426,908
1988	304,064	200,443	38,841	13,008	42,817	105,777	361,256	360,208
1989	302,349	155,903	34,785	10,692	33,950	76,476	255,156	240,152
Average:	463,330	46,962	16,162	5,199	28,863	54,803	397,862	364,360

Notes: Owens Valley Runoff Includes Long and Round Valley.
Flow to Los Angeles is less than Haiwee flow due to transit losses.

Table 3A–7. Summary Comparison of Hydrologic Effects of the Alternatives

Alternative	Mono Lake Elevations Start (ft)	Min (ft)	Median (ft)	Max (ft)	Ending (ft)	Mono Lake Releases (TAF)	Mono Basin Exports (TAF)	Mono Basin Irrigation (TAF)	Lee Vining Creek Flow (cfs)	Walker Creek Flow (cfs)	Parker Creek Flow (cfs)	Rush Creek Flow (cfs)	Pleasant Valley Outflow (TAF)	Exports to Los Angeles (TAF)	Owens Valley Uses (TAF)	Owens Valley Spread (TAF)	Owens Valley Spill (TAF)
No–Restriction Alternative:																	
First 50 Years	6,376.3	6,350.4	6,362.2	6,376.6	6,363.1	32.2	85.0	8.9	19.0	0.0	0.0	25.3	303.8	445.9	114.8	10.2	7.8
Second 50 Years	6,363.1	6,345.5	6,355.3	6,366.2	6,360.0												
Third 50 Years	6,360.0	6,344.3	6,353.6	6,365.4	6,359.2												
Point–of–Reference Scenario:																	
First 50 Years	6,376.3	6,360.4	6,368.2	6,376.5	6,370.8	44.6	72.7	8.9	21.2	0.0	0.0	40.2	291.7	437.8	109.7	10.4	8.6
Second 50 Years	6,370.8	6,359.0	6,365.9	6,375.6	6,370.1												
6372–Ft Alternative:																	
First 50 Years	6,376.3	6,372.2	6,375.1	6,378.8	6,375.5	61.2	64.3	0.7	35.8	3.1	7.2	38.4	283.4	421.0	110.0	16.6	12.7
6377–Ft Alternative:																	
First 50 Years	6,376.3	6,376.5	6,379.2	6,382.9	6,379.1	73.8	51.8	0.7	42.3	3.7	7.9	48.2	271.1	412.2	108.3	15.7	12.1
6383.5–Ft Alternative:																	
First 50 Years	6,376.3	6,376.5	6,384.8	6,389.5	6,384.8	88.0	37.7	0.7	48.6	3.7	7.9	61.3	257.2	403.2	106.5	13.3	11.0
Second 50 Years	6,384.8	6,382.9	6,385.8	6,389.6	6,384.9	82.2	43.5	0.7	45.4	3.7	7.9	56.4	262.9	408.0	107.1	13.5	11.0
6390–Ft Alternative:																	
First 50 Years	6,376.3	6,376.5	6,387.5	6,395.0	6,390.1	95.9	29.8	0.7	51.8	3.7	7.9	69.1	249.3	398.6	106.2	13.2	10.5
Second 50 Years	6,390.1	6,388.8	6,391.6	6,395.2	6,390.2	88.7	37.0	0.7	48.6	3.7	7.9	62.8	256.4	404.3	106.8	13.7	11.3
6410–Ft Alternative:																	
First 50 Years	6,376.3	6,376.5	6,392.4	6,407.7	6,404.0	114.8	11.0	0.7	62.0	3.7	7.9	84.8	230.7	385.8	105.0	9.5	7.8
Second 50 Years	6,404.0	6,403.6	6,408.8	6,414.9	6,409.3	108.0	17.7	0.7	58.7	3.7	7.9	79.0	237.3	389.5	105.1	12.0	9.6
Third 50 Years	6,409.3	6,407.9	6,410.9	6,415.1	6,409.5	104.0	21.7	0.7	56.5	3.7	7.9	75.4	241.3	393.3	105.5	12.0	9.4
No–Diversion Alternative:																	
First 50 Years	6,376.3	6,376.3	6,395.8	6,413.8	6,410.2	124.2	0.0	0.7	67.0	7.5	12.6	84.5	219.9	373.6	104.5	9.3	6.9
Second 50 Years	6,410.2	6,409.4	6,417.6	6,429.0	6,424.9												
Third 50 Years	6,424.9	6,424.0	6,428.3	6,436.5	6,432.1												

Table 3A-8. Simulated Median Monthly Flows in Owens River Basin for Each Alternative

Owens River Below East Portal:

Alternative	Monthly Median Streamflow in Cubic Feet Per Second											
	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
No-Restriction Alternative	271	248	192	155	144	164	157	166	162	152	145	160
Point-of-Reference Scenario	192	246	192	137	120	138	133	136	143	135	130	142
6,372-Ft Alternative	138	197	299	286	173	122	113	126	122	114	109	130
6,377-Ft Alternative	113	159	106	223	141	109	111	122	122	112	107	130
6,383.5-Ft Alternative	75	101	97	97	109	101	113	122	122	114	109	130
6,390-Ft Alternative	71	90	95	80	79	98	113	122	121	111	109	130
6,410-Ft Alternative	70	84	95	77	71	69	73	81	108	109	109	130
No-Diversion Alternative	70	84	95	77	71	69	71	70	68	68	67	67

Owens River Below Pleasant Valley Reservoir:

Alternative	Monthly Median Streamflow in Cubic Feet Per Second											
	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
No-Restriction Alternative	504	482	522	592	532	492	332	344	342	358	339	356
Point-of-Reference Scenario	480	444	475	559	521	482	332	352	342	352	335	355
6,372-Ft Alternative	444	392	424	529	534	304	294	331	306	323	308	342
6,377-Ft Alternative	419	364	364	492	407	258	221	317	310	302	301	350
6,383.5-Ft Alternative	383	313	364	476	417	259	230	325	308	302	323	350
6,390-Ft Alternative	381	300	342	427	280	273	253	289	319	336	319	341
6,410-Ft Alternative	338	273	318	411	240	214	222	277	249	327	311	340
No-Diversion Alternative	284	260	290	433	231	214	220	271	235	257	250	256

Owens River Below Big Pine Canal:

Alternative	Monthly Median Streamflow in Cubic Feet Per Second											
	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
No-Restriction Alternative	607	562	550	580	564	580	466	488	464	484	468	479
Point-of-Reference Scenario	607	560	537	550	540	534	471	493	472	483	465	474
6,372-Ft Alternative	573	488	473	535	533	437	419	457	442	439	444	470
6,377-Ft Alternative	565	456	422	494	461	366	348	467	451	430	444	470
6,383.5-Ft Alternative	530	419	422	470	438	373	347	466	437	440	452	472
6,390-Ft Alternative	529	419	412	409	354	392	386	444	448	461	450	455
6,410-Ft Alternative	473	399	400	400	325	338	343	421	378	444	452	459
No-Diversion Alternative	427	359	359	401	306	350	329	421	370	391	375	388

Table 3A-9. Summary Comparison of Simulated Flows and Estimated Irrigation Diversions in the Upper Owens River

Alternative or Condition	Parameter	Unit	Monthly Streamflows											
			Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
	Percent of annual water use	%	2	19	31	26	17	5	0	0	0	0	0	0
	Maximum irrigation diversion[a]	af/mo	182	1,730	2,823	2,367	1,548	455	0	0	0	0	0	0
	Maximum irrigation diversion	cfs	3	29	47	39	26	8	0	0	0	0	0	0
No restriction	Minimum flow of Owens River[b]	cfs	114	77	88	73	70	78	77	84	86	82	61	55
	Minimum flow after irrigation diversions[c]	cfs	111	48	41	34	44	70	77	84	86	82	61	55
Point of reference	Minimum flow of Owens River	cfs	111	77	94	73	70	66	77	86	80	87	61	55
	Minimum flow after irrigation diversions	cfs	108	48	47	34	44	58	77	86	80	87	61	55
6,372 Ft	Minimum flow of Owens River	cfs	58	63	55	32	55	37	54	57	62	67	69	73
	Minimum flow after irrigation diversions	cfs	55	34	8	-7	29	29	54	57	26	67	69	73
6,377 Ft	Minimum flow of Owens River	cfs	39	51	45	32	28	25	41	45	44	50	52	73
	Minimum flow after irrigation diversions	cfs	36	22	-2	-7	2	17	41	45	44	50	52	73
6,383.5 Ft	Minimum flow of Owens River	cfs	39	47	45	32	28	25	46	43	44	50	51	61
	Minimum flow after irrigation diversions	cfs	36	18	-2	-7	2	17	46	43	44	50	51	61
6,390 Ft	Minimum flow of Owens River	cfs	39	25	45	32	28	25	36	43	44	50	51	50
	Minimum flow after irrigation diversions	cfs	36	-4	-2	-7	2	17	36	43	44	50	51	50
6,410 Ft	Minimum flow of Owens River	cfs	39	25	45	32	28	25	36	43	44	50	51	50
	Minimum flow after irrigation diversions	cfs	36	-4	-2	-7	2	17	36	43	44	50	51	50
No diversion	Minimum flow of Owens River	cfs	39	25	45	32	28	25	36	43	44	50	51	50
	Minimum flow after irrigation diversions	cfs	36	-4	-2	-7	2	17	36	43	44	50	51	50

[a] Irrigated area is 1,821 acres. Annual irrigation diversion is 5 af/acre (total irrigation diversion equals 9,105 af).

[b] LAAMP hydrologic simulation using minimum monthly flows in a 50-year period (2% probability). No deficits would occur during the more frequent dry years (10% and 20% probability).

[c] Each 1 cfs of flow deficit (negative values) indicates a 40-acre irrigation reduction.

Table 3A-10. Monthly Cumulative Flow Distribution of Diverted Streams for the Point–of–Reference Scenario

	Monthly Streamflows in Cubic Feet Per Second											
Percentiles	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Lee Vining Creek:												
0%	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
10%	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
20%	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
30%	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
40%	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
50%	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
60%	5.0	5.0	5.0	27.8	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
70%	5.0	5.0	76.3	159.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
80%	5.0	5.0	152.7	193.6	99.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0
90%	5.0	19.0	219.0	231.3	114.7	59.6	5.0	5.4	5.0	12.8	18.6	5.0
100%	50.2	176.2	338.2	297.6	208.6	116.2	79.7	65.4	63.8	52.6	49.5	48.0
Walker Creek:												
0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Parker Creek:												
0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100%	0.0	0.0	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rush Creek:												
0%	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.1	19.0
10%	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.1	19.0
20%	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.1	19.0
30%	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.1	19.0
40%	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.1	19.0
50%	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.1	19.0
60%	19.0	19.0	19.0	41.8	19.0	19.0	19.0	19.0	19.0	19.0	19.1	19.0
70%	19.0	19.0	90.4	173.6	19.0	19.0	19.0	19.0	19.0	19.0	19.1	19.0
80%	19.0	19.0	150.1	276.2	136.8	19.0	19.0	19.0	19.0	19.0	19.1	19.0
90%	19.0	33.1	223.8	349.8	174.5	124.6	19.0	19.4	19.0	26.8	32.6	19.0
100%	64.2	200.7	484.9	546.0	321.8	167.8	144.9	145.6	134.5	106.2	95.2	105.2

Table 3A-11. Monthly Cumulative Flow Distribution of Diverted Streams for the No–Restriction Alternative

Percentiles	Monthly Streamflows in Cubic Feet Per Second											
	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Lee Vining Creek:												
0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	5.4	85.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	0.0	0.0	92.0	166.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80%	0.0	0.0	182.0	193.6	99.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90%	0.0	109.6	240.9	231.3	114.7	59.6	5.5	38.6	0.0	19.0	7.7	0.0
100%	49.5	176.2	338.2	297.6	208.6	116.2	79.7	65.4	63.8	52.6	49.5	48.0
Walker Creek:												
0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Parker Creek:												
0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100%	0.0	0.0	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rush Creek:												
0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	3.6	120.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	0.0	0.0	92.0	166.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80%	0.0	0.0	181.6	276.2	136.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90%	0.0	109.6	226.6	349.8	174.5	124.6	5.5	39.2	0.0	19.0	7.7	0.0
100%	49.5	226.6	491.1	546.0	321.8	167.8	144.9	145.6	134.5	106.2	95.2	105.2

Table 3A–12. Monthly Cumulative Flow Distribution of Diverted Streams for the 6,372–Ft Alternative

	Monthly Streamflows in Cubic Feet Per Second											
Percentiles	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Lee Vining Creek:												
0%	20.8	26.5	37.9	26.0	18.6	10.9	16.4	17.6	10.5	19.2	17.7	13.6
10%	25.9	74.9	93.7	47.2	29.0	19.9	18.8	17.7	19.0	19.2	17.7	16.2
20%	25.9	75.7	93.7	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
30%	25.9	75.7	93.7	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
40%	25.9	75.7	93.7	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
50%	25.9	75.7	93.7	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
60%	25.9	75.7	93.7	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
70%	25.9	75.7	93.7	49.1	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
80%	25.9	75.7	93.7	51.9	30.0	19.9	18.8	17.7	19.0	19.2	17.7	16.2
90%	27.3	79.7	95.4	122.4	51.2	19.9	18.8	17.7	19.0	19.2	17.7	16.2
100%	73.5	117.3	226.2	309.6	192.1	41.5	18.8	19.5	19.0	19.4	19.5	17.8
Walker Creek:												
0%	0.4	1.1	6.6	3.9	2.2	1.8	2.0	0.6	2.1	2.0	1.6	0.6
10%	1.1	2.5	10.0	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
20%	1.1	2.5	10.0	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
30%	1.1	2.5	10.0	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
40%	1.1	2.5	10.0	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
50%	1.1	2.5	10.0	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
60%	1.1	2.5	10.0	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
70%	1.1	2.5	10.0	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
80%	1.1	2.5	10.0	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
90%	1.1	2.5	10.0	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.3	2.1
100%	1.2	2.6	10.5	5.0	3.4	2.4	2.6	2.7	2.7	2.4	2.4	2.2
Parker Creek:												
0%	3.6	4.7	13.7	12.9	9.6	3.9	2.9	2.7	2.8	2.7	1.7	2.6
10%	4.2	7.4	20.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
20%	4.2	7.4	20.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
30%	4.2	7.4	20.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
40%	4.2	7.4	20.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
50%	4.2	7.4	20.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
60%	4.2	7.4	20.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
70%	4.2	7.4	20.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
80%	4.2	7.4	20.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
90%	4.2	7.4	21.3	18.3	11.0	5.7	3.9	3.1	3.4	3.3	3.0	3.4
100%	4.5	7.6	22.6	19.7	12.2	6.2	4.2	3.3	3.5	3.5	3.3	3.6
Rush Creek:												
0%	31.6	34.7	39.4	36.2	26.9	27.5	29.5	32.0	25.9	27.5	27.5	21.2
10%	31.6	50.0	61.5	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
20%	31.6	50.0	61.5	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
30%	31.6	50.0	61.5	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
40%	31.6	50.0	61.5	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
50%	31.6	50.0	61.5	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
60%	31.6	50.0	61.5	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
70%	31.6	50.0	61.5	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
80%	31.6	50.0	61.5	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
90%	31.6	50.0	95.7	115.9	49.0	33.5	34.9	32.7	25.9	27.5	27.5	21.2
100%	104.0	149.3	254.5	305.3	189.9	55.0	34.9	32.7	26.0	28.1	28.1	21.9

Table 3A–13. Monthly Cumulative Flow Distribution of Diverted Streams for the 6,377–Ft Alternative

	Monthly Streamflows in Cubic Feet Per Second											
Percentiles	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Lee Vining Creek:												
0%	20.8	26.5	37.9	26.0	18.6	10.9	16.4	17.6	10.5	19.2	17.7	13.6
10%	25.9	74.9	95.4	47.2	29.0	19.9	18.8	17.7	19.0	19.2	17.7	16.2
20%	25.9	75.7	120.4	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
30%	25.9	75.7	131.0	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
40%	25.9	75.7	168.6	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
50%	25.9	75.7	183.3	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
60%	25.9	75.7	183.3	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
70%	25.9	75.7	183.3	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
80%	42.2	81.4	183.3	49.3	30.7	19.9	18.8	17.7	19.0	19.2	17.7	16.2
90%	56.8	114.1	202.4	107.9	59.4	30.8	18.8	19.5	19.0	23.1	21.3	16.2
100%	89.1	190.1	243.7	254.5	192.1	71.6	58.2	50.6	67.5	35.2	34.7	17.8
Walker Creek:												
0%	0.4	1.1	6.6	3.9	2.2	1.8	2.0	0.6	2.1	2.0	1.6	0.6
10%	1.1	2.5	10.5	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
20%	1.1	2.5	13.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
30%	1.1	2.5	14.4	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
40%	1.1	2.5	17.6	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
50%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
60%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
70%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
80%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
90%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.3	2.1
100%	1.2	2.6	22.7	5.0	3.4	2.4	2.6	2.7	2.7	2.4	2.4	2.2
Parker Creek:												
0%	3.6	4.7	13.7	12.9	9.6	3.9	2.9	2.7	2.8	2.7	1.7	2.6
10%	4.2	7.4	21.3	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
20%	4.2	7.4	24.1	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
30%	4.2	7.4	27.1	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
40%	4.2	7.4	30.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
50%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
60%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
70%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
80%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
90%	4.2	7.4	31.9	18.3	11.0	5.7	3.9	3.1	3.4	3.3	3.0	3.4
100%	4.5	7.6	33.1	19.7	12.2	6.2	4.2	3.3	3.5	3.5	3.3	3.6
Rush Creek:												
0%	31.6	34.7	39.4	36.2	26.9	27.5	29.5	32.0	25.9	27.5	27.5	21.2
10%	31.6	50.0	89.1	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
20%	31.6	50.0	111.2	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
30%	31.6	50.0	134.8	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
40%	31.6	50.0	151.6	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
50%	31.6	50.0	159.4	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
60%	31.6	50.0	159.4	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
70%	31.6	50.0	159.4	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
80%	74.5	115.8	159.4	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
90%	90.7	151.7	187.2	98.7	69.4	52.5	34.9	39.3	40.8	40.4	46.9	31.0
100%	104.0	184.3	364.5	281.0	189.9	79.4	65.0	81.3	116.5	80.6	71.0	54.7

Table 3A–14. Monthly Cumulative Flow Distribution of Diverted Streams for the 6,383.5–Ft Alternative

	Monthly Streamflows in Cubic Feet Per Second											
Percentiles	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Lee Vining Creek:												
0%	20.8	26.5	37.9	26.0	18.6	10.9	16.4	17.6	10.5	19.2	17.7	13.6
10%	25.9	74.9	95.4	47.2	29.0	19.9	18.8	17.7	19.0	19.2	17.7	16.2
20%	25.9	75.7	120.4	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
30%	25.9	75.7	131.0	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
40%	25.9	75.7	168.6	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
50%	39.0	86.2	183.3	49.3	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
60%	42.2	98.3	183.3	70.4	29.4	19.9	18.8	17.7	19.0	19.2	17.7	16.2
70%	46.5	117.3	209.8	107.9	34.6	19.9	18.8	17.7	19.0	19.2	17.7	16.2
80%	60.2	138.5	239.4	141.7	51.2	22.7	18.8	17.7	19.0	19.2	17.7	16.2
90%	75.7	168.5	257.2	204.6	98.6	38.2	26.3	23.8	19.0	19.4	17.7	16.2
100%	97.1	208.8	299.1	242.8	192.1	55.8	34.7	50.6	26.3	26.7	32.1	20.4
Walker Creek:												
0%	0.4	1.1	6.6	3.9	2.2	1.8	2.0	0.6	2.1	2.0	1.6	0.6
10%	1.1	2.5	10.5	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
20%	1.1	2.5	13.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
30%	1.1	2.5	14.4	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
40%	1.1	2.5	17.6	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
50%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
60%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
70%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
80%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
90%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.3	2.1
100%	1.2	2.6	22.7	5.0	3.4	2.4	2.6	2.7	2.7	2.4	2.4	2.2
Parker Creek:												
0%	3.6	4.7	13.7	12.9	9.6	3.9	2.9	2.7	2.8	2.7	1.7	2.6
10%	4.2	7.4	21.3	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
20%	4.2	7.4	24.1	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
30%	4.2	7.4	27.1	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
40%	4.2	7.4	30.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
50%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
60%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
70%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
80%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
90%	4.2	7.4	31.9	18.3	11.0	5.7	3.9	3.1	3.4	3.3	3.0	3.4
100%	4.5	7.6	33.1	19.7	12.2	6.2	4.2	3.3	3.5	3.5	3.3	3.6
Rush Creek:												
0%	31.6	34.7	39.4	36.2	26.9	27.5	29.5	32.0	25.9	27.5	27.5	21.2
10%	31.6	50.0	89.1	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
20%	31.6	50.0	111.2	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
30%	31.6	50.0	134.8	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
40%	60.9	69.7	152.5	41.3	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
50%	70.3	101.1	159.4	79.5	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
60%	74.5	118.2	174.3	101.3	46.8	33.5	34.9	32.7	25.9	27.5	27.5	21.2
70%	86.2	148.7	215.3	138.2	52.0	36.9	34.9	32.7	25.9	27.5	27.5	21.2
80%	96.2	162.3	251.3	195.8	73.1	45.9	34.9	32.7	25.9	27.5	27.5	21.2
90%	105.6	184.3	312.8	254.1	129.6	61.4	48.6	44.9	38.1	28.1	28.1	21.3
100%	124.8	270.5	364.5	327.9	189.9	100.0	104.0	59.5	51.1	43.4	46.9	52.1

Table 3A–15. Monthly Cumulative Flow Distribution of Diverted Streams for the 6,390–Ft Alternative

	Monthly Streamflows in Cubic Feet Per Second											
Percentiles	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Lee Vining Creek:												
0%	20.8	26.5	37.9	26.0	18.6	10.9	16.4	17.6	10.5	19.2	17.7	13.6
10%	25.9	74.9	95.4	47.2	29.0	19.9	18.8	17.7	19.0	19.2	17.7	16.2
20%	27.3	75.7	120.4	47.2	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
30%	37.1	79.7	131.0	50.8	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
40%	40.1	89.4	168.6	60.1	29.1	19.9	18.8	17.7	19.0	19.2	17.7	16.2
50%	42.3	98.3	183.3	73.6	30.5	19.9	18.8	17.7	19.0	19.2	17.7	16.2
60%	45.4	112.1	203.9	91.7	36.8	20.5	18.8	17.7	19.0	19.2	17.7	16.2
70%	52.8	120.5	233.7	122.8	46.6	23.3	18.8	17.7	19.0	19.2	17.7	16.2
80%	64.2	140.3	242.7	154.5	65.9	29.0	26.3	23.7	19.0	19.4	19.5	16.6
90%	75.7	170.5	273.0	192.8	104.7	41.5	30.4	27.0	23.7	23.5	25.1	26.2
100%	97.1	208.8	325.2	242.8	192.1	55.8	34.7	50.6	55.5	30.5	32.1	36.5
Walker Creek:												
0%	0.4	1.1	6.6	3.9	2.2	1.8	2.0	0.6	2.1	2.0	1.6	0.6
10%	1.1	2.5	10.5	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
20%	1.1	2.5	13.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
30%	1.1	2.5	14.4	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
40%	1.1	2.5	17.6	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
50%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
60%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
70%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
80%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
90%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.3	2.1
100%	1.2	2.6	22.7	5.0	3.4	2.4	2.6	2.7	2.7	2.4	2.4	2.2
Parker Creek:												
0%	3.6	4.7	13.7	12.9	9.6	3.9	2.9	2.7	2.8	2.7	1.7	2.6
10%	4.2	7.4	21.3	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
20%	4.2	7.4	24.1	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
30%	4.2	7.4	27.1	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
40%	4.2	7.4	30.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
50%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
60%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
70%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
80%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
90%	4.2	7.4	31.9	18.3	11.0	5.7	3.9	3.1	3.4	3.3	3.0	3.4
100%	4.5	7.6	33.1	19.7	12.2	6.2	4.2	3.3	3.5	3.5	3.3	3.6
Rush Creek:												
0%	31.6	34.7	39.4	36.2	26.9	27.5	29.5	32.0	25.9	27.5	27.5	21.2
10%	31.6	50.0	89.1	40.7	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
20%	56.8	77.9	119.7	54.8	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
30%	62.7	88.5	134.8	66.2	26.9	33.5	34.9	32.7	25.9	27.5	27.5	21.2
40%	67.9	101.1	152.5	87.8	46.1	33.5	34.9	32.7	25.9	27.5	27.5	21.2
50%	74.5	118.1	160.1	115.2	49.3	37.1	34.9	32.7	25.9	27.5	27.5	21.2
60%	79.1	130.5	210.1	135.6	57.3	45.5	34.9	32.7	25.9	27.5	27.5	21.2
70%	88.4	148.7	221.5	165.3	73.1	52.5	34.9	32.7	26.0	27.5	27.5	21.2
80%	100.0	162.3	268.5	236.3	100.6	62.2	38.3	41.5	33.1	32.9	39.7	45.6
90%	105.6	184.3	318.3	302.8	152.3	79.8	48.6	48.8	42.9	42.6	46.5	55.6
100%	124.8	274.0	468.0	490.2	194.7	103.9	104.0	59.5	75.3	66.2	58.2	81.9

Table 3A–16. Monthly Cumulative Flow Distribution of Diverted Streams for the 6,410–Ft Alternative

	Monthly Streamflows in Cubic Feet Per Second											
Percentiles	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Lee Vining Creek:												
0%	20.8	26.5	37.9	26.0	18.6	10.9	16.4	17.6	10.5	19.2	17.7	13.6
10%	30.5	74.9	95.4	49.1	29.0	20.5	18.8	17.7	19.0	19.2	17.7	16.2
20%	37.2	86.2	120.4	51.9	31.9	23.3	26.3	17.7	19.0	19.2	17.7	16.2
30%	40.1	92.1	131.0	70.4	39.6	30.3	28.4	17.7	19.0	19.2	17.7	16.2
40%	42.3	100.3	168.6	97.9	46.6	32.8	33.1	22.4	19.0	19.2	17.7	16.2
50%	45.4	114.1	189.9	114.4	55.1	38.2	36.3	24.3	19.0	19.2	17.7	16.2
60%	52.8	120.5	213.9	138.3	71.3	42.1	39.2	30.4	19.0	19.2	17.7	16.2
70%	59.1	138.4	239.4	180.2	98.6	54.1	44.0	35.3	19.0	19.2	17.7	16.2
80%	69.1	146.9	257.2	205.6	111.3	59.0	47.6	40.2	25.8	21.6	20.2	17.8
90%	77.9	180.3	283.9	243.3	122.9	71.6	55.0	50.6	32.8	24.4	25.1	29.4
100%	97.1	208.8	347.8	309.6	216.7	118.6	80.0	67.1	55.5	39.4	32.1	36.5
Walker Creek:												
0%	0.4	1.1	6.6	3.9	2.2	1.8	2.0	0.6	2.1	2.0	1.6	0.6
10%	1.1	2.5	10.5	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
20%	1.1	2.5	13.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
30%	1.1	2.5	14.4	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
40%	1.1	2.5	17.6	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
50%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
60%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
70%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
80%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.2	2.1
90%	1.1	2.5	20.7	4.8	3.2	2.2	2.3	2.5	2.5	2.2	2.3	2.1
100%	1.2	2.6	22.7	5.0	3.4	2.4	2.6	2.7	2.7	2.4	2.4	2.2
Parker Creek:												
0%	3.6	4.7	13.7	12.9	9.6	3.9	2.9	2.7	2.8	2.7	1.7	2.6
10%	4.2	7.4	21.3	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
20%	4.2	7.4	24.1	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
30%	4.2	7.4	27.1	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
40%	4.2	7.4	30.7	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
50%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
60%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
70%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
80%	4.2	7.4	31.9	18.3	11.0	5.7	3.8	3.1	3.3	3.2	3.0	3.3
90%	4.2	7.4	31.9	18.3	11.0	5.7	3.9	3.1	3.4	3.3	3.0	3.4
100%	4.5	7.6	33.1	19.7	12.2	6.2	4.2	3.3	3.5	3.5	3.3	3.6
Rush Creek:												
0%	39.6	34.7	39.4	36.2	39.1	27.5	29.5	32.0	25.9	27.5	27.5	21.2
10%	57.6	84.8	89.1	53.6	46.3	37.1	34.9	32.7	25.9	27.5	27.5	21.2
20%	65.2	94.1	119.7	57.6	49.3	41.3	38.3	33.9	25.9	27.5	27.5	21.2
30%	70.3	105.7	138.4	79.5	56.9	50.1	44.0	41.5	25.9	27.5	27.5	21.2
40%	74.5	118.2	152.5	100.8	69.4	54.1	49.6	48.8	25.9	27.5	27.5	21.2
50%	79.1	128.7	177.7	126.7	84.3	61.4	55.5	53.3	28.4	27.5	27.5	21.2
60%	86.2	146.5	219.8	152.9	114.1	75.2	64.2	60.0	37.1	27.5	27.5	21.2
70%	90.7	155.7	233.7	195.8	151.8	93.2	76.3	72.2	40.9	32.9	27.5	21.2
80%	100.4	167.7	289.2	258.1	181.4	108.6	85.7	87.3	46.6	41.8	43.3	49.0
90%	107.2	193.1	359.7	309.3	210.0	139.5	105.5	112.0	94.5	55.8	47.9	55.6
100%	124.8	274.0	468.0	490.2	325.0	206.3	151.7	138.8	135.9	75.3	58.2	81.9

Table 3A–17. Monthly Cumulative Flow Distribution of Diverted Streams for the No–Diversion Alternative

Percentiles	Monthly Streamflows in Cubic Feet Per Second											
	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Lee Vining Creek:												
0%	20.8	26.5	37.9	26.0	18.6	10.9	16.4	17.6	10.5	19.4	19.5	13.6
10%	30.5	74.9	95.4	49.1	29.0	22.4	27.4	23.8	21.7	23.3	22.6	19.2
20%	37.2	86.7	120.4	51.9	31.9	24.4	30.4	27.0	24.4	24.9	25.1	25.5
30%	40.1	94.4	131.0	70.4	39.6	30.8	32.3	29.5	26.3	28.2	26.7	28.6
40%	42.3	101.0	168.6	97.9	46.6	32.9	34.7	33.9	29.9	30.5	27.8	29.9
50%	45.4	114.1	189.9	114.4	55.1	38.2	36.9	35.0	32.7	32.3	29.1	31.8
60%	52.8	120.5	213.9	138.3	71.3	42.1	43.5	37.8	34.5	33.4	30.8	34.6
70%	59.1	138.4	239.4	180.2	98.6	54.1	46.1	39.2	35.8	35.1	32.9	36.7
80%	69.1	146.9	257.2	205.6	111.3	59.0	48.2	44.7	47.5	39.1	34.8	38.6
90%	77.9	180.3	283.9	243.3	122.9	71.6	57.5	55.8	58.1	46.8	43.1	45.9
100%	97.1	208.8	347.8	309.6	216.7	118.6	80.0	67.1	78.5	56.5	56.4	61.3
Walker Creek:												
0%	0.4	1.1	6.6	3.9	2.2	1.8	2.0	0.6	2.1	2.0	1.6	0.6
10%	1.2	2.6	10.5	4.9	3.2	2.2	2.4	2.6	2.5	2.3	2.3	2.2
20%	1.7	4.3	13.7	6.8	3.8	2.8	3.0	3.3	2.9	2.5	2.4	2.6
30%	2.1	5.9	14.4	7.6	4.4	3.5	4.0	4.1	3.3	2.8	2.6	2.7
40%	2.8	7.3	17.6	11.1	6.0	3.9	4.5	4.9	3.4	2.9	2.8	2.9
50%	3.1	8.0	21.2	14.4	7.2	4.4	5.3	5.4	3.6	3.1	3.0	3.0
60%	3.6	10.9	24.0	17.8	8.0	5.4	6.4	6.7	3.9	3.4	3.3	3.2
70%	3.9	14.3	26.1	22.4	11.5	6.5	7.6	7.8	4.1	3.8	3.8	3.4
80%	4.4	15.1	27.4	25.2	13.6	7.3	9.0	8.8	4.7	4.2	4.2	4.0
90%	6.1	18.1	30.5	29.6	17.2	9.5	9.6	10.2	6.2	5.0	4.8	4.3
100%	8.6	22.5	45.8	36.9	33.7	16.1	10.8	14.4	11.8	9.8	7.6	7.0
Parker Creek:												
0%	3.6	4.7	13.7	12.9	9.6	3.9	2.9	2.7	2.8	2.7	1.7	2.6
10%	4.5	8.6	21.3	19.4	11.5	6.1	3.9	3.2	3.4	3.2	3.0	3.3
20%	5.2	10.4	24.1	20.9	13.0	7.2	4.2	3.7	3.5	3.5	3.4	3.6
30%	5.5	11.9	27.1	23.8	14.1	7.7	4.4	4.1	4.3	3.8	3.7	4.0
40%	6.2	13.8	30.7	26.5	15.5	8.1	4.8	4.3	4.4	4.0	4.0	4.2
50%	6.5	15.7	31.9	33.0	17.8	9.7	5.4	4.7	4.7	4.2	4.1	4.5
60%	7.0	17.7	36.8	35.2	21.5	10.5	6.4	5.5	4.9	4.5	4.2	5.0
70%	8.0	20.9	38.7	42.2	24.8	11.9	6.7	5.8	5.2	5.2	4.6	5.3
80%	8.8	22.3	40.1	50.4	28.9	13.0	7.8	6.0	5.5	5.4	5.5	6.1
90%	10.6	24.6	43.2	54.4	34.7	17.0	8.6	7.1	7.3	6.2	6.2	7.1
100%	14.8	38.2	57.7	71.2	53.6	24.9	12.8	12.0	10.6	8.1	9.6	11.7
Rush Creek:												
0%	31.6	34.7	39.4	36.2	26.9	27.5	29.5	32.0	25.9	27.5	27.5	21.2
10%	51.2	70.8	89.1	40.7	33.2	33.5	34.9	32.7	30.2	39.1	45.1	45.3
20%	57.6	88.2	111.2	40.7	36.6	38.5	35.8	43.6	40.2	43.8	47.0	50.5
30%	62.0	99.1	134.8	51.2	45.8	44.1	41.6	50.7	50.6	50.0	51.6	52.7
40%	68.2	110.8	151.6	85.7	55.5	46.6	44.6	55.8	55.2	52.6	53.2	55.8
50%	73.3	118.1	165.0	112.5	63.0	51.1	50.9	59.0	57.9	55.3	55.1	60.8
60%	79.7	126.3	191.8	139.2	85.8	58.6	56.2	68.3	59.9	60.2	56.8	64.1
70%	86.1	147.6	221.3	184.7	107.4	67.4	65.3	75.6	67.1	63.2	58.5	66.5
80%	96.3	161.0	267.9	241.7	125.9	80.6	74.1	84.1	71.9	71.4	61.8	71.1
90%	103.0	186.1	322.3	294.9	142.5	103.7	82.7	100.9	99.8	77.4	72.7	77.3
100%	125.6	256.5	413.8	476.6	256.9	129.2	123.5	121.1	118.3	95.2	101.0	114.0

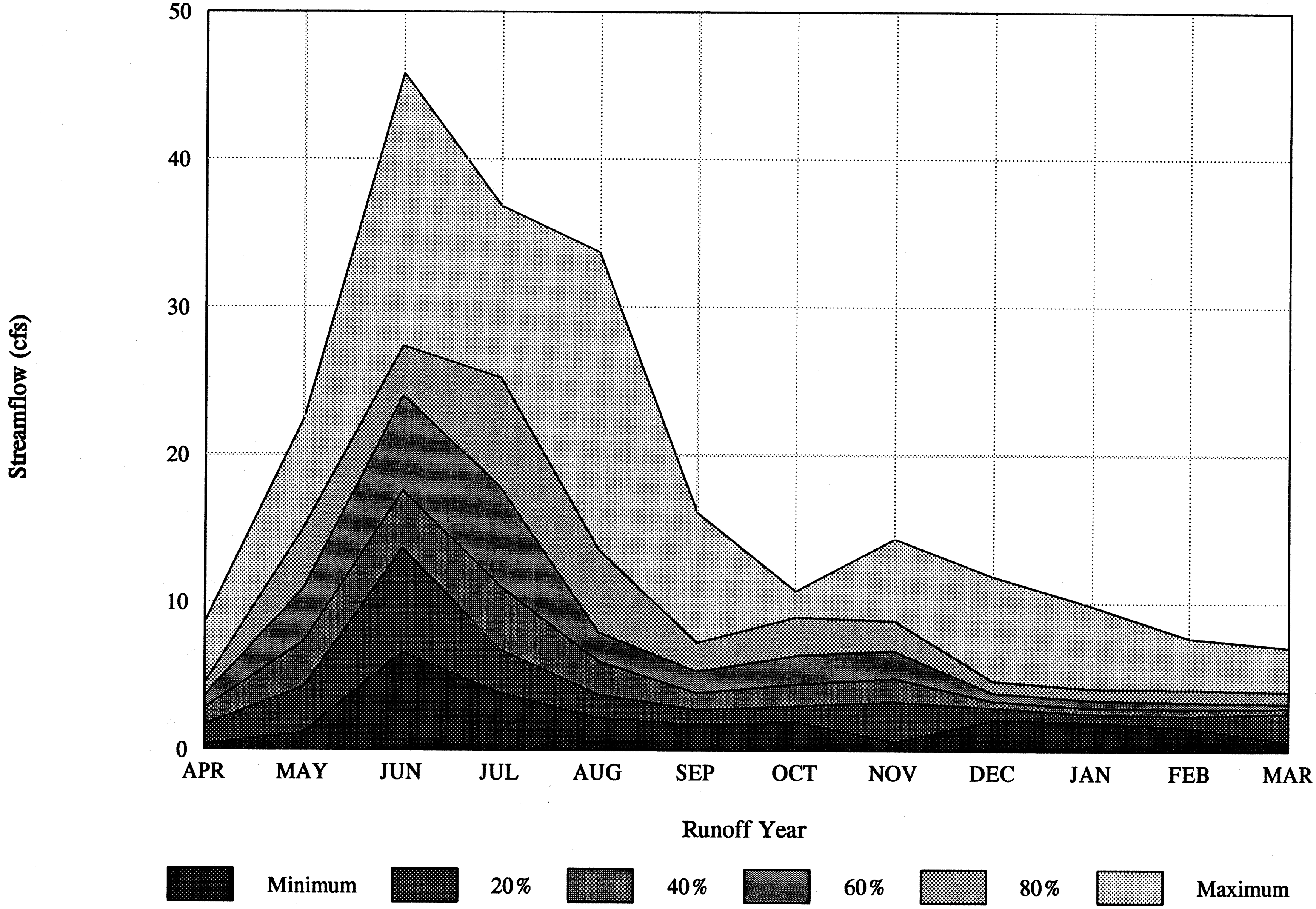


Figure 3A-3.
Monthly Walker Creek Streamflow Distribution

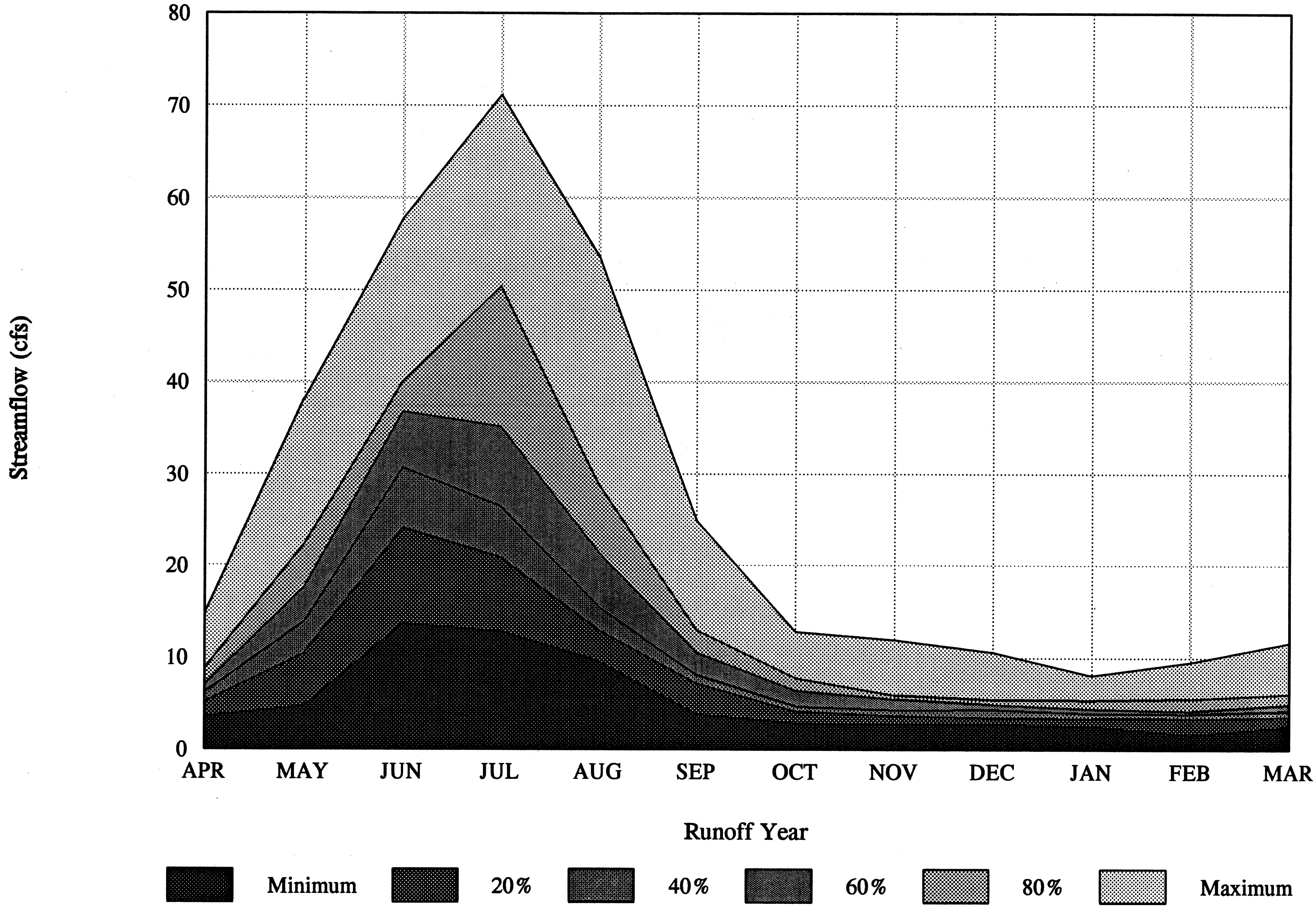


Figure 3A-4.
Monthly Parker Creek Streamflow Distribution

MONO BASIN EIR
Prepared by Jones & Stokes Associates

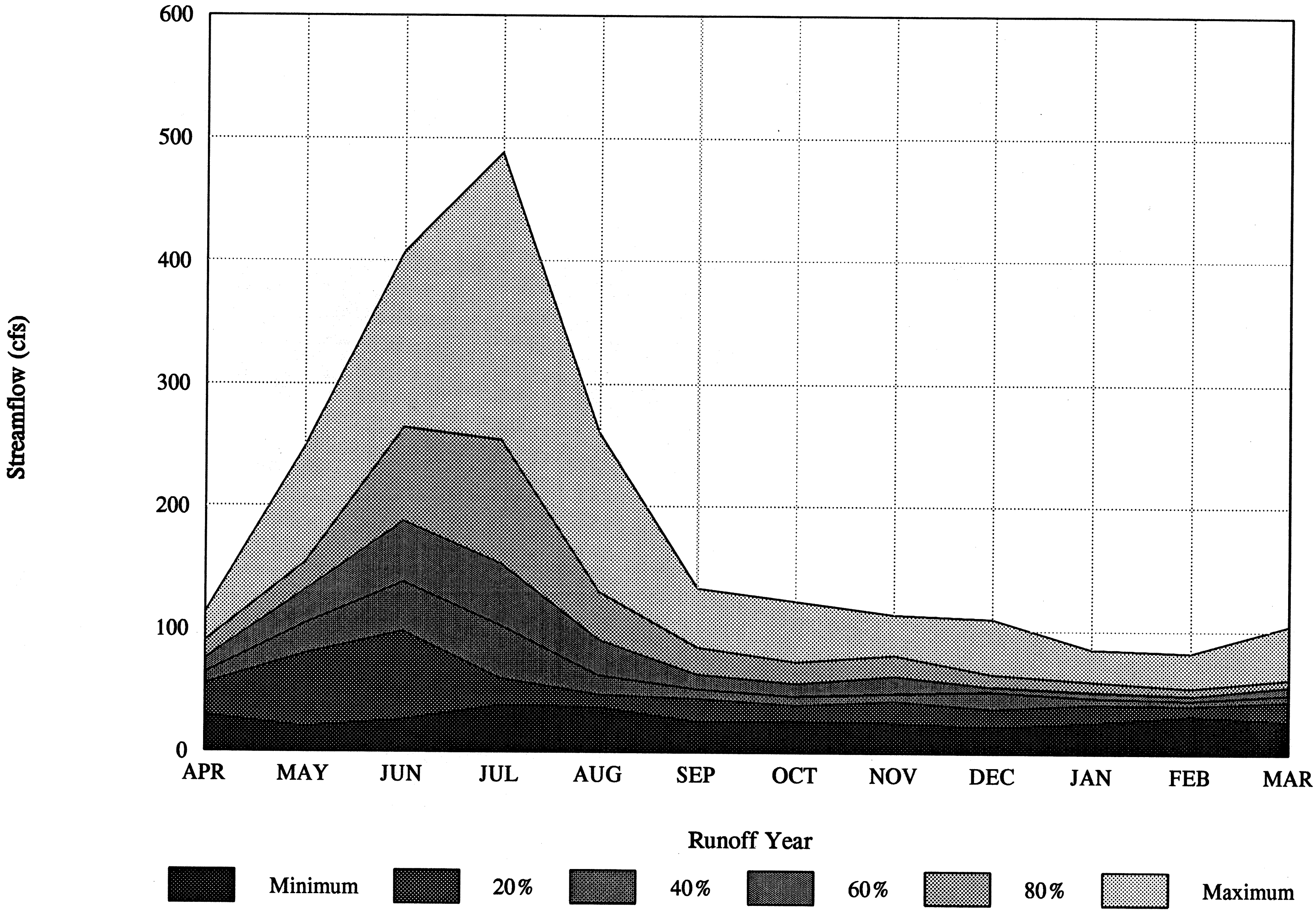


Figure 3A-5.
Monthly Rush Creek Streamflow Distribution

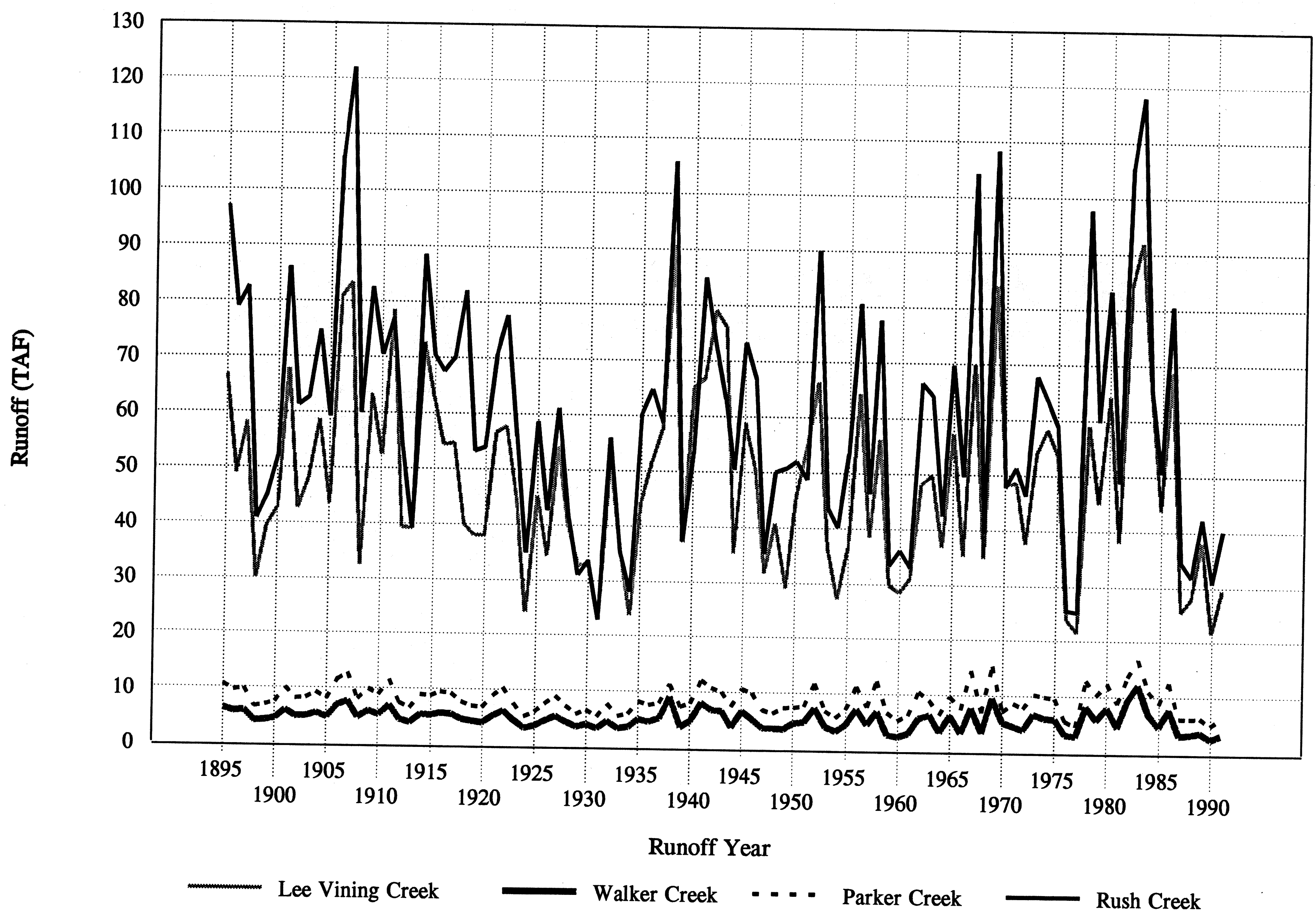


Figure 3A-1.
Annual Runoff of Diverted Streams

MONO BASIN EIR
Prepared by Jones & Stokes Associates

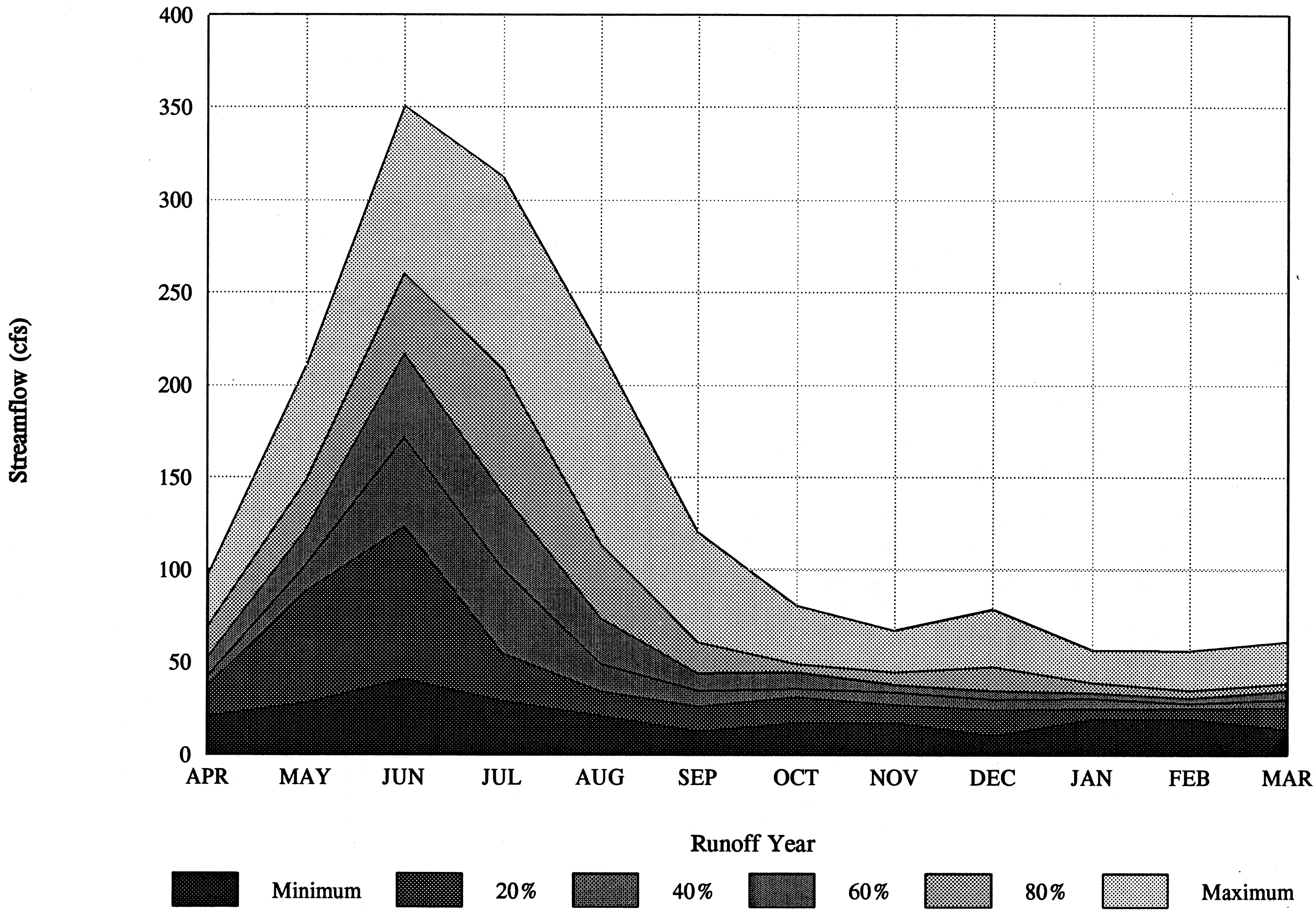
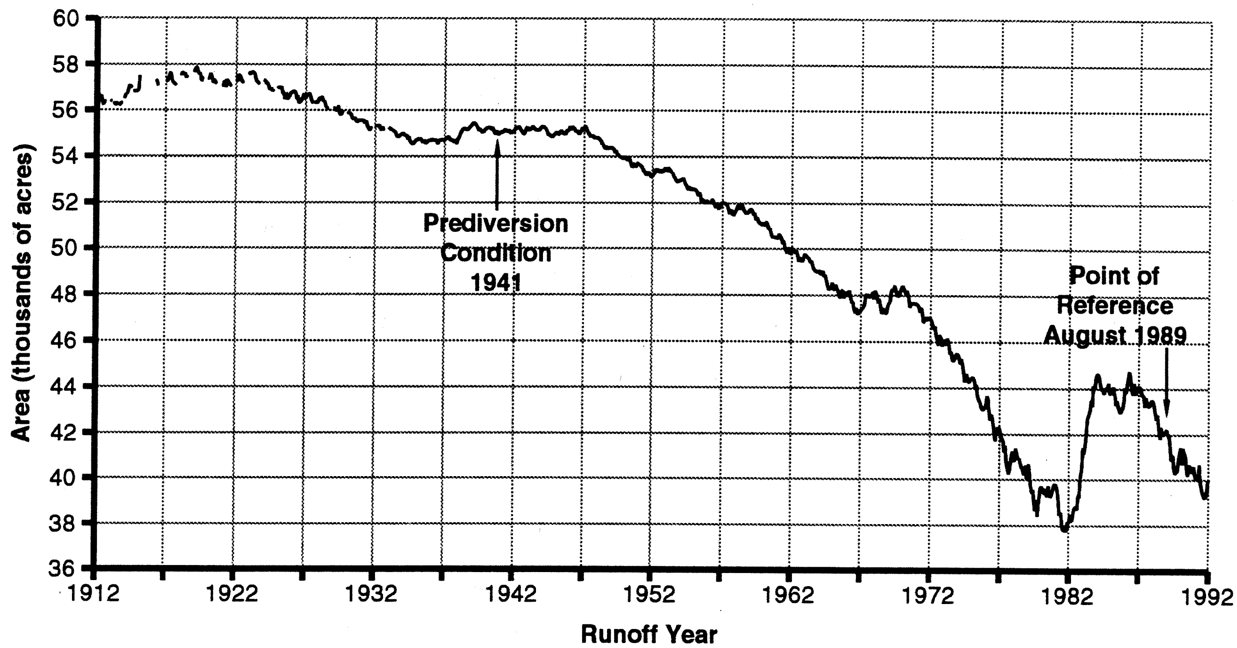


Figure 3A-2.
Monthly Lee Vining Creek Streamflow Distribution

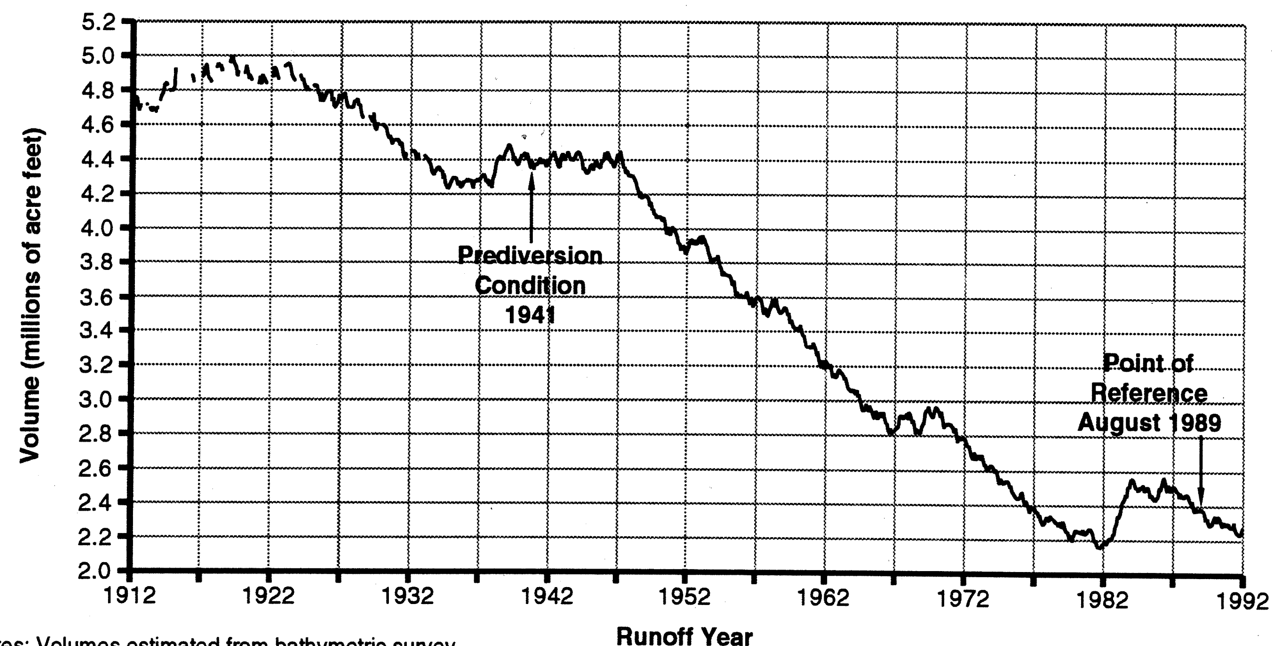
MONO BASIN EIR
Prepared by Jones & Stokes Associates

Figure 3A-6.
Historical Mono Lake Surface Area, 1912-1991



Note: Breaks in the record prior to the early 1930s occur because of intermittent data collection.

Figure 3A-7.
Historical Mono Lake Volume, 1912-1991



Notes: Volumes estimated from bathymetric survey by Pelagos Corporation.
Breaks in the record prior to the early 1930s occur because of intermittent data collection.

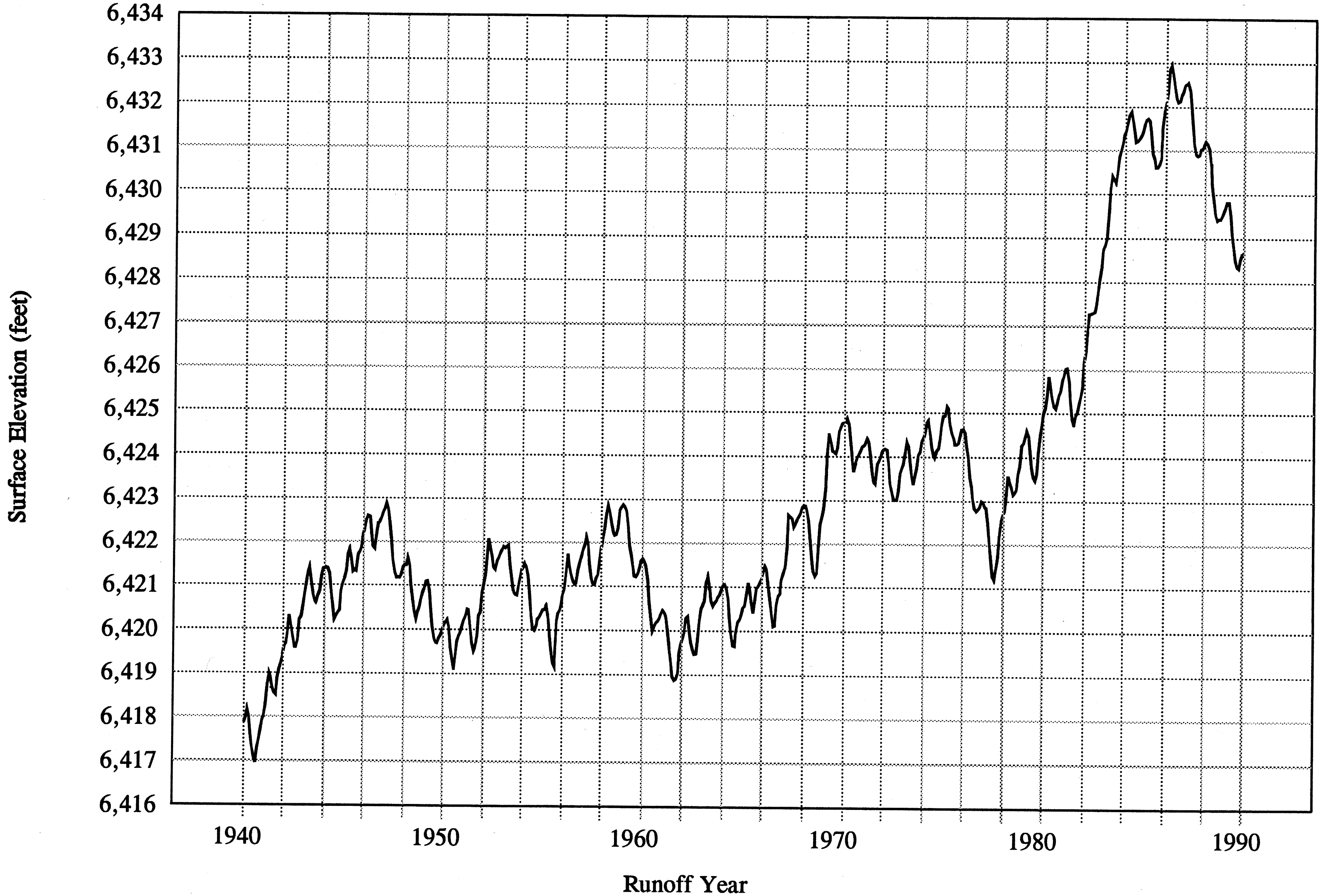


Figure 3A-8.
Simulated Mono Lake Surface Elevation in the Absence
of LADWP Diversions, 1940-1989

MONO BASIN EIR

Prepared by Jones & Stokes Associates

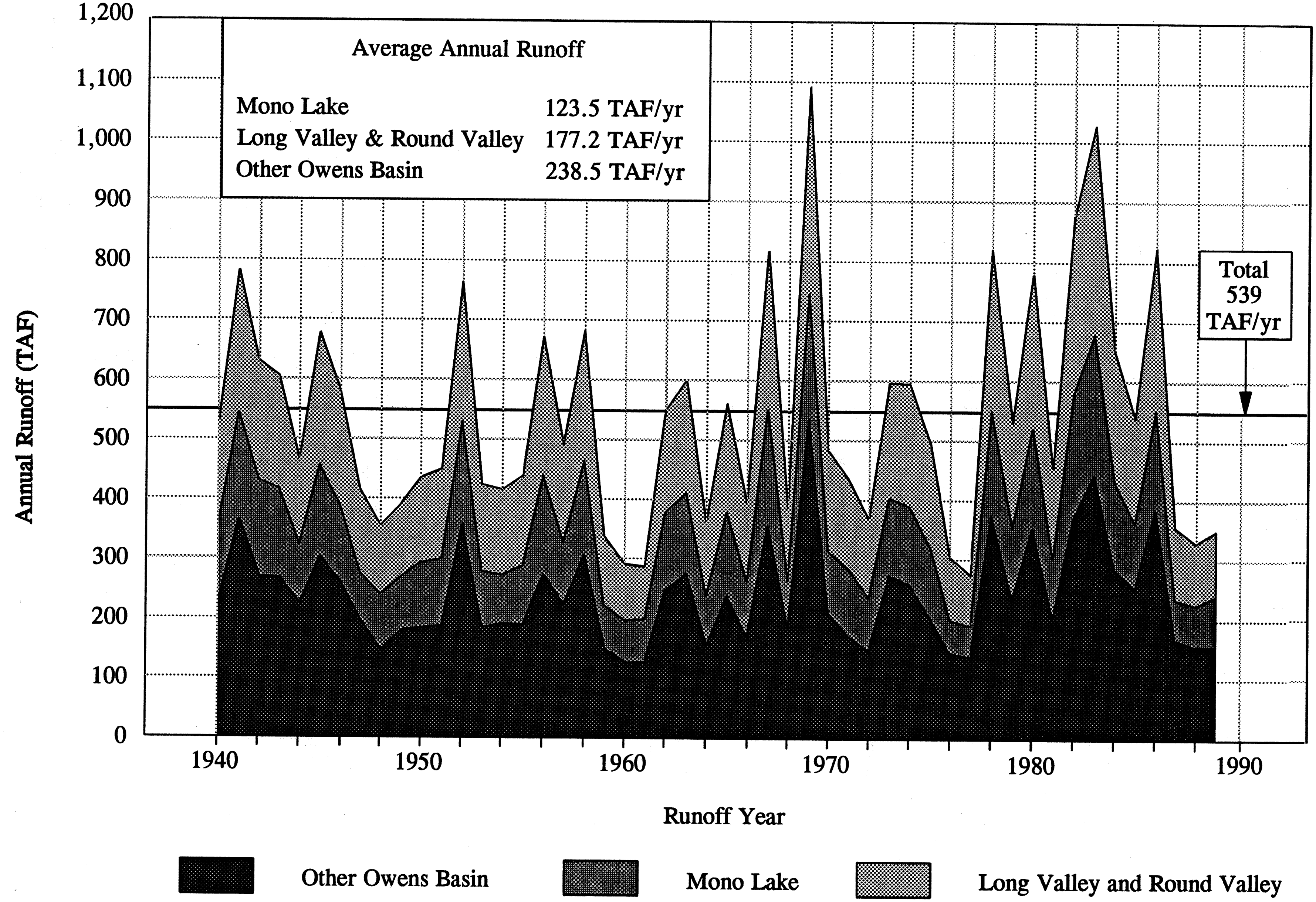
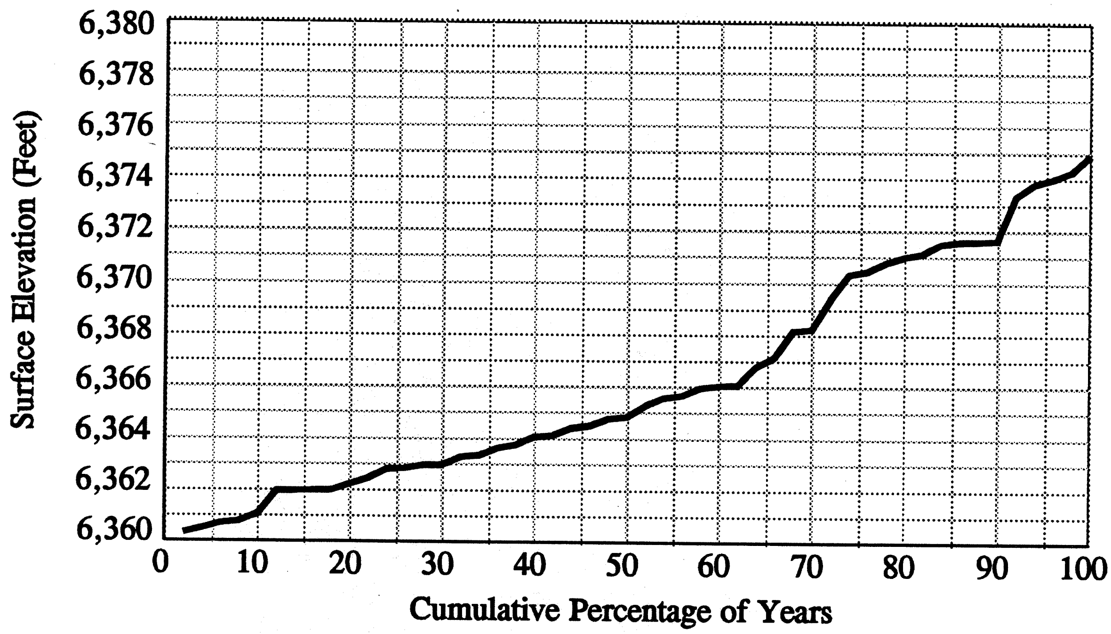


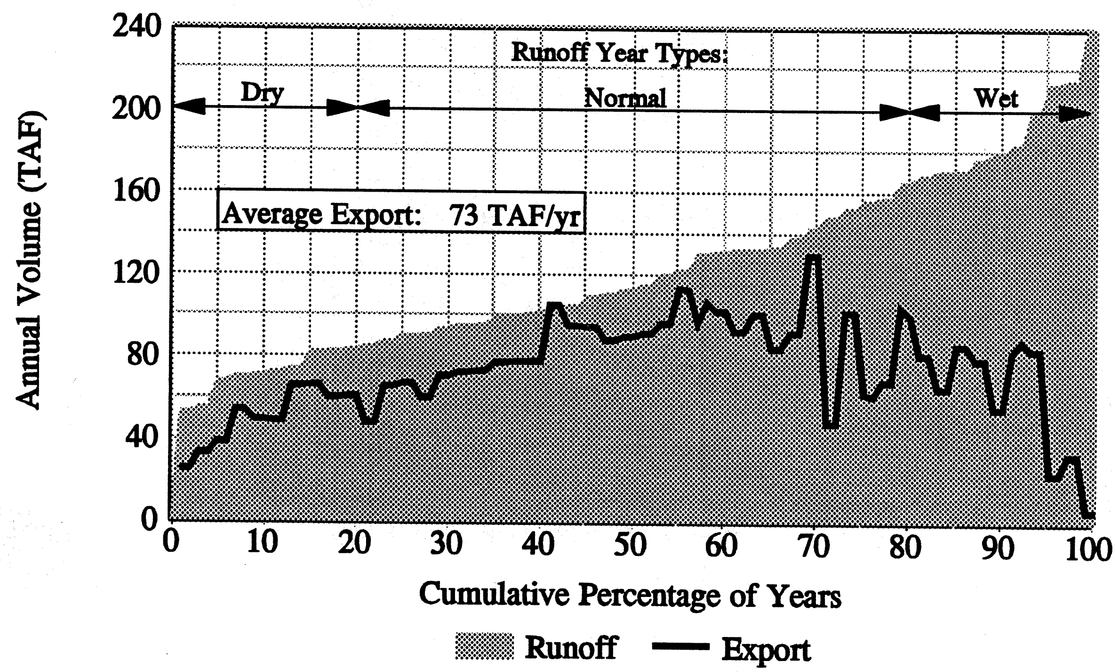
Figure 3A-9.
Total Historic Annual Runoff
Mono Lake, Owens River, Long Valley and Round Valley Basins

Figure 3A-10.
Simulated Mono Lake Surface Elevation
Point-of-Reference Scenario



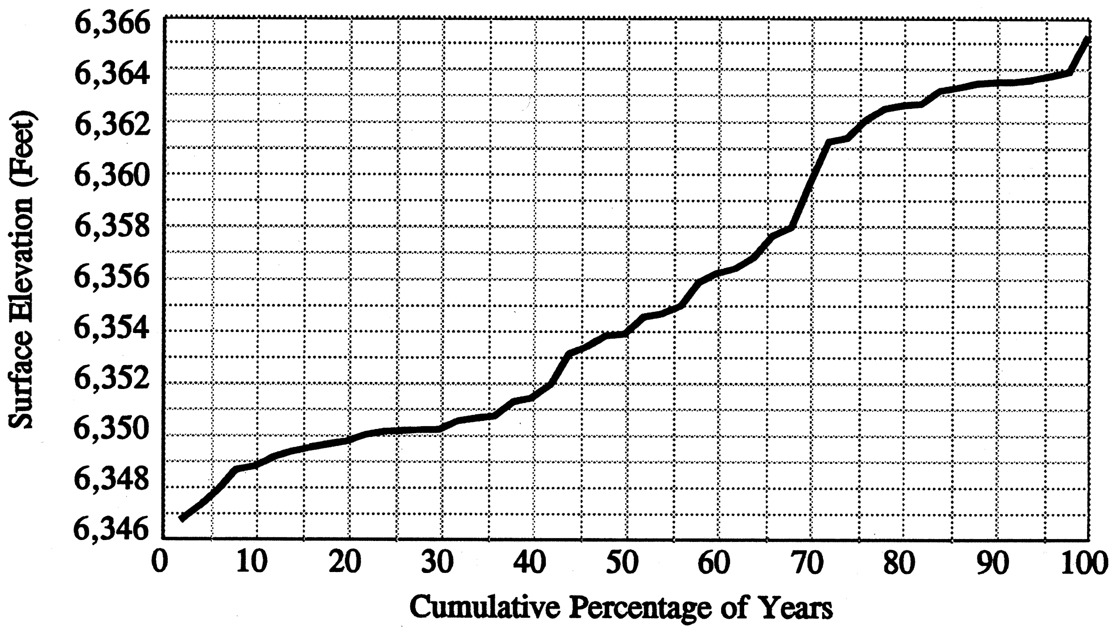
Note: Based on second fifty years of simulated lake elevations.

Figure 3A-11.
Frequency Distribution of Runoff and Simulated Mono Basin Exports
Point-of-Reference Scenario



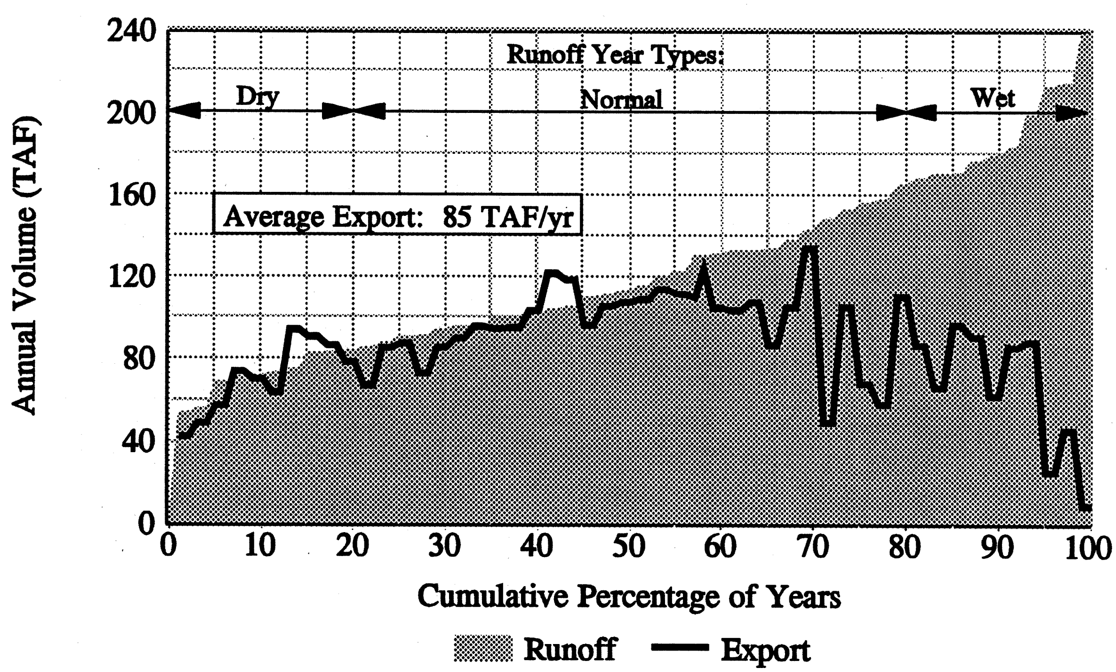
Note: Based on repeated 1940-1989 hydrology starting at a 6,376-ft surface elevation.

Figure 3A-12.
Simulated Mono Lake Surface Elevation
No-Restriction Alternative



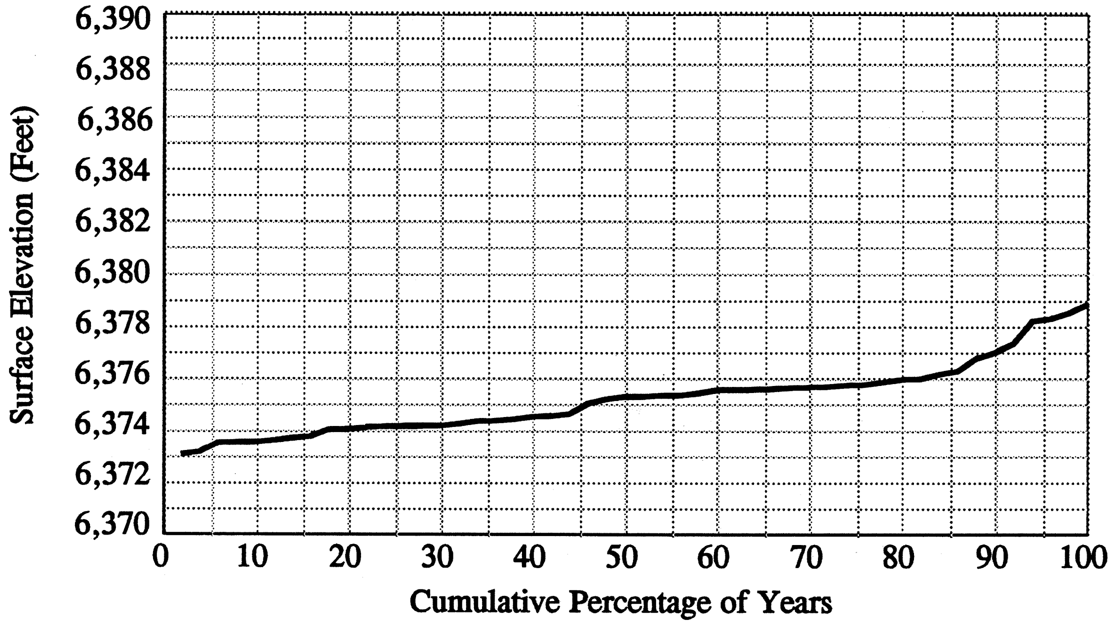
Note: Based on second fifty years of simulated lake elevations.

Figure 3A-13.
Frequency Distribution of Runoff and Simulated Mono Basin Exports
No-Restriction Alternative



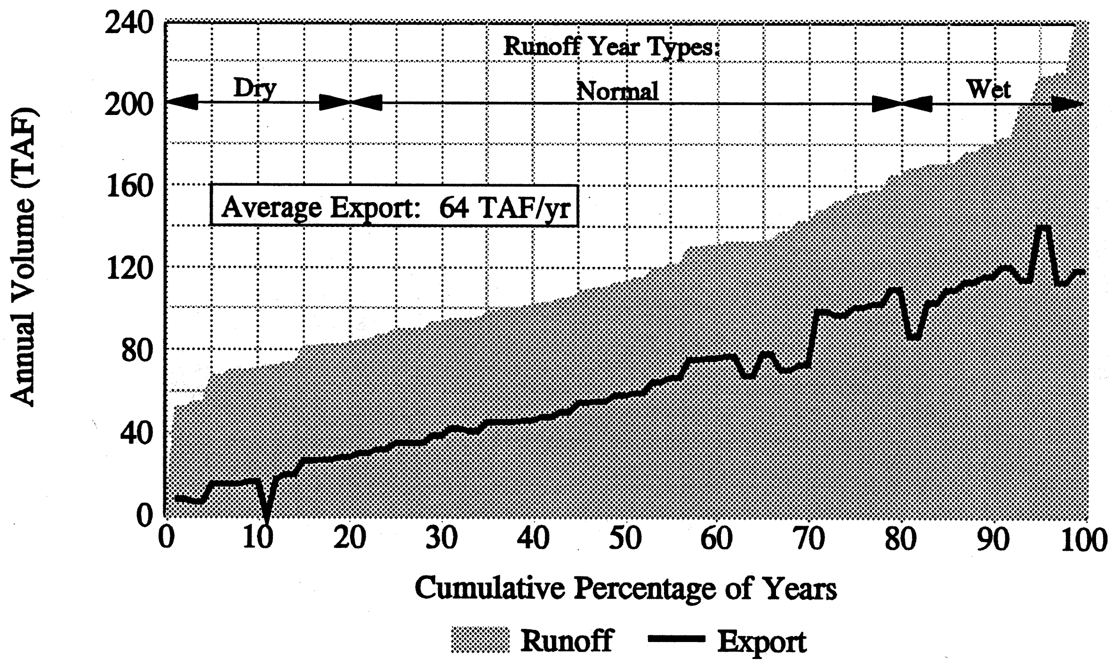
Note: Based on repeated 1940-1989 hydrology starting at a 6,376-ft surface elevation.

Figure 3A-14.
Simulated Mono Lake Surface Elevation
6,372-Ft Alternative



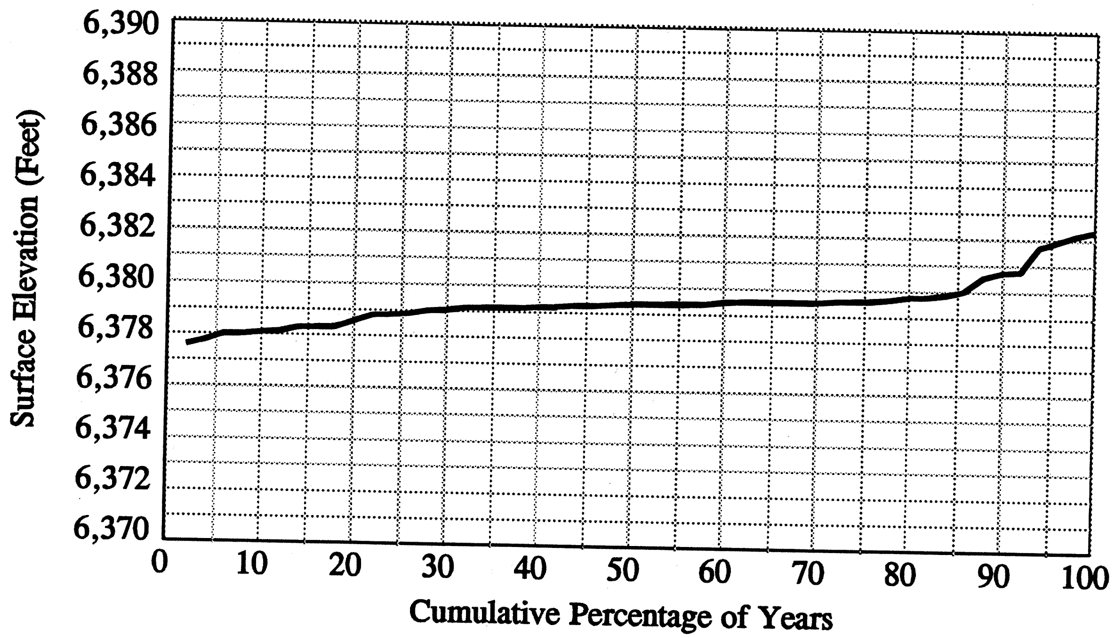
Note: Based on second fifty years of simulated lake elevations.

Figure 3A-15.
Frequency Distribution of Runoff and Simulated Mono Basin Exports
6,372-Ft Alternative



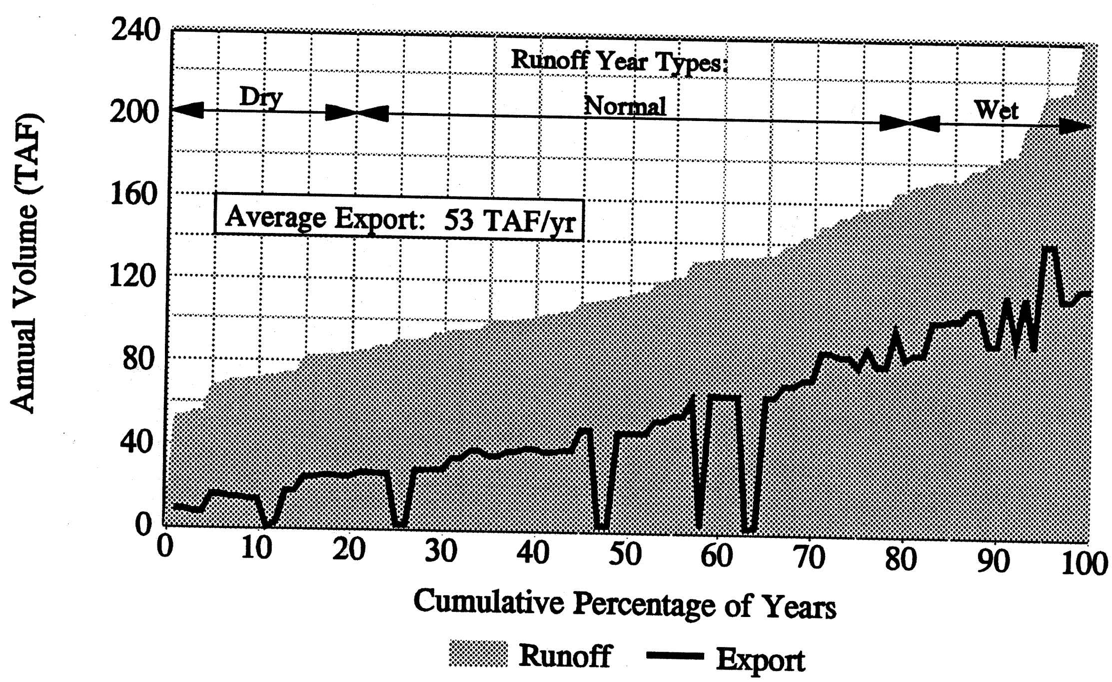
Note: Based on repeated 1940-1989 hydrology starting at a 6,376-ft surface elevation.

Figure 3A-16.
Simulated Mono Lake Surface Elevation
6,377-Ft Alternative



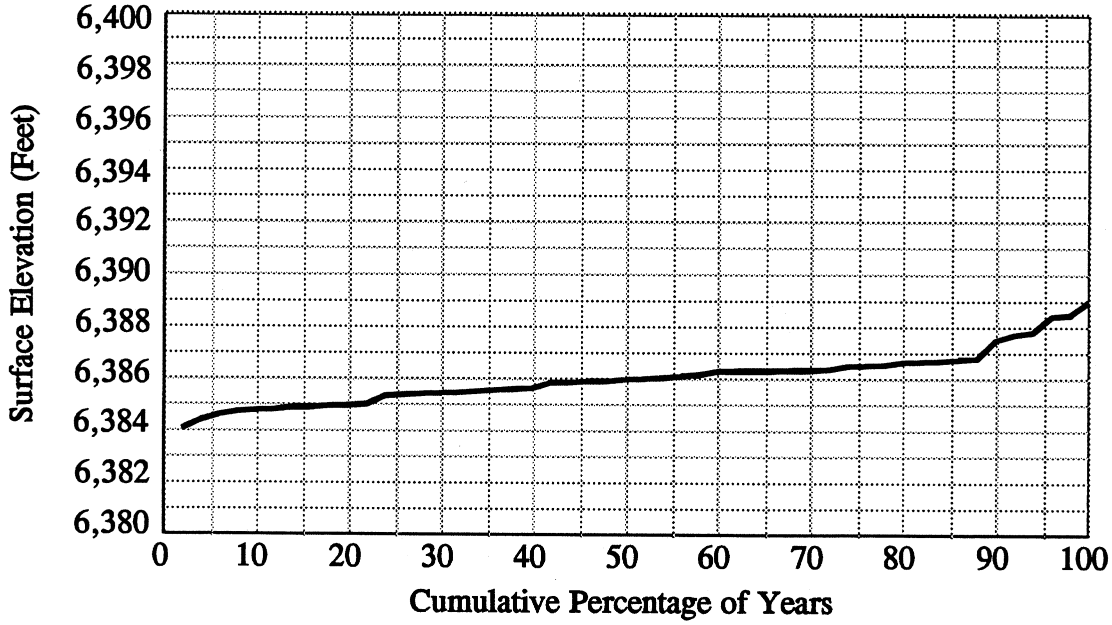
Note: Based on second fifty years of simulated lake elevations.

Figure 3A-17.
Frequency Distribution of Runoff and Simulated Mono Basin Exports
6,377-Ft Alternative



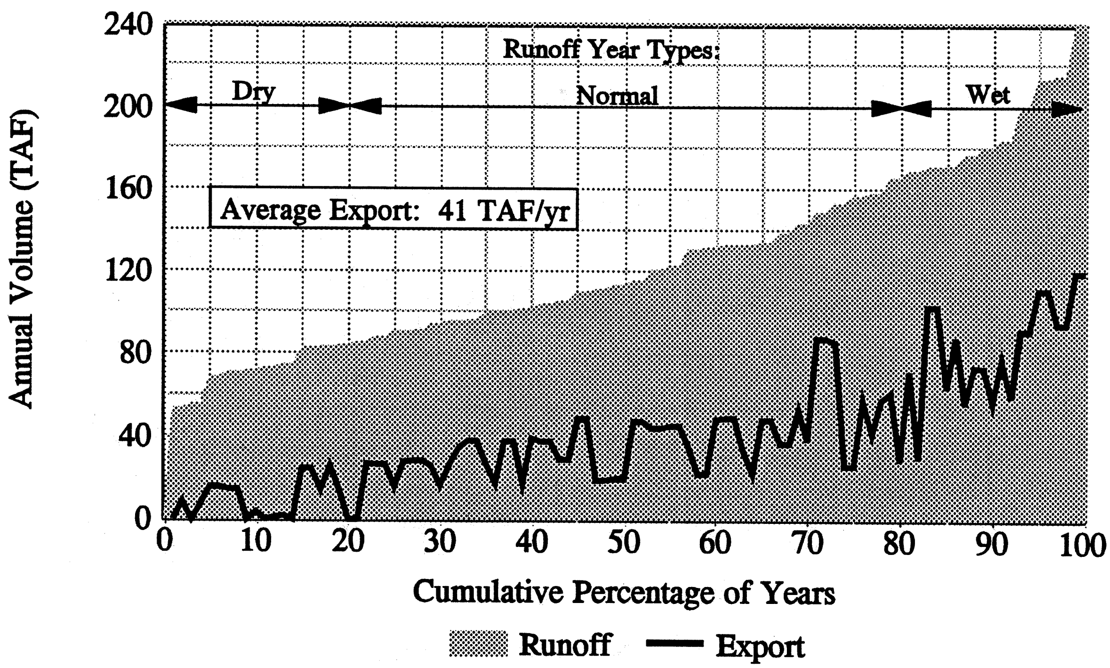
Note: Based on repeated 1940-1989 hydrology starting at a 6,376-ft surface elevation.

Figure 3A-18.
Simulated Mono Lake Surface Elevation
6,383.5-Ft Alternative



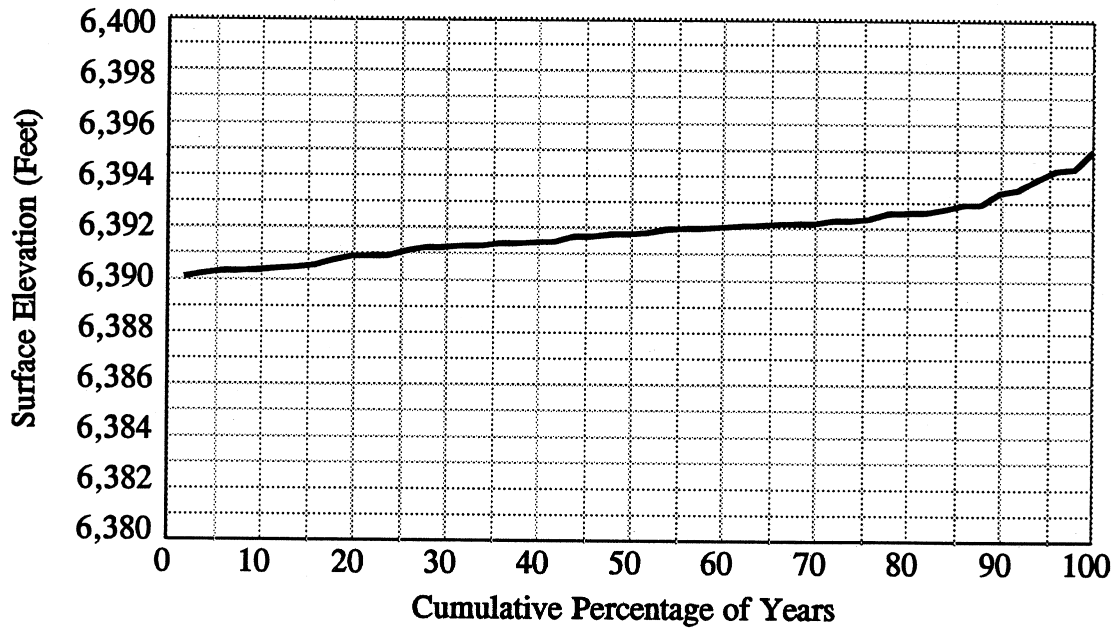
Note: Based on second fifty years of simulated lake elevations.

Figure 3A-19.
Frequency Distribution of Runoff and Simulated Mono Basin Exports
6,383.5-Ft Alternative



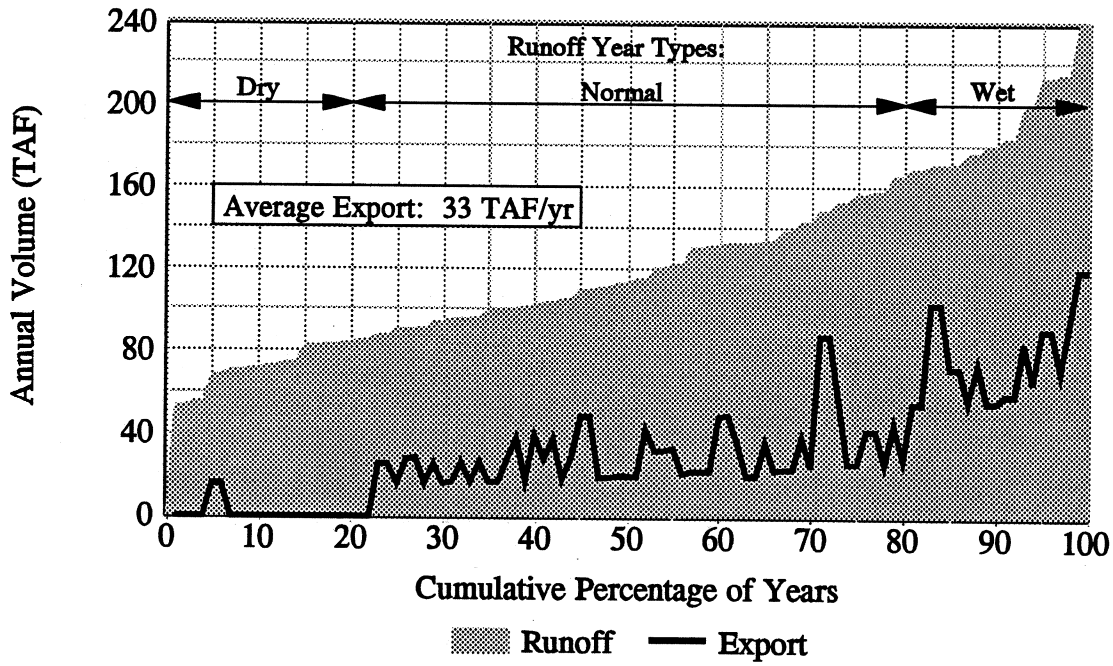
Note: Based on repeated 1940-1989 hydrology starting at a 6,376-ft surface elevation.

Figure 3A-20.
Simulated Mono Lake Surface Elevation
6,390-Ft Alternative



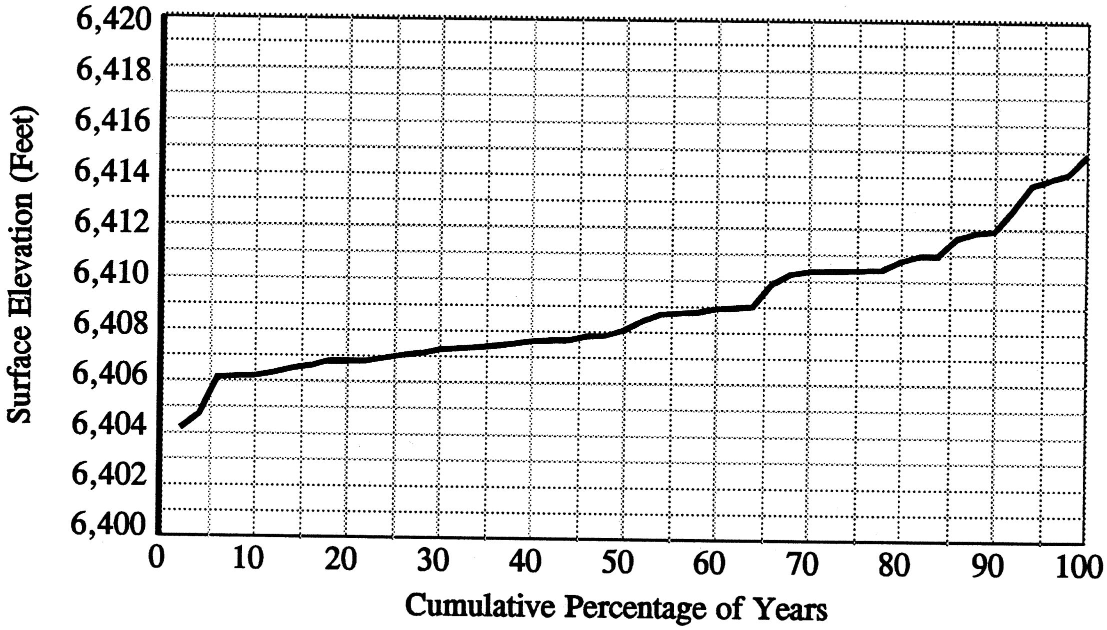
Note: Based on second fifty years of simulated lake elevations.

Figure 3A-21.
Frequency Distribution of Runoff and Simulated Mono Basin Exports
6,390-Ft Alternative



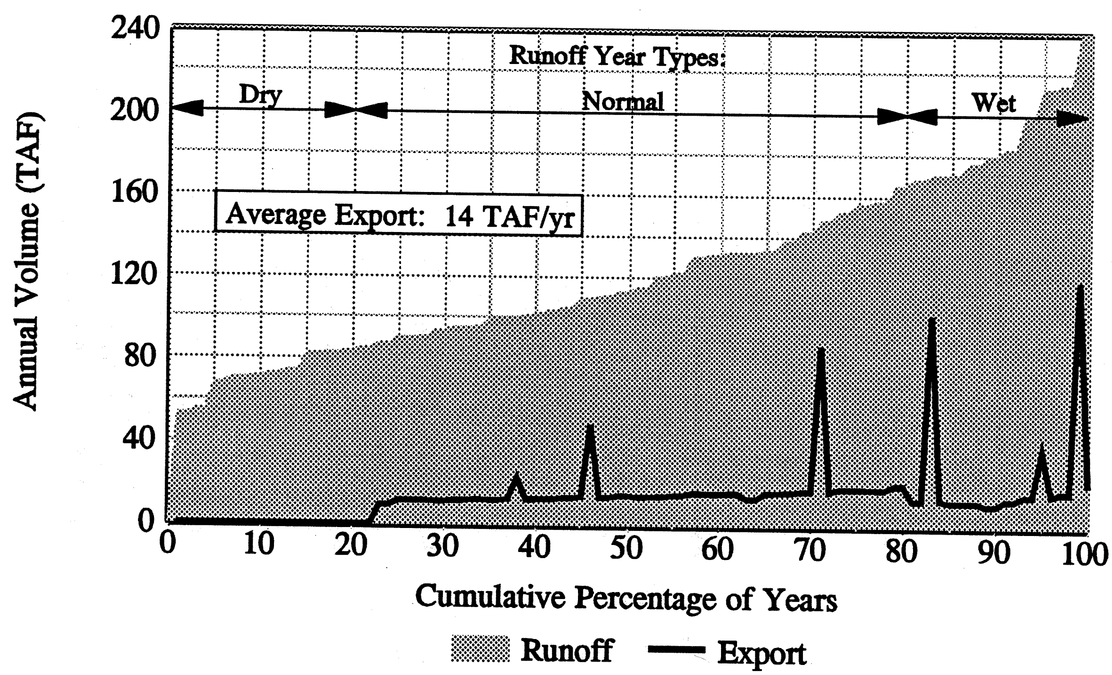
Note: Based on repeated 1940-1989 hydrology starting at a 6,376-ft surface elevation.

Figure 3A-22.
Simulated Mono Lake Surface Elevation
6,410-Ft Alternative



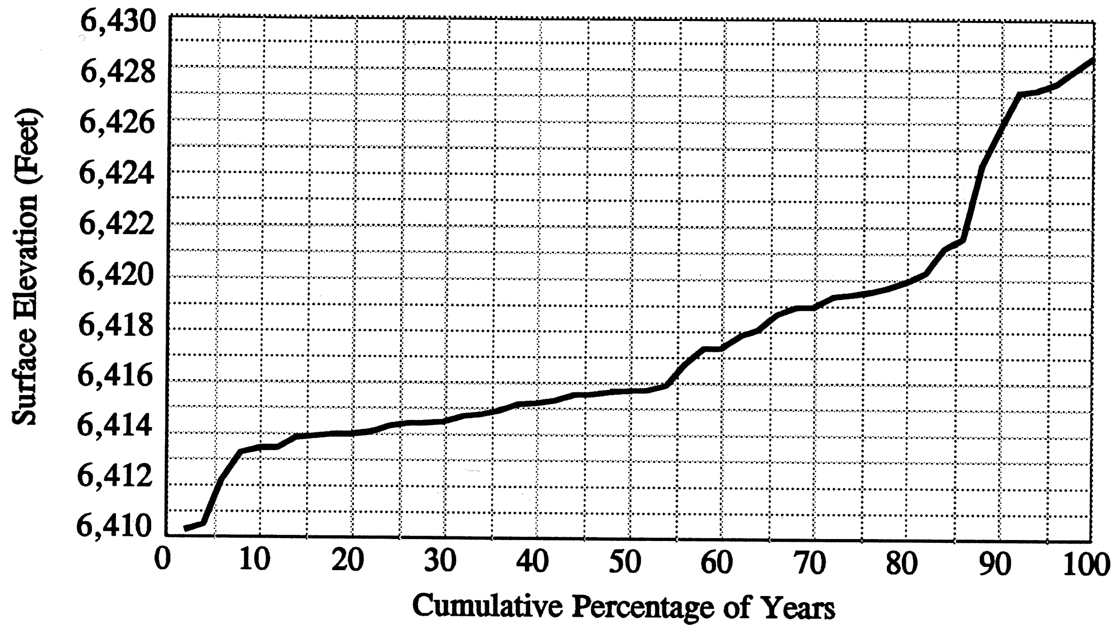
Note: Based on second fifty years of simulated lake elevations.

Figure 3A-23.
Frequency Distribution of Runoff and Simulated Mono Basin Exports
6,410-Ft Alternative



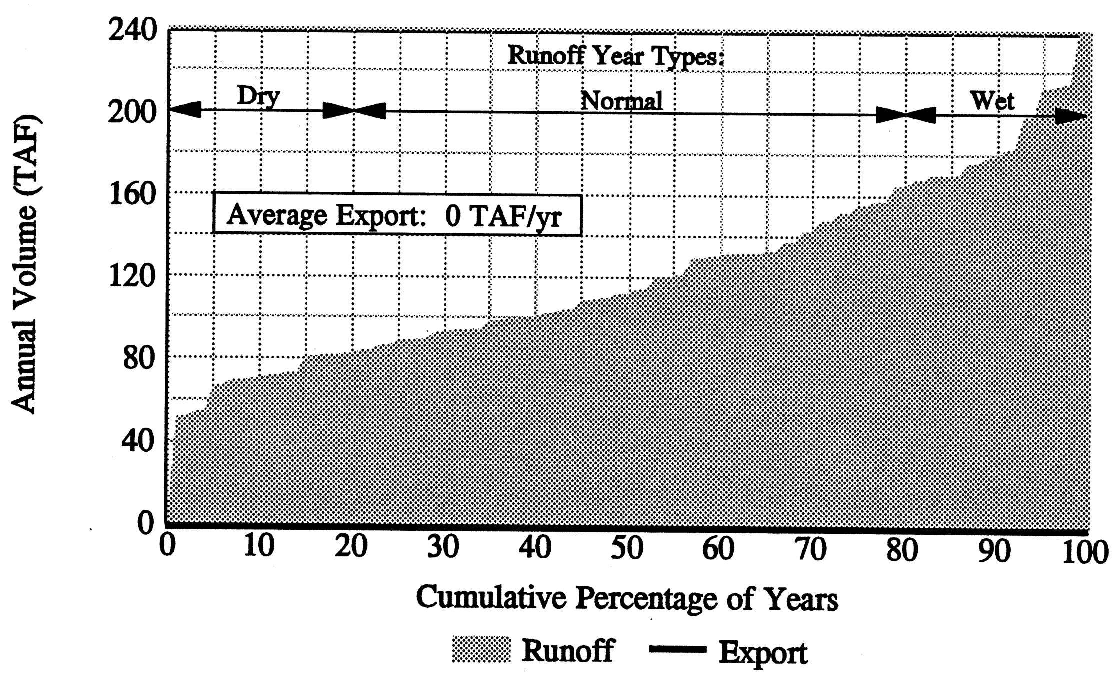
Note: Based on repeated 1940-1989 hydrology starting at a 6,376-ft surface elevation.

Figure 3A-24.
Simulated Mono Lake Surface Elevation
No-Diversion Alternative



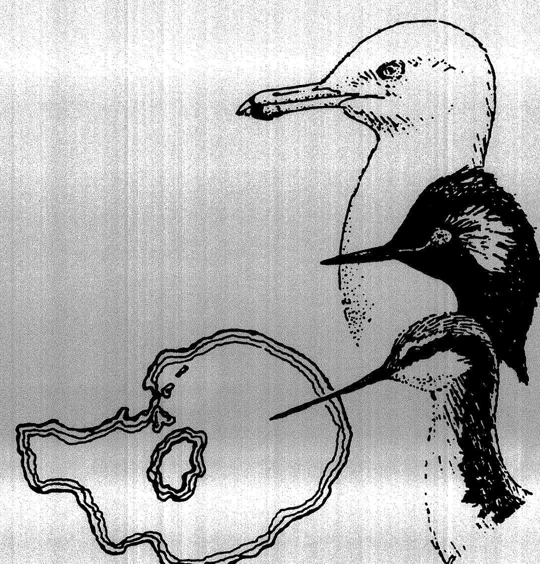
Note: Based on second fifty years of simulated lake elevations.

Figure 3A-25.
Frequency Distribution of Runoff and Simulated Mono Basin Exports
No-Diversion Alternative



Note: Based on repeated 1940-1989 hydrology starting at a 6,376-ft surface elevation.

Chapter 3B. Environmental Setting, Impacts, and Mitigation Measures - Water Quality



Chapter 3B. Environmental Setting, Impacts, and Mitigation Measures - Water Quality

INTRODUCTION

This chapter examines water quality conditions in Mono Lake, the four diverted Mono Lake tributary streams, the Owens River basin, the Los Angeles Aqueduct (LA Aqueduct), and the city's water supply. Available historical data and recent data collected by the SWRCB contractor are discussed. These data have been analyzed to quantify water quality impacts of the alternatives.

Water quality conditions of concern at Mono Lake are all related to salinity levels, which depend almost entirely on the lake volume, which in turn is a direct function of the lake elevation. The bathymetry of the lake is well known (Appendix G). Salinity, alkalinity, and other water quality conditions in Mono Lake can therefore be accurately characterized for any selected lake level. This chapter describes changes in salinity posed by the alternatives, and Chapter 3E, "Aquatic Productivity", describes the significance of such changes as they affect invertebrate productivity in the lake.

Water quality conditions in the LA Aqueduct system depend on the relative mixture of various sources of aqueduct water. Each tributary, major spring, or groundwater source has a characteristic water quality that can be described using average mineral concentrations, although tributary water quality will vary in response to runoff conditions, exhibiting both seasonal and year-to-year variations. Export volumes of the alternatives will affect the mixture of water sources supplying the aqueduct and the city.

APPLICABLE WATER QUALITY STANDARDS AND CRITERIA

The water quality standards and criteria applicable to this EIR are those intended to protect the beneficial uses, including human consumption, designated by the Lahontan Regional Water Quality Control Board (RWQCB) for each stream or lake, or are the general standards and criteria established by SWRCB for surface waters in California. The water quality standards and criteria provide the rational basis for judging the significance of the expected changes in water quality from the point of reference under each alternative.

Water Quality Control Plan for Inland Surface Waters

SWRCB has adopted the Water Quality Control Plan for Inland Surface Waters (SWRCB 1991), establishing statewide water quality objectives for a wide variety of surface water bodies and discharges. The focus of the plan is on reducing all types of discharges of wastes containing toxic pollutants. Different water quality objectives can be adopted by individual RWQCBs in their basin plans for specific sites; however, if these objectives are less restrictive than those in the statewide plan, they would require approval by SWRCB and the U.S. Environmental Protection Agency (EPA).

Numerical water quality objectives have been established for 38 types of pollutants, including 67 priority pollutants identified by EPA. The objectives are applicable to all surface waters, including those used as sources of drinking water. Substances regulated by the SWRCB plan include cadmium, copper, zinc, and other heavy metals; pesticides; chlorinated hydrocarbons; and carcinogens such as arsenic, benzene, and polychlorinated biphenyls (PCBs).

Objectives for some pollutants, particularly carcinogens, are different for water bodies that serve as sources of drinking water. An example is arsenic, which is present in Hot Creek and other tributaries of the Owens River; its concentration in the aqueduct could be affected by Mono Basin export alternatives. The existing maximum contaminant level (MCL) for arsenic in drinking water is 50 micrograms per liter (μg/l). However, because arsenic is an identified carcinogen, SWRCB reduced the limit in surface waters used for drinking to 5 μg/l in the plan. As adopted, the new plan criterion could be applicable to drinking water supplies with arsenic concentrations exceeding the objective of 5 μg/l. Under the Clean Water Act (40 CFR 131.10[g]), exceptions to water quality objectives can be granted if the source of the pollutant is natural. Because SWRCB has not decided if the new plan criterion will apply to Grant Lake reservoir or Lake Crowley reservoir outflows, the established MCL is still considered applicable.

Lahontan Regional Water Quality Control Basin Plan

The Porter-Cologne Water Quality Control Act of the State of California (1969 statutes) designates SWRCB and the RWQCBs as the principal agencies with responsibility for control of water quality. The primary mechanism by which control is accomplished is a region-specific water quality control plan or basin plan. Mono Basin and the Owens River system are in the South Lahontan Basin, RWQCB, Region 6 (RWQCB Lahontan Region 6 1987).

The key elements specified in the Lahontan basin plan for the maintenance of water quality are:

- identification of beneficial uses and the water quality objectives necessary to maintain those uses,
- problem assessments and control measures, and
- an implementation plan to manage identified problems.

The existing Lahontan basin plan, adopted in 1975 and amended from time to time thereafter, is being revised. The draft basin plan incorporating these revisions has been circulated, and public workshops have been held. The final revised basin plan must be completed and approved by EPA by September 1993 (Rofer pers. comm.). Significant changes proposed in the revised Lahontan basin plan are discussed below.

Beneficial uses are a controlling factor in establishing water quality objectives for a particular water body or group of water bodies. Beneficial uses are identified during the development of a water quality control plan, and the level of water quality needed to protect and maintain those uses is determined. The existing and proposed beneficial uses for the diverted tributaries and Mono Lake are given in Table 3B-1.

The water quality objectives in the basin plan are in both written form, constituting the majority of the objectives listed, and numeric form. Written objectives include descriptive limitations on water quality parameters, such as color, taste, and odor; floating material; suspended material; and toxicity. Toxicity objectives in the revised basin plan have been expanded to include chlorine residue and ammonia limits and have been clarified. Numeric objectives for conventional pollutants, which include turbidity, pH, dissolved oxygen, unionized ammonia, total dissolved solids (TDS), chloride, sulfate, fluoride, boron, and nutrients, have undergone minor changes in the revised basin plan. The most significant proposed revision incorporates numerical objectives for toxic pollutants from the Inland Surface Waters Control Plan.

The purpose of the monitoring and compliance program is to measure water quality changes and identify the effects of any changes on established beneficial uses. The monitoring and compliance program must identify sources of water quality degradation and provide for collecting and analyzing samples and preparing reports. The monitoring and compliance program requirements are being revised in the new plan to allow for changing program needs and funding.

Water quality objectives for the salinity of Mono Lake in the existing basin plan call for salinity limits that had recently been surpassed at the time of plan formulation in 1975. The TDS objective of 76 grams per liter (g/l) has been exceeded since 1972, when the lake surface elevation fell below 6,386 feet. The chloride objective of 17.7 g/l has also been exceeded. Salinity objectives of the revised basin plan may change.

Federal Antidegradation Policy

EPA water quality standards and regulations require that each state have an antidegradation policy. This policy must, at a minimum, be consistent with the principles set forth in the Federal Antidegradation Regulation (40 CFR 131.12), which serves as a baseline water quality narrative standard to be applied where other water quality standards are too general or do not address a particular pollutant. This regulation was adopted in November 1975 and applies to actions affecting water quality after that date, including diversions of water.

In November 1975, the Mono Lake surface elevation was approximately 6,379.3 feet, with a salinity of 85 g/l. Although water diversions were initiated before 1975, water diversions continuing after 1975 have influenced the water surface elevation and salinity of Mono Lake. The Federal Antidegradation Regulation is therefore applicable to SWRCB's water rights decision-making process.

Federal Policy

The federal antidegradation policy stems from the fundamental objective and certain related goals of the Clean Water Act (Federal Water Pollution Control Act as amended by the Water Quality Act of 1987). Section 101(a) states:

> The objective of this act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters.
>
> Section 101(a)(2) states:
>
> The national goal is that whenever attainable, an interim goal of water quality which provides for protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved.

The antidegradation policy (40 CFR 131.12) establishes a three-part test (tiered approach) to maintaining and protecting water quality and beneficial uses (as set forth in 40 CFR 131.12). The first tier as set forth in Section 131.12(a)(1) requires that "existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected."

The second tier of the antidegradation policy is set forth in Section 131.12(a)(2) as follows:

> Where the quality of the waters exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the State finds, after full satisfaction of the intergovernmental coordination and public participation

provisions of the State's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the State shall assure water quality adequate to protect existing uses fully. Further, the State shall assure that there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control.

The third tier, as set forth in Section 131.12(a)(3), requires:

Where high quality waters constitute an outstanding National resource, such as waters of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.

Tier I establishes the absolute baseline for water quality for the surface waters of the United States in that all existing beneficial uses and the water quality necessary to support them must be maintained as a minimum.

Tier II applies to waters in which the quality exceeds that necessary to support the existing beneficial uses. Water quality reductions in these waters can be allowed, provided that existing uses are fully protected and that important socioeconomic need for such degradation is demonstrated.

Tier III precludes allowing water quality degradation in waters that are viewed as exceptional resources, such as Outstanding National Resource Waters (ONRW) or waters that could qualify for ONRW designation.

California Policy

The federal water quality policy requires that each state develop and adopt a state-wide antidegradation policy. In California, this requirement is satisfied by SWRCB Resolution No. 68-16 (Order No. WQ 86-17), the "Statement of Policy with Respect to Maintaining High Quality of Waters in California". The SWRCB has interpreted Resolution No. 68-16 to incorporate the federal antidegradation policy in situations where the federal policy applies.

As part of state policy for water quality control, Resolution No. 68-16 applies to actions of the RWQCB and is incorporated in each regional basin plan. It is also incorporated in SWRCB-adopted plans, such as the Inland Surface Waters Control Plan. Resolution No. 68-16 serves as both a water quality standard in and of itself and as a guide for standard setting and other regulatory decisions.

Mono Lake as an ONRW

As described above, possible candidates for ONRW designation include waters of the state and national parks, wildlife refuges, and waters of exceptional recreational or ecological significance. In California, Lake Tahoe is the only water that has been designated as an ONRW; however, other waters of this state are likely to meet the criteria for designation.

Mono Lake is a possible candidate for ONRW designation. The unique or important resource values of Mono Lake have previously been recognized by the following designations:

- **Mono Basin National Forest Scenic Area.** The Mono Basin National Forest Scenic Area was designated by Congress in 1984 to protect the natural, cultural, and scenic resources of Mono Basin. The Mono Basin National Forest Scenic Area is the first of its kind in the National Forest system.

- **Mono Lake Tufa State Reserve.** The Mono Lake Tufa State Reserve was established in 1982 to preserve its native ecological associations, unique fauna or floral characteristics, geological features, and scenic qualities in a condition of undisturbed integrity.

- **Western Hemisphere Shorebird Reserve Network Member.** Mono Lake has been designated as part of the Western Hemisphere Shorebird Reserve Network. Mono Lake is one of 17 other worldwide reserves located in Argentina, Brazil, Canada, the United States, and Surinam.

As stated in 48 FR 51402, ONRW are "waters of exceptional recreational or ecological significance". This may include waters of exceptionally high quality. ONRW may also include water bodies which are important, unique, or sensitive ecologically, but whose water quality as measured by traditional parameters may not be particularly high or whose character cannot be adequately described by these parameters. Based on data developed for this EIR, Mono Lake would qualify for nomination as an ONRW.

ONRW may be designated as part of adoption or amendment of water quality control plans. The Lahontan RWQCB may amend the existing South Lahontan Basin Plan as a result of the SWRCB's water rights decision. The different lake level alternatives result in different lake salinities that may result in the need for an amendment to the basin plan standards. If Mono Lake is identified as an ONRW, protection of its water quality consistent with federal antidegradation regulations requires that lake salinity be maintained at or less than the 85 g/l concentration that existed in November 1975.

California Department of Health Services Criteria for Identification of Hazardous Wastes

As a part of the studies described in this chapter, reservoir bottom sediments have been sampled to determine concentrations of bioaccumulative or persistent substances. These concentrations can be compared to State of California standards for the identification of hazardous wastes, which are expressed as total threshold limit concentrations (TTLC). These standards, developed for purposes of requiring proper management of hazardous wastes from manufacturing and other human activities to protect human health (Title 26 of the California Code of Regulations), are used here for comparative purposes in characterizing the quality of water-borne sediments.

WATER QUALITY PARAMETERS OF CONCERN AND LOCATIONS OF INTEREST

Water Quality Parameters

Water quality parameters can be generally classified as:

- mineral parameters,
- nutrients and organics,
- particulates and adsorbed metals, and
- sediment quality parameters.

Mineral parameters include the major anions and cations (calcium, magnesium, sodium, potassium, chloride, sulfate, and bicarbonate), trace elements (boron, fluoride, and bromide), silica, alkalinity, hardness, TDS, and electrical conductivity (EC). Nutrient and organic parameters include nitrate, ammonia, total Kjeldahl nitrogen, total and dissolved phosphorus, total organic carbon, chlorophyll, and color. Particulates and adsorbed metals include total suspended solids (SS), turbidity, arsenic, barium, selenium, aluminum, cadmium, chromium, copper, iron, mercury, manganese, lead, and zinc. Not all parameters sampled historically in Mono Basin and Owens River basin were selected for assessment in this EIR.

EC has been selected as the indicator mineral parameter because it has been consistently measured in the most samples from all locations and is related to drinking water quality. Chloride and fluoride have been selected as other mineral parameters directly related to drinking water quality. Arsenic and phosphorus have been selected as parameters directly related to aquatic toxicity or eutrophication in Lake Crowley reservoir. Arsenic has been identified in the Inland Surface Waters Control Plan as a human carcinogen, as described previously.

Locations of Interest

Primary locations of interest include Mono Lake, primarily because of salinity effects on invertebrate productivity, and the East Portal, which provides a water quality characterization of Mono Basin water exported for water supply. Water quality has been sampled in Mono Lake and at several locations along the Mono Lake tributaries. LADWP has conducted special surveys of Mono Basin springs and groundwater wells (LADWP 1986).

The primary location of interest for impact assessment in the Upper Owens River basin is the outlet from Lake Crowley reservoir, which is a major contributor to the aqueduct water supply. Important sampling sites include the Owens River above the East Portal (Big Springs), the East Portal (export outlet from Mono Basin), the Owens River below the East Portal, Mammoth Creek, Hot Creek below Hot Springs, Owens River at Benton Crossing, and several Lake Crowley reservoir tributaries (Convict, McGee, Hilton, Crooked, and Rock Creeks). Limnological studies have been performed at stations in Lake Crowley reservoir. The reservoir outlet also has been sampled extensively by LADWP.

Other locations of interest and places where historical water quality data are available include the inflow to the LA Aqueduct filtration plant and the other primary water sources delivered by MWD to the city: the Colorado River Aqueduct and California Aqueduct.

PREDIVERSION CONDITIONS

Sources of Information

Mono Lake water quality was first sampled by I. C. Russell during his geological survey of Mono Basin in 1883 (Russell 1984 [c1884]). LADWP has maintained records of lake elevations since 1912 and has measured TDS at various locations in Mono Lake since 1937. Water samples were collected in the early 1930s by the Pacific Alkali Company while it was exploring possible commercial recovery of salts from Mono Lake.

Mono Lake Water Quality

Mono Lake is a closed hydrologic system with no outlet. Inflow from tributaries, groundwater, and mineral springs contain dissolved salts, which have accumulated in the lake for thousands of years. Geothermal processes have contributed an unknown portion of the minerals. Continual surface evaporation has concentrated the minerals.

Although salts continue to accumulate and concentrate in Mono Lake, these processes proceed so slowly that the total mass of dissolved salts in Mono Lake can be considered a constant. It is estimated that 285 million tons of minerals are dissolved in Mono Lake (LADWP 1987). Based on the bathymetry of the lake, the estimated salinity as measured by TDS was 48 g/l in 1941 when the lake stood at 6,417 feet and the diversions began. (The method of estimating salinity for various lake levels is described in the "Impact Assessment Methodology" section.) The prediversion salinity was about 37% greater than ocean salinity, which is approximately 35 g/l.

Water Quality at Other Locations of Interest

The characteristic water quality of various streams in Mono Basin and Owens River basin was similar in the prediversion period to water quality at the point of reference. Water quality at the locations of interest depended, as today, on the mix of sources utilized. Water quality data were first collected by LADWP in 1933, and data from 1933 through 1991 are used in the following section to characterize water quality variations at the other locations of interest.

ENVIRONMENTAL SETTING

Sources of Information

This section presents and interprets water quality data collected from surface and groundwater sampling stations operated by several agencies in Mono Basin and Owens River basin from 1933 through 1991. LADWP and U.S. Geological Survey (USGS) provided the majority of the measurements. In addition, SWRCB contractors conducted a field sampling program in 1991 in Mono Basin and Owens River basin to augment and verify existing water quality data.

Much of this water quality data has been organized into computer data files to allow for graphical and statistical analyses. Auxiliary Report No. 17, "Water Quality Data Report", (Jones & Stokes Associates 1993) was prepared from these data files and provides a detailed description and summary of the available information.

Several LADWP reports on hydrology and water quality in Mono Basin, geothermal investigations by USGS and California Department of Water Resources (DWR) in Long Valley, and Lahontan RWQCB reports were obtained to provide general water quality information and identify potential water quality impact issues. However, no comprehensive document summarizes and characterizes general water quality throughout the city's aqueduct system, so this water quality assessment relies primarily on the analyses of historical data presented in the auxiliary report.

Mono Lake Data Sources

In July 1964, D. T. Mason (1967) collected samples of Mono Lake waters and analyzed previous data as part of a limnological survey. He attempted to characterize the chemical composition of the water using ratios of individual ions to chloride and described the correlation between lake volume and ion concentrations. Metals and other previously unmeasured trace elements also were analyzed in this survey.

A limnological study conducted in 1974 by students and faculty from UC Davis did not specifically collect water quality samples, but nutrient determinations were part of their primary productivity experiments (Winkler 1977).

LADWP collected samples at several depths and locations in different seasons during 1974 and in subsequent years to provide the first comprehensive sampling of Mono Lake mineral water quality. Nearly 250 samples have been collected from Mono Lake. Water quality samples also were analyzed by LADWP from two ponds used for evaporation suppression experiments between 1980 and 1983. Combined, these data provide an accurate characterization of the mineral water quality of Mono Lake. Metals and trace elements have not been routinely measured and are less accurately known.

Graduate students and staff from UC Santa Barbara have conducted limnological surveys of Mono Lake since 1979, measuring salinity, temperature, light absorption, nutrients, chlorophyll, and brine shrimp lifestages. Nutrients (ammonia and phosphorus) have been regularly sampled. Minerals and metals have not been analyzed routinely. These limnological data have been organized in a database (Dana et al. 1990).

Data Sources for Other Areas of Interest

Historical water temperature data for the four Mono Basin tributaries are sparse. Data were collected for the Rush Creek Instream Flow Incremental Methodology (IFIM) study in 1987 (California Department of Fish and Game 1991). Water temperature monitors were placed at four locations in lower Rush Creek: Grant Lake reservoir outlet, old U.S. Highway 395 (U.S. 395) bridge, downstream of Walker Creek, and the culvert crossing upstream of County Road. Data were collected from July 1987 to July 1988.

Rush Creek temperatures were monitored in August-October 1991 at the same four locations as for the 1987 study, and temperatures in Lee Vining Creek were measured below the LADWP diversion, below U.S. 395, and at the mouth as part of the stream restoration efforts (Trihey & Associates 1992). Temperatures in Walker and Parker Creeks were measured at the confluence of Rush Creek during August-October 1991.

Available water quality data at Hot Creek include historical LADWP mineral measurements and data collected by USGS between 1982 and 1991 for selected minerals indicative of geothermal sources. The USGS data and the SWRCB contractor samples from 1991 provide the opportunity to confirm the LADWP data for Hot Creek.

EPA conducted a water quality study of Lake Crowley reservoir in 1975 during the National Eutrophication Survey, a sampling program initiated in 1972 to investigate the threat of accelerated eutrophication in freshwater lakes. Three stations were sampled during June and November 1975 for chemical parameters indicative of eutrophication, including nutrients and chlorophyll *a*. Melack and Lesack (1982) conducted a research program in 1982 to evaluate algal growth dynamics and potential algal growth controls.

SWRCB contractors conducted bimonthly water quality studies of Lake Crowley reservoir from May to September 1991. Data were collected from four sampling locations: Dam Arm, Chalk Cliffs, Green Banks, and McGee Bay. Temperature, pH, conductivity, and dissolved oxygen (DO) data were collected at 1-meter increments from the surface to the lake bottom. Minerals, nutrients, metals, and chlorophyll *a* samples were collected at the surface at each station and from the bottom near the dam. LADWP has collected monthly samples of Lake Crowley reservoir outlet for minerals since 1940.

LADWP has collected monthly water quality samples at Tinemaha Reservoir outlet since 1933. USGS sampled the outlet monthly for most parameters from 1974 to 1986 and collected daily measurements of conductivity from 1975 to 1981. The USGS data generally confirm the LADWP data.

Water Quality Conditions in Mono Basin

Mono Lake

Salinity. The calculated average salinity of Mono Lake water at elevation 6,376.3 feet (the point of reference) was approximately 90 g/l, or nearly 90% greater than the prediversion condition and more than 2.5 oceanic salinity. This increase reflects the corresponding decrease in lake volume over the diversion period. Estimated salinities for 1913-1991 are shown in Figure 3B-1.

Mineral Quality. Evaporation pond experiments conducted by LADWP indicate that the chemical composition of Mono Lake water remains constant even at TDS values above 150 g/l. Mineral precipitation in addition to calcium and magnesium is apparently not a significant factor at or below these concentrations. Because the composition of dissolved salts in Mono Lake can be considered constant, it is possible to estimate individual ion concentrations for various lake levels from estimates of the total salt concentration.

Sodium (39%), alkalinity (as bicarbonate) (24%), and chloride (23%) are the dominant minerals in Mono Lake. In addition, sulfate contributes 13% and potassium 2% to TDS. Calcium and magnesium concentrations are quite low. Table 3B-2 shows summary statistics for the LADWP mineral water quality data from Mono Lake, including the evaporation pond measurements. (The measurements have been standardized to a TDS of 100 g/l based on the average estimated TDS at the time of measurement.) Sampling shows that the major ion concentrations appear to increase linearly with TDS concentration.

Boron, fluoride, and arsenic concentrations are extremely high in Mono Lake, reflecting the influence of geothermal springs and other volcanic inputs. The boron concentration of 475 milligrams per liter (mg/l) (for 100 g/l TDS) is one of the highest concentrations in any saline lake (NAS 1987). The fluoride concentration of 65 mg/l and the arsenic concentration of 17 mg/l are extremely high, but acute toxicity of the Mono Lake brine shrimp (*Artemia monica*) or alkali fly (*Ephydra hians*) apparently does not occur. Mason (1967) reported toxicity to *Artemia* adults at higher concentrations of more than 250 mg/l for fluoride and more than 50 mg/l for arsenic.

Nutrients and Temperature. Mono Lake is thermally stratified seasonally. Density of water increases with salinity but decreases with temperature. Because of the high salt content of Mono Lake, density continues to increase with cooling to 0°C. Ice formation is rare on the surface of Mono Lake because cooling surface water becomes more dense than underlying water and sinks. This high salinity permits complete mixing of the water column, in contrast to fresh water, which decreases in density once it cools below 4°C and rises to the surface. (Temperature and salinity profiles from Mono Lake measured between 1983 and 1991 are available [University of California, Santa Barbara 1990]).

Mono Lake becomes salinity stratified in years with large freshwater inflows (1983 and 1986). Vertical mixing across the chemocline is an important mechanism for supplying nutrients into the euphotic zone for phytoplankton growth and erosion of chemical stratification (NAS 1987).

The nutrients nitrogen and phosphorus often limit algal productivity in lakes. In Mono Lake, phosphate is present in substantial concentrations (88 mg/l at a TDS of 100 g/l), but nitrogen (ammonia) concentrations are usually low. Nitrogen is the limiting nutrient for algae growth, and ammonia is the only inorganic nitrogen form present in Mono Lake (University of California, Santa Barbara 1990). Nitrate concentrations are low because nitrifying bacteria that usually oxidize ammonia to nitrate in aquatic systems are absent in Mono Lake.

The effects of thermal and salinity stratification on nutrient supply and aquatic productivity are discussed in Chapter 3E, "Aquatic Productivity".

Metals. Metals have not been routinely measured in Mono Lake, with the only published values presented by Mason (1967). These data are given in Table 3B-2 (adjusted from the measured TDS to the reference TDS of 100 g/l).

Diverted Mono Lake Tributaries and Grant Lake

Water quality in the major tributaries (Lee Vining, Walker, Parker, and Rush Creeks) is typical of eastern Sierra Nevada snowmelt runoff streams. This area is largely undeveloped and undisturbed above the LADWP diversion structures, except for recreation-residential developments near June Lake and on Rush and Walker Creeks and recreational facilities on Lee Vining Creek. Natural weathering and erosion processes are the main factors affecting water quality in these streams. A seasonal difference in quality between groundwater-fed baseflow and snowmelt runoff can be measured.

Temperature. Water temperatures in Lee Vining, Rush, Parker, and Walker Creeks depend on streamflow and weather conditions. Reduced and eliminated streamflows from the diversions created dry downstream conditions, which led to substantial losses in riparian vegetation (Chapter 3C, "Vegetation"). Streambank shading from riparian vegetation generally cools and moderates temperature changes. Because of the losses of riparian vegetation, the streams are now less protected from solar radiation and daily air temperature extremes.

Water temperatures at monitoring stations along the tributary streams exhibited similar patterns, although the magnitude of temperature fluctuation increased downstream. The dry, clear atmosphere of the 7,000-foot elevation, combined with the general absence of shading, causes solar radiation and the diurnal temperature variations to dominate stream thermal dynamics. Water temperatures exhibited the least variation at Grant Lake reservoir outlet, with a maximum daily difference of about 3°C. Diurnal variations of up to 15°C were observed at the downstream stations. The warmest water temperatures occurred in July and August (maximum 27.5°C), and the coldest temperatures occurred in December and January (near 0°C).

Temperatures measured during the 1991 sampling period indicated that Lee Vining Creek temperatures were coldest, Walker and Parker Creeks temperatures were intermediate, and Rush Creek temperatures were warmest. Table 3B-3 gives the monthly average temperatures observed in Walker, Parker, Rush, and Lee Vining Creeks during the IFIM studies and grab measurements during the 1991 SWRCB contractor sampling surveys. A discussion of stream temperature effects on fisheries can be found in Chapter 3D, "Fishery Resources".

During the 1991 SWRCB contractor sampling program, limited temperature stratification was observed at the inlet area of Grant Lake reservoir. Maximum temperature differences between surface and bottom samples were generally about 2°C and were apparently caused by cool inflow temperatures. Temperature stratification was much weaker at the outlet of Grant Lake reservoir. Surface temperatures were similar at the inlet and outlet location.

Minerals. The mineral content of the Mono Lake tributaries is very low, similar to other high-quality Sierra Nevada streams. These streams have a low alkalinity and hardness and low concentrations of calcium, magnesium, sodium, potassium, and other ions. Concentrations of all mineral parameters are low enough to result in excellent drinking water quality.

The quality of water from Grant Lake reservoir outlet, monitored by LADWP for selected parameters since 1934, results from a mixture of the four tributary streams that constitute Mono Basin's export. Table 3B-4 provides a summary of LADWP and SWRCB contractor data collected at Grant Lake outlet. The 1991 SWRCB contractor data generally conform to the LADWP historical data, suggesting that runoff quality has remained unchanged.

The low mineral content of the Mono Lake tributaries contrasts with geothermal springs and groundwater sources in the Owens River basin. Table 3B-5 gives the average mineral quality for Grant Lake reservoir outlet and each of the other major sources of water for the LA Aqueduct system.

Nutrients, Organics, and Metals. Mono Lake tributary streams are very low in nitrogen and phosphorus. Chlorophyll *a* values in Grant Lake reservoir ranged from 0.9 to 13.3 $\mu g/l$, with an average of 5.8 $\mu g/l$, indicating an oligotrophic (low in nutrients and therefore low biological productivity), high-altitude reservoir. Trace element concentrations were frequently undetectable or very low in Grant Lake reservoir outlet.

Sediment Quality. SWRCB's contractor sampled sediment at four locations in Grant Lake reservoir during July 1991, and laboratory analyses are presented in the water quality auxiliary report. Mineral and metal sediment concentrations were generally higher at the outlet than at the other sampling locations, but all were well within normal background ranges.

Water Quality Conditions in the Owens River Basin

Upper Owens River Sources

Geothermal activity strongly influences water quality in the Upper Owens River basin upstream of Lake Crowley reservoir. Visible geothermal activity consists of hot springs, fumaroles, and thermally altered rock centered primarily around Hot Creek, Little Hot Creek, Casa Diablo Hot Springs, Whitmore Hot Springs, and the Alkali Lakes (California Department of Water Resources 1967). These phenomena are associated with past volcanism, which has recently shown signs of renewal in the area.

East Portal. Exports from Mono Basin emerge from the Mono Crater Tunnel at East Portal and flow into the Upper Owens River. Water quality in the East Portal is influenced by a nearly constant tunnel inflow of mineralized groundwater, referred to as "tunnel make" by LADWP. Its mineral character dominates the quality of East Portal when exports from Mono Basin are low.

East Portal conductivity is strongly correlated with flow, as shown in Figure 3B-2. Measured conductivity at East Portal has ranged from 75 to 450 microsiemens per centimeter (μS/cm), but in 1991, when no exports occurred, conductivity remained high at about 408-433 μS/cm. (A microsiemen is a standard unit of electrical conductivity across 1 centimeter of water.) The dilution of highly mineralized tunnel make with Mono Basin export flows can be described mathematically and used to predict impacts of alternative export rates. Similar relations are observed at other locations where a runoff source is diluting a geothermal or groundwater baseflow. Tunnel water quality is summarized in Table 3B-5; as shown, nutrient, organics, and metal concentrations are generally low.

Owens River above East Portal (Big Springs). Big Springs is a relatively constant groundwater spring that provides baseflow for the Upper Owens River. Deadman Creek, Glass Creek, and other tributaries provide additional runoff from snowmelt. The average annual flow for Big Springs is approximately 50 cfs, based on historical LADWP flow data.

Conductivity at Big Springs (measured during the 1991 sampling program) is about half that of the East Portal tunnel inflow water, but several times that of the exports (Table 3B-5).

Arsenic and fluoride are accurate indicators of geothermal sources. Arsenic concentrations in Big Springs increase directly with EC. Fluoride concentrations in Big Springs and the tunnel inflow water are similar and higher than from other sources. Arsenic and fluoride concentrations are much higher than those measured at Grant Lake reservoir outlet and indicate some geothermal influence at Big Springs.

Historical and 1991 nitrate concentrations in Big Springs are very low, and phosphate concentrations in Big Springs are relatively high. Concentrations of metals other than arsenic are generally less than detection limits.

Hot Creek below Hot Springs. Hot Springs, the major geothermal spring in the Upper Owens Valley, discharges into Hot Creek about 2 miles below DFG's Hot Creek Fish Hatchery. Above Hot Creek Fish Hatchery, the creek is known as Mammoth Creek. Hot Creek water quality is poor and therefore exerts a considerable influence on downstream water quality, although conductivity is only somewhat higher than that of the tunnel inflow water (Table 3B-5).

Minerals. High conductivity values in Hot Creek indicate the strong geothermal influence from Hot Springs. Conductivities generally range from about 500 to 700 μS/cm, except when spring runoff from Mammoth Creek dilutes geothermal sources (U.S. Geological Survey 1984). Flows are well correlated with conductivity (Figure 3B-3), reflecting the relatively constant source of dissolved salts from Hot Springs.

The concentrations of all minerals increase with conductivity. Calcium and magnesium concentrations are relatively low, with 12 mg/l and 5.5 mg/l mean values, respectively (Table 3B-4). Hot Creek contains moderate to high concentrations of geothermal trace elements, including boron, fluoride, arsenic, and antimony (California Department of Water Resources 1967, U.S. Geological Survey 1984).

All measured arsenic and fluoride concentrations in Hot Creek have been high, with mean values of 224 μg/l and 2 mg/l, respectively. Arsenic is well correlated with conductivity, although some arsenic also is present in the commingling Mammoth Creek water.

Nutrients and Organics. Historical and 1991 data indicate that Hot Creek has high (0.26 mg/l mean) concentrations of phosphate. Both Hot Springs and the Hot Creek Hatchery are significant sources of phosphorus, which has resulted in abundant growth of algae and macrophytes in Hot Creek (U.S. Geological Survey 1984). Nitrate concentrations are low.

Particulates and Metals. Iron, barium, aluminum, and manganese concentrations are higher in Hot Creek because of the geothermal waters from Hot Springs than in most of the other streams sampled during 1991. Mercury also was detected in 1991 in three of eight samples at relatively low concentrations (0.17-0.30 μg/l) compared to the fish and aquatic life criteria of 2.4 μg/l. Other metals remained below detection limits.

Other Lake Crowley Reservoir Tributaries

In addition to the Upper Owens River, five other streams are tributary to Lake Crowley reservoir, including Rock Creek, which is partially diverted into Lake Crowley reservoir. Water quality in each of these tributary streams is excellent and similar to that for the Mono Lake tributaries (Table 3B-5). The relationship between flow and mineral concentrations is dampened somewhat because of the mixing and storage effects of alpine lakes in the upper watersheds of each stream.

Mineral concentrations in Convict Creek measured in 1991 were higher than historical levels because of the effects of drought conditions; a greater portion of the flow was groundwater baseflow.

Hilton Creek has the lowest conductivities of the Lake Crowley reservoir tributaries. Several water quality parameters in Crooked Creek, including total organic carbon and iron, were high compared to other Lake Crowley reservoir tributaries and indicate the influence of the large wet pasture area upstream of the sampling location.

Rock Creek diversions to Lake Crowley reservoir occur only during excess runoff periods because minimum instream flows must be maintained below the diversion. Historical data for most water quality parameters are substantially higher than the 1991 data, suggesting that a different (downstream) location was historically sampled by LADWP.

Lake Crowley Reservoir

Temperature. Lake Crowley reservoir is thermally stratified in spring and summer. Temperature profiles and hourly data from LADWP datapods located at the surface and bottom at Dam Arm show thermal stratification beginning in late May, strengthening through summer with a maximum temperature difference of about 9°C in July (when the surface temperature reached about 21°C) and weakening substantially in September until the lake completely mixed in October, at a temperature of about 16°C.

Surface temperatures reached a peak of 24°C for several days at the beginning of July, while bottom temperatures seemingly peaked at 17°C in September before mixing occurred. The surface mixed layer was just 2 meters deep at the beginning of June, increased to about 5 meters by the end of June, and fluctuated between 3 and 6 meters through July. During August and September, the mixed layer deepened to 10 meters as surface temperatures cooled slightly. Figure 3B-4 shows the seasonal temperature profiles in Lake Crowley reservoir during 1991.

Dissolved Oxygen. Lake Crowley reservoir is eutrophic (high nutrients and high primary productivity), and the epilimnion (surface layer) is replenished with DO by primary production and atmospheric aeration. The hypolimnion (bottom layer), in contrast, becomes gradually depleted of DO as respiration and decomposition processes consume DO. It eventually becomes anoxic (without oxygen). DO is not replenished in the hypolimnion because of insufficient light for photosynthesis and the limited mixing with the epilimnion.

Figure 3B-5 shows the measured DO profiles for 1991. DO concentrations in late June sharply declined near the bottom. Hypolimnetic DO concentrations were anoxic below 15 meters depth in mid-July and remained anoxic below 10 meters depth through August. Deepening of the surface mixed layer in September allowed re-aeration within the mixed layer, but by late September complete lake mixing had not yet occurred. The bottom concentrations of phosphorus and ammonia increased significantly during the anoxic period.

Minerals. The mineral quality of Lake Crowley reservoir is governed by the variable mixture of Mono Basin exports, Upper Owens River and tributary runoff, geothermal springs, and Rock Creek diversions. The resulting chemical composition is remarkably constant. The general effect of reduced Mono Basin exports on Lake Crowley reservoir water quality would be to reduce the dilution of the geothermal and tunnel make sources, causing higher mineral concentrations in the outlet from Lake Crowley reservoir.

The mineral quality of Lake Crowley reservoir is indicated by the historical conductivity data that have been collected from the outlet since 1940, shown in Figure 3B-6. Higher conductivity values observed in 1991 indicate drought conditions and a lack of seasonal runoff dilution in Lake Crowley reservoir in recent years. Other historical periods of elevated conductivity values can be seen during the early 1940s, 1977, and the 1987-1991 dry periods.

Mineral concentrations increase directly with EC values, and the 1991 measurements from the bottom of Lake Crowley reservoir confirm the historical LADWP data for Lake Crowley reservoir outlet.

Nutrients and Organics. Melack and Lesack (1982) sampled Lake Crowley reservoir in 1982 to evaluate algal growth dynamics and potential algal growth limits. During that study, concentrations of nitrogen were low in surface waters and concentrations of phosphorus were relatively high. Ratios of nitrogen to phosphorus, important in determining algal growth conditions, were generally low (less than 15) and indicated favorable conditions for the growth of blue-green nitrogen-fixing algae. However, algal identification was not part of their study. Algal blooms were observed in July and August 1982, with phosphorus concentrations dropping during the blooms. Tributary sampling indicated that the two major sources of phosphorus were Big Springs and Hot Creek.

Surface samples collected in 1991 confirmed that Lake Crowley reservoir has low nitrogen concentrations. Higher nitrogen and phosphorus concentrations in the outlet of Lake Crowley reservoir may be the result of sediment release during anoxic periods, as reported by Melack and Lesack (1982).

Chlorophyll *a* concentrations observed during 1991 from all four sampling locations were similar, except for one high value of 80 μg/l at Chalk Cliffs. The lowest values were found at Green Banks, which is in the upstream portion of Lake Crowley reservoir (Auxiliary Report No. 17 [Jones & Stokes Associates 1993]).

Because chlorophyll measurements were not obtained for all months, Secchi depth (light penetration) measurements were used to estimate algal patterns. Secchi depth estimates of algae generally match the measured chlorophyll concentrations.

Particulates and Metals. Metal and particulate concentrations are generally low in Lake Crowley reservoir outlet samples, and most 1991 samples from the bottom of Lake Crowley reservoir were below detection limits for metals.

Sediment Quality. Sediment samples were collected from four locations in July 1991 by SWRCB's contractor. Sediment samples from Green Banks, where the Owens River enters Lake Crowley reservoir, contained sand and had no odor. The lake bottom at Green Banks was well oxygenated. Silica concentrations were high at this location because of the high sand content. Concentrations of minerals and metals were lower than for the other locations because these parameters generally attach to silt and clay, which are transported toward the lake outlet before settling.

Sediment samples gathered at Dam Arm, Chalk Cliffs, and McGee Bay consisted of fine, black-grey, viscous to gelatinous mud with a distinct sulfurous odor, indicating an anoxic lake bottom. DO profiles taken at these sites confirmed that oxygen was present at less than 0.1 mg/l at the bottom water layer because of the development of a summer thermocline.

All constituent concentrations were within the ranges typically found in sediment, except for arsenic and mercury. Arsenic concentrations at the outlet are approximately twice as high as the upper limit of typical sediment concentrations in the western United States, probably caused by high arsenic contributions from Hot Creek. However, sediment arsenic concentrations (always less than 81 milligrams per kilogram (mg/kg) at the outlet) are well below the total threshold limit concentration (TTLC) of 500 mg/kg for identifying hazardous wastes.

Mercury concentrations in Lake Crowley reservoir sediments ranged from below detection limits to 0.6 mg/kg at Chalk Cliffs, with an average of 0.4 mg/kg. Sediments in the western United States typically have mercury concentrations ranging from below detection to 0.2 mg/kg, indicating that mercury concentrations in Lake Crowley reservoir sediments are elevated. However, the TTLC for mercury is considerably higher at 20 mg/kg.

Middle Owens River

Minerals. Water quality in Tinemaha Reservoir (Table 3B-5) is a variable mixture of releases from Lake Crowley reservoir, Owens River basin tributary runoff, and groundwater pumping. Lake Crowley reservoir is the principal water source and largely determines water quality at Tinemaha Reservoir. Average conductivity is only slightly less than Lake Crowley reservoir outlet conductivity.

USGS daily conductivity data show the seasonal decrease in conductivity that typically occurs in June-July as a result of dilution from snowmelt runoff. The effects of the 1976-1977 drought conditions can be seen in these daily records, indicated by a lack of seasonal runoff dilution and a steady increase in conductivity from 275 μS/cm to 400 μS/cm (Auxiliary Report 17, Figures 106A-106G [Jones & Stokes Associates 1993]).

Average mineral concentrations at Tinemaha Reservoir are summarized in Table 3B-5. LADWP and USGS data agree closely for all parameters.

Arsenic concentrations generally range from 10 to 50 μg/l and averaged 24 μg/l for LADWP and USGS data. The large decrease in arsenic concentration from Lake Crowley reservoir outlet, which averaged 44 μg/l, results from dilution with Owens River tributaries and groundwater. Fluoride concentrations average about 0.6 mg/l, only slightly less than the Lake Crowley reservoir outlet average of 0.7 mg/l.

Nutrients and Organics. Nitrate and phosphate concentrations are generally low at Tinemaha Reservoir. Total organic carbon measurements by LADWP and USGS are inconsistent.

Owens River Basin Groundwater

In 1908, LADWP drilled its first test wells in the Middle and Lower Owens River basin to investigate the feasibility of exporting groundwater to supplement surface water diversions. The majority of the wells are drilled at depths ranging from 100 to 600 feet and are located on the west side of the Owens River Valley. Although about 80% of the wells are artesian, these free-flowing wells generally have contributed less than 10% of the total groundwater export in recent years. Most of the groundwater is obtained from about 90 productions wells equipped with pumps and yielding 2-10 cfs each (LADWP and Inyo County 1990).

Wells in the Owens Valley can be grouped into four major wellfields: Laws (LW), Bishop-Warm Springs (BW), Big Pine-Crater Mountain (BP), and below Tinemaha (BT). The BT wellfield group encompasses all wellfields located between Tinemaha and Haiwee Reservoirs. Groundwater pumped from the Laws, Bishop, and Big Pine wellfields are discharged into the Middle Owens River and affect water quality at the Tinemaha Reservoir outlet. Groundwater from the numerous wellfields between Tinemaha and Haiwee Reservoirs are discharged into the aqueduct at several points along this reach and affect water quality at the LA Aqueduct filtration plant. Groundwater has the greatest effect on water quality when pumping is high relative to runoff and releases from Lake Crowley reservoir.

Temperature. Groundwater temperatures generally fluctuate much less than surface water temperatures, and historical LADWP data average 17°C (Table 3B-5). Local geothermal activity may influence some wells. Pumping has been used to control ice damage to the aqueduct during winter.

Minerals. Groundwater generally has a higher mineral content than the surface water recharging the groundwater. Mineral quality from an individual well is generally constant, although different wells can vary widely. LADWP samples of the production wells indicate that Owens Valley groundwater conductivities range from 100 to 1,600 μS/cm, as shown in Figure 3B-7. The Laws wellfield has the highest median conductivity, followed by Big Pine and Bishop. Wells between Tinemaha and Haiwee Reservoirs have the lowest conductivities, but some very productive wells have conductivities above 1,000 μS/cm.

Groundwater from these high conductivity wells generally has high boron concentrations and a few also have elevated arsenic levels, indicating a geothermal influence. Additional analysis of the groundwater quality is provided in Auxiliary Report No. 17 (Jones & Stokes Associates 1993).

Water Quality at the LA Aqueduct Intake

The final raw water quality at the aqueduct filter plant results from the mixture of Mono Basin exports, surface runoff from the Owens River basin, and pumped groundwater from the Owens Valley. The aqueduct filtration plant utilizes ozonation and deep-bed filtration in addition to conventional treatment processes of screening, flocculation, sedimentation, and chlorination of filtered water to purify and disinfect these raw water supplies.

Minerals

Conductivity at the LA Aqueduct filtration plant averages 340 μS/cm, slightly higher than Tinemaha Reservoir outlet conductivity. This mineral parameter is five to six times greater than that of Mono Basin export water. Chloride concentrations are slightly increased over Tinemaha Reservoir values but are nine times the Mono Basin export values. Other mineral concentrations at the filtration plant are very similar to Tinemaha Reservoir outlet concentrations (Table 3B-5).

Arsenic concentrations averaged 22 μg/l, about the same as the average Tinemaha Reservoir outlet concentration and half the Lake Crowley reservoir outlet concentration. Fluoride concentrations were almost identical to those at the Tinemaha and Lake Crowley Reservoir outlets.

Nutrients and Organics

LA Aqueduct filtration plant nitrate and phosphate concentrations are generally low. Total organic carbon (TOC) measured by LADWP averaged about 2 mg/l, about the same as the Tinemaha Reservoir measurements. USGS measurements at Tinemaha Reservoir were about 50% higher. Nevertheless, the TOC concentrations in LA Aqueduct water is quite low, and the concentrations of disinfection byproducts (such as trihalomethanes) after treatment have been well within drinking water standards.

Water Quality of the Metropolitan Water District Water Supply

As described in Chapter 3L, "Water Supply", water supplies for the City of Los Angeles are obtained from a combination of local groundwater wells, aqueduct deliveries from Owens River and Mono Basin, and purchases from Metropolitan Water District (MWD). Recently, as aqueduct deliveries have been limited because of extended drought conditions, groundwater pumping agreements, and court injunctions, purchases from MWD have increased to more than 50% of the total water supply. The final water quality of LADWP water deliveries in the city therefore depends on a mixture of local groundwater, aqueduct water, and MWD water.

MWD completed the Colorado River Aqueduct in 1941 and contracted with State Water Project (SWP) to obtain water from the California Aqueduct in 1960 (LADWP 1991).

SWP deliveries to MWD began in 1973. MWD blends water from both sources and distributes this water to LADWP. The composition of blended MWD water is highly variable and affected by water availability, distribution system capacities, and delivery agreements.

Because decreased exports from Mono Basin will cause a decrease in LA Aqueduct deliveries, more MWD water may be required to satisfy water needs in the city. Chapter 3L, "Water Supply", provides a discussion of the possible replacement sources. This water quality assessment focuses on the primary effects of reduced Mono exports on water quality in the aqueduct system; secondary effects from increased MWD water should be considered when alternative supplies are purchased.

Historical MWD monthly 1985-1990 water quality data from Lake Mathews and Castaic Lake represent the Colorado River Aqueduct and California Aqueduct, respectively.

Colorado River Supply

Average Colorado River conductivity from 1985 to 1990 was two to three times higher than the aqueduct water. Chloride concentrations were three to four times higher. The average arsenic concentration was 3 $\mu g/l$, however, only one-seventh of the aqueduct concentration (Table 3B-5). Fluoride concentrations averaged 0.3 mg/l, half the aqueduct value.

State Water Project Supply

SWP water is pumped from the Sacramento-San Joaquin River Delta and is occasionally influenced by seawater intrusion. SWP water can be stored in San Luis Reservoir and Pyramid and Castaic Lakes before entering MWD's treatment plant.

Conductivity at the treatment plant during 1985-1990 was nearly 60% higher than the aqueduct supply. Chloride values increased threefold during this period, apparently as a result of increased seawater intrusion in the Delta. The average for the period was nearly four times the conductivity of the aqueduct waters.

Fluoride concentrations are one-third the aqueduct supply, and arsenic concentrations were similar to the Colorado River, only one-seventh of the aqueduct concentrations (Table 3B-5).

IMPACT ASSESSMENT METHODOLOGY

Impact Prediction Methodology

Salinity of Mono Lake

The salinity of Mono Lake, measured as the concentration of TDS (grams per liter [g/l]), can be calculated as a constant divided by the lake volume:

$$\text{TDS (g/l)} = 209{,}588 \,/\, \text{volume (TAF)}$$

Lake volume can be calculated from measurements of lake elevation because the bathymetry is well known (see Appendix A, "Mono Lake Monthly Water Balance Model"). Figures 1-7 and 3A-7 show Mono Lake elevations and corresponding fluctuations in lake volume from 1913 to 1991. Figure 3B-1 shows the average Mono Lake salinity, estimated from this equation, for the historical period from 1913 to 1991. Lake average salinity ranged between 42 g/l and 97 g/l. Table A-1 in Appendix A gives the average salinity and specific gravity estimated for each lake elevation.

Water Quality of Diversions and Los Angeles Water Supply

Changes in Mono Basin export volumes will alter the dilution of high mineral content waters of Hot Creek and other geothermal sources entering Lake Crowley reservoir with Upper Owens River water. These changed dilution effects will be conveyed from Lake Crowley reservoir down the LA Aqueduct system and ultimately could affect the quality of water delivered to the City of Los Angeles.

Replacing Mono Basin exports with alternate water supply sources may cause an additional incremental change in the quality of water delivered to the City of Los Angeles. Potential water quality impacts associated with alternate water supply sources were not evaluated, however, because reduction in demand or replacement supply alternatives are too uncertain (see Chapter 3L, "Water Supply").

A mass balance model of the LA Aqueduct system, described in detail in Appendix K, was used to assess water quality changes for each alternative at three locations:

- East Portal,
- Lake Crowley reservoir outflow, and
- LA Aqueduct filtration plant inflow.

Parameters of Concern. Parameters of concern were identified based on analysis of available historical water quality data and were selected if they were:

- consistently detected in substantial concentrations at the three locations,
- of concern for drinking water quality, and
- of concern for aquatic habitat quality.

As described in the "Prediversion Conditions" section, electrical conductance (conductivity) was selected as the general indicator of dissolved mineral water quality. Chloride, fluoride, arsenic, and phosphate were identified as constituents of concern because they met this criteria.

Relationship between Conductivity and Flow. Conductivity was used as the primary indicator of water quality because it was determined to be directly related to flow and the other selected constituents of concern. The model estimated incremental changes in conductivity under different Mono Basin export volumes, using a mass balance to calculate total mass units (load) of conductivity at each stream or water body (see Appendix K). The calculated conductivity loads for individual streams in a given hydrologic location were added and then divided by the total flow to obtain the mixed conductivity. Relationships between flow and conductivity were determined for various streams that provide a significant source of water for the LA Aqueduct.

Concentrations of Constituents of Concern. Analysis of historical data indicated that concentrations of chloride, fluoride, arsenic, and phosphate have a relatively linear relationship with conductivity for each aqueduct water source. The concentration of each constituent can therefore be estimated at each location using a constant ratio to conductivity. Ratios for each constituent with conductivity were determined from historical data at each location and are presented in Appendix K.

LAAMP Simulation Data. The water quality mass balance model uses monthly flows calculated by the LAAMP aqueduct operations model for each alternative. LAAMP simulated flows correspond to the three locations of interest. The LAAMP model uses actual historical runoff data for each stream location. The major variable from the LAAMP model affecting water quality is the monthly Mono Basin export volume. The LAAMP model uses Owens Valley groundwater pumping volumes that are the same under each alternative.

Model Calibration for Conductivity. The model calculation of conductivity was calibrated using historical flow and conductivity values at the key locations. The modeled conductivity values were compared graphically and statistically with actual historical conductivity values. Mean, minimum, and maximum conductivity values were compared with historical data at each location, and adjustments were made, if necessary, to regression equations for conductivity as a function of monthly flow for selected water sources.

Model Calibration for Other Constituents of Concern. Ratios between the other constituents of concern and conductivity were calibrated by statistically comparing the mean, minimum, and maximum of the estimated concentrations of the other constituents of concern with historical concentrations for these constituents and adjusting the ratios for the selected water sources, if necessary.

Analysis of Mass Balance Model Results. The major relationship observed to affect water quality is the dilution of geothermal waters (and tunnel make) by the monthly Mono Basin export volume. The No-Restriction and No-Diversion Alternatives represent the extreme cases for such water quality changes. Comparisons of the No-Restriction and No-Diversion Alternatives with point-of-reference conditions represent the extreme-case analyses and were used to determine the need for additional analysis of other alternatives.

Criteria for Determining Impact Significance

Mono Lake Salinity

The significance of salinity changes can be judged only by effects on aquatic productivity, which is assessed in Chapter 3E, "Aquatic Productivity".

Water Quality of Diversions and Los Angeles Water Supply

Impact significance is based on exceedance of applicable drinking water MCLs, criteria to protect aquatic life, and suggested criteria to prevent aquatic habitat degradation (phosphates) within specific time periods. Predicted monthly concentrations of each constituent for a given alternative are compared with applicable criteria concentrations.

The significance of a change in the concentration of the constituents of concern is based on the water quality standards and criteria that have been established by regulatory agencies. Maximum contaminant limits (MCLs) established by the California Department of Health Services for conductivity, chloride, fluoride, and arsenic have been set for both primary and secondary drinking water standards. Primary standards were established as thresholds to protect public health. Secondary standards were established for constituents that are generally not hazardous to health but that may be objectionable to the general public if present at high levels. The applicable MCLs and EPA criteria that are used as thresholds to determine the significance of water quality impacts of the project alternatives are presented in Table 3B-6. Currently, if a monthly sample exceeds the MCL, three additional samples are taken in the same month and the four values are averaged. A monthly average value that is higher than the MCL is considered an exceedance.

The regulatory basis of the MCL used as the significance criterion for arsenic must be considered in determining the significance of the increase in arsenic concentrations presented. The MCL of 50 $\mu g/l$ was adopted by the California Department of Health Services as the maximum acceptable long-term daily intake of arsenic to protect public health over an average lifetime; occasional exceedances are therefore not of significant concern.

An EPA water quality criterion for arsenic has been established to protect aquatic life: a 4-day average value not to be exceeded more than once every 3 years (Table 3B-6).

The SWRCB plan criterion for arsenic is 5 μg/l; however, it is not considered to be applicable to the modeled locations pending decisions by the Lahontan RWQCB and SWRCB.

EPA has suggested criteria for phosphates to prevent eutrophication in lakes and streams, but they have not been established as national criteria. Phosphate criteria are applicable to reservoirs and to streams at the closest point of entry into a reservoir (Table 3B-6). The stream criteria are higher because a substantial portion of the inflowing phosphorus is expected to be adsorbed and settled in reservoirs. Phosphate criteria are maximum suggested concentrations.

The selected significance criteria apply to concentrations of the respective constituents of concern at specific locations in the LA Aqueduct water delivery system. For the purposes of this analysis, MCLs for conductivity, chloride, arsenic, and fluoride are applicable to the LA Aqueduct filtration plant inflow. The EPA criterion for arsenic and the suggested criteria for phosphate are applicable to East Portal and Lake Crowley reservoir outflows.

Model output contains monthly values of each constituent concentration for 50 years (600 values). Significant impacts under a given alternative will be determined from the frequency of monthly values that exceed the criteria for conductivity, chloride, fluoride, arsenic, and phosphate, when compared to point-of-reference conditions. If the criteria for the constituent of concern in point-of-reference conditions is already exceeded during the same period, the impact is not considered significant.

SUMMARY COMPARISON OF IMPACTS AND BENEFITS OF THE ALTERNATIVES

As described in the assessment methodology section, water quality effects of the alternatives are assessed in this chapter through several key variables:

- salinity of Mono Lake;
- concentrations of chloride, arsenic, fluoride, and total dissolved solids (as conductivity) in water delivered to the LA Aqueduct that might affect consumers; and
- concentrations of arsenic and phosphate in exported waters and in the Upper Owens River that might affect aquatic ecosystems.

Table 3B-7 provides a summary comparison of the alternatives using these variables. Values of the variables for each alternative are compared to values for the prediversion and point-of-reference conditions and to regulatory threshold concentrations.

No significant impacts are predicted for any alternatives, although the significance of estimated Mono Lake salinities is treated in Chapter 3E, "Aquatic Productivity". A discussion of these variables for each alternative is provided in the following sections of this chapter.

CHARACTERIZATION OF POINT-OF-REFERENCE CONDITIONS

Mono Lake Salinity

At the point-of-reference lake elevation (6,376.3 feet), the salinity of Mono Lake was 90 g/l, which is about 6% greater than the antidegradation salinity threshold (Table 3B-7). Under the point-of-reference scenario, salinity would increase to 108 g/l (27% greater than the antidegradation threshold) on average once dynamic equilibrium of lake level fluctuation was attained.

Los Angeles Water Supply Quality

Conductivity

Historical and point-of-reference conductivity values are similar at the LA Aqueduct filtration plant inflow. Point-of-reference values ranged from 214 to 434 μS/cm and averaged 313 μS/cm (Table 3B-8; Figure 3B-8). Historical data ranged from 173 to 618 μS/cm and averaged 334 μS/cm. No point-of-reference conductivity values exceeded the significance criterion of 900 μS/cm (Table 3B-6).

Chloride

Point-of-reference chloride concentrations ranged from 7.77 to 26.26 mg/l and averaged 17.41 mg/l (Table 3B-8; Figure 3B-9). Historical data ranged from 6.0 to 47.0 mg/l and averaged 17.48 mg/l. No point-of-reference chloride values exceeded the significance criterion of 250 mg/l (Table 3B-6).

Arsenic

Point-of-reference arsenic concentrations ranged from 1.20 to 43.37 μg/l and averaged 23.22 μg/l (Table 3B-8; Figure 3B-10). Historical data ranged from 5.0 to 66.0 μg/l and averaged 22.0 μg/l. No point-of-reference arsenic values exceeded the significance criterion of 50 μg/l. Historical data ranged higher than point-of-reference data, although the averages were similar, with seven values after 1959 (Figure 3B-6) equal or exceeding the significance criterion.

Fluoride

Point-of-reference fluoride concentrations ranged from 0.24 to 0.89 mg/l and averaged 0.56 mg/l (Table 3B-8; Figure 3B-11). Historical data ranged from 0.16 to 0.96 mg/l and averaged 0.59 mg/l. No point-of-reference fluoride values exceeded the significance criterion of 1.6 mg/l (Table 3B-6).

East Portal and Lake Crowley Reservoir Outflow Water Quality

Arsenic

East Portal arsenic concentrations under point-of-reference conditions show a typical pattern of high values (maximum of 25.50 μg/l) during periods of no diversions and lower values during diversion periods of between 5 and 10 μg/l. East Portal point-of-reference concentrations ranged from 2.53 to 25.50 μg/l and averaged 8.59 μg/l (Table 3B-8; Figure 3B-12).

Lake Crowley reservoir arsenic concentrations under point-of-reference conditions ranged from 32.33 μg/l to 101.64 μg/l and averaged 46.70 μg/l (Table 3B-7; Figure 3B-13). Historical levels of arsenic at Lake Crowley reservoir ranged higher (4.0-150.0 μg/l) than point-of-reference values, but the average was similar (45.47 μg/l). All arsenic values for East Portal and Lake Crowley reservoir outflows were below the applicable significance criteria of 190 μg/l.

Phosphate

East Portal phosphate concentrations under point-of-reference conditions ranged from 0.06 to 0.85 mg/l and averaged 0.26 mg/l (Table 3B-8; Figure 3B-14). Historical levels of phosphate at East Portal ranged from 0.01 to 2.25 mg/l and averaged 0.19 mg/l. Both historical and point-of-reference East Portal values consistently exceeded the applicable significance criterion of 0.05 mg/l.

Lake Crowley reservoir phosphate concentrations ranged from 0.12 to 0.33 mg/l and averaged 0.20 mg/l (Table 3B-8; Figure 3B-15). Historical data ranged from 0.0 to 0.65 mg/l and averaged 0.13 mg/l. Modeled point-of-reference values were not adjusted for the expected adsorption and sedimentation of phosphate in Lake Crowley reservoir, and thus point-of-reference values appear higher than historical values. All point-of-reference phosphate values for Lake Crowley reservoir exceeded the applicable significance criterion of 0.025 mg/l, as did most historical values.

IMPACTS AND MITIGATION MEASURES FOR THE NO-RESTRICTION ALTERNATIVE

Changes in Resource Condition

Mono Lake Salinity

Under this alternative, the average salinity of Mono Lake would be 133 g/l, which is 56% higher than the antidegradation threshold and 47% higher than under the point-of-reference condition.

Los Angeles Water Supply Quality

Conductivity. Conductivity values under the No-Restriction Alternative would range from 212 to 410 μS/cm and average 307 μS/cm, which is approximately equal to point-of-reference values discussed above (Table 3B-8; Figure 3B-8). All values would be below the significance criterion of 900 μS/cm applicable to LA Aqueduct filtration plant inflow. Therefore, no significant change from point-of-reference conditions of Los Angeles water supply quality would be expected.

Chloride. Chloride concentrations under the No-Restriction Alternative would range from 7.77 to 24.61 mg/l and average 17.10 mg/l, which is similar to the range and average for point-of-reference chloride values discussed above (Table 3B-8; Figure 3B-9). All values would be below the applicable significance criterion of 250 mg/l. Therefore, no significant change from point-of-reference conditions of Los Angeles water supply quality would be expected.

Arsenic. Arsenic concentrations under the No-Restriction Alternative would range from 1.20 to 42.43 μg/l and average 22.77 μg/l, which is similar to the range and average for point-of-reference arsenic values discussed above (Table 3B-8; Figure 3B-10). All values would be below the applicable significance criterion of 50 μg/l. Therefore, no significant change from point-of-reference conditions of Los Angeles water supply quality would be expected.

Fluoride. Fluoride concentrations under the No-Restriction Alternative would range from 0.24 to 0.84 mg/l and average 0.55 mg/l, which is similar to the range and average for point-of-reference arsenic values discussed above (Table 3B-8; Figure 3B-11). All values would be below the applicable significance criterion of 1.6 mg/l. Therefore, no significant change from point-of-reference conditions of Los Angeles water supply quality would be expected.

East Portal and Lake Crowley Reservoir Outflow Water Quality

Arsenic. Arsenic concentrations under the No-Restriction Alternative at the East Portal outflow would range from 2.53 to 25.50 μg/l and average 8.20 μg/l, which is similar to the range and average for point-of-reference arsenic values discussed above (Table 3B-8; Figure 3B-12). Arsenic concentrations at Lake Crowley reservoir outflow would range from 31.87 to 100.53 μg/l and average 44.00 μg/l, which is also similar to the range and average for point-of-reference arsenic values discussed above (Table 3B-8; Figure 3B-13). All values at the East Portal and Lake Crowley reservoir outflows would be below the applicable significance criterion of 190 μg/l. Therefore, no significant change from point-of-reference conditions of East Portal or Lake Crowley reservoir outflow quality would be expected.

Phosphate. Phosphate concentrations under the No-Restriction Alternative at the East Portal outflow would range from 0.06 to 0.85 mg/l and average 0.25 mg/l, which is approximately equal to the range and average for point-of-reference phosphate values discussed above (Table 3B-8; Figure 3B-14). Values under both point-of-reference conditions and the No-Restriction Alternative at the East Portal outflows would consistently exceed the applicable significance criterion of 0.05 mg/l. Phosphate concentrations at Lake Crowley reservoir outflow would range from 0.12 to 0.29 mg/l and average 0.19 mg/l, which is also approximately equal to the range and average for point-of-reference phosphate data discussed above (Table 3B-8; Figure 3B-15). Values under both point-of-reference conditions and the No-Restriction Alternative at Lake Crowley reservoir outflows would consistently exceed the applicable significance criterion of 0.025 mg/l.

Since point-of-reference values already exceeded the significance criteria, no significant change relative to point-of-reference conditions of East Portal or Lake Crowley reservoir outflow quality would be expected.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (No-Restriction Alternative)

- Mono Lake salinity increases more than 50% beyond antidegradation threshold (see Chapter 3E, "Aquatic Productivity", for assessment of significance).
- Los Angeles water supply quality remains relatively unchanged.
- Excessive phosphate in Mono Basin exports remains relatively unchanged.

IMPACTS AND MITIGATION MEASURES FOR THE NO-DIVERSION ALTERNATIVE

Changes in Resource Condition

Mono Lake Salinity

Under this alternative, the average salinity of Mono Lake would be 48 g/l, which is 44% less than the antidegradation threshold and 47% less than the point-of-reference condition.

Los Angeles Water Supply Quality

Conductivity. Conductivity values under the No-Diversion Alternative would range from 222 to 495 μS/cm and average 350 μS/cm (Table 3B-8; Figure 3B-8). These values are higher than point-of-reference conductivity values, which range from 214 to 434 μS/cm and average 313 μS/cm. All values were below the significance criterion of 900 μS/cm applicable to LA Aqueduct filtration plant inflow. Therefore, no significant change from point-of-reference conditions of Los Angeles Water supply quality would be expected.

Chloride. Chloride concentrations under the No-Diversion Alternative would range from 7.77 to 30.45 mg/l and average 19.56 mg/l (Table 3B-8; Figure 3B-9). These concentrations are slightly higher than point-of-reference chloride values, which range from 7.77 mg/l to 26.26 mg/l and average 17.41 mg/l. All values were below the applicable significance criterion of 250 mg/l. Therefore, no significant change from point-of-reference conditions of Los Angeles water supply quality would be expected.

Arsenic. Arsenic concentrations under the No-Diversion Alternative would range from 1.2 to 53.89 μg/l and average 26.35 μg/l (Table 3B-8; Figure 3B-10). Point-of-reference arsenic values range from 1.2 to 43.37 μg/l and average 23.22 μg/l. In the simulations, only one No-Diversion Alternative arsenic value exceeded the significance criterion of 50 μg/l (53.89 μg/l). Several arsenic values would increase substantially over point-of-reference values and approach the 50 μg/l criterion (Figure 3B-10). Table 3B-9 presents a summary of simulated arsenic values over 40 μg/l for the No-Diversion Alternative, the percent increase over point-of-reference conditions, and the month and year of occurrence in the historical data set.

Over the 50-year period data set, arsenic concentrations for the No-Diversion Alternative exceeded those of the point-of-reference scenario 13% of the months. However, 21% of the values were less than point-of-reference values. The overall average arsenic concentration is 26.35 μg/l, an increase of 3.13 μg/l (13%) over the point-of-reference average of 23.22 μg/l.

Overall, the increase in arsenic concentrations from point-of-reference conditions is not considered significant because high concentrations would not persist for more than a few days.

Fluoride. Fluoride concentrations under the No-Diversion Alternative would range from 0.24 to 1.05 mg/l and average 0.64 mg/l (Table 3B-8; Figure 3B-11). These concentrations are slightly higher than point-of-reference fluoride values, which range from 0.24 to 0.89 mg/l and average 0.56 mg/l. All values are below the applicable significance criterion of 1.60 mg/l. Therefore, no significant change from point-of-reference conditions of Los Angeles water supply quality would be expected.

East Portal and Lake Crowley Reservoir Outflow Water Quality

Arsenic. Arsenic concentrations under the No-Diversion Alternative at the East Portal outflow would be constant at 25.50 μg/l (Table 3B-8; Figure 3B-12). This is the maximum arsenic concentration determined for the No-Restriction Alternative and point-of-reference scenario, and results from arsenic present in the constant flow of tunnel make, which is the only East Portal flow in the absence of any freshwater diversions from Mono Basin.

Arsenic concentrations at Lake Crowley reservoir outflow would range from 36.88 to 107.95 μg/l and average 68.51 μg/l (Table 3B-8; Figure 3B-13). These concentrations are similar to point-of-reference values, which range from 32.33 to 101.64 and average 46.70 μg/l. All values at the East Portal and Lake Crowley reservoir outflows are below the applicable significance criterion of 190 μg/l. Therefore, no significant change from point-of-reference conditions of East Portal or Lake Crowley reservoir outflow quality would be expected.

Phosphate. Phosphate concentrations under the No-Diversion Alternative at the East Portal outflow would be constant at 0.85 mg/l (Table 3B-8; Figure 3B-14). This is the maximum concentration determined for the No-Restriction Alternative and point-of-reference scenario as described above for arsenic. Under both the No-Diversion Alternative and point-of-reference scenario, phosphate levels at the East Portal outflows consistently exceed the applicable significance criterion of 0.05 mg/l.

Phosphate concentrations at Lake Crowley reservoir outflow would range from 0.14 to 0.43 mg/l and average 0.29 mg/l, a very slight increase over point-of-reference phosphate values (Table 3B-8; Figure 3B-15). Both point-of-reference scenario and No-Diversion Alternative concentrations at Lake Crowley reservoir outflows would consistently exceed the applicable significance criterion of 0.025 mg/l.

Since point-of-reference values already exceed significance criteria, no significant change relative to point-of-reference conditions on East Portal or Lake Crowley reservoir outflow quality would be expected.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (No-Diversion Alternative)

- Mono Lake salinity decreases well below the antidegradation threshold (see Chapter 3E, "Aquatic Productivity", for assessment and significance).
- Los Angeles water supply quality diminishes insignificantly.
- Excessive phosphate in Mono Basin exports remains relatively unchanged.

IMPACTS AND MITIGATION MEASURES FOR TARGET LAKE-LEVEL ALTERNATIVES

Changes in Resource Condition

Mono Lake Salinity

Average salinity levels for the alternatives after the lake reaches dynamic equilibrium are shown in Table 3B-7. The 6,372-Ft and 6,377-Ft Alternatives would have average salinities greater than the antidegradation threshold. Only the 6,372-Ft Alternative would represent an adverse change from the point of reference. The significance of these changes is evaluated from a biological perspective (see Chapter 3E, "Aquatic Productivity").

Water Quality of Diversions and Los Angeles Water Supply

Analysis of the individual target lake-level alternatives is not necessary because no significant impacts are associated with either the No-Restriction or No-Diversion Alternatives.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (Target Lake-Level Alternatives)

- Mono Lake salinity is above the antidegradation threshold of the point-of-reference conditions under the 6,372-Ft Alternative, and under the 6,377-Ft Alternative by a slight amount (see Chapter 3E, "Aquatic Productivity", for assessment of biological significance).

- Los Angeles water supply quality remains relatively unchanged or diminishes insignificantly.

- Excessive phosphates in Mono Basin exports remains relatively unchanged.

CUMULATIVE IMPACTS OF THE ALTERNATIVES

Related Impacts of Earlier Stream Diversions by LADWP

Mono Lake Salinity

As described previously, LADWP exports from Mono Basin resulted in a doubling of lake salinity from 1941 to 1989. The significance of this change is evaluated from a biological productivity standpoint in Chapter 3E, "Aquatic Productivity".

Water Quality of Diversions and Los Angeles Water Supply

The quality of exported waters for a given annual runoff volume has not changed during the diversion period. The quality of water delivered to the LA Aqueduct intake has benefited over the years of Mono Basin exports, as geothermal waters in the Upper Owens River basin have been diluted by the exported water.

Related Impacts of Other Past, Present, or Anticipated Projects or Events

Mono Lake Salinity

No other projects are known to have or are anticipated to affect Mono Lake salinity.

Water Quality of Diversion and Los Angeles Water Supply

Continued pumping of groundwater in the Owens River basin has had the effect of lessening seasonal or dry-year increases in water quality constituents of concern, as a result of the dilution effect noted. The pattern of pumping is assumed to remain the same under all Mono Basin export alternatives.

Proposed pumping of groundwater by the Town of Mammoth Lakes for domestic supply would not likely be of sufficient magnitude to significantly reduce the flow of the Upper Owens River.

Cumulative Impacts

- Following nearly 50 years of lake volume decreases, lake salinity would remain above the antidegradation threshold for the No-Restriction, 6,372-Ft, and 6,377-Ft Alternatives (see Chapter 3E, "Aquatic Productivity" for a determination of significance). Lake salinity under all other alternatives would eventually fall below the antidegradation threshold, at a rate that depends entirely on near-term precipitation.

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Table 3B–1. Beneficial Uses of Surface Waters in Mono Basin

Surface Water Body	Municipal and Domestic Supply	Industrial Supply	Agricultural Supply	Groundwater Recharge	Water Contact Recreation	Nonwater Contact Recreation	Coldwater Fish Habitat	Fish Spawning Habitat	Wildlife Habitat	Saline Aquatic Habitat	Hydropower Generation	Water Replenishment	Special Biological Significance	Shellfish Harvesting
Mono Lake														
Lake waters	–	12	–	–	12	12	–	2	12	12	–	–	2	2
Springs	2	–	–	–	2	2	2	–	2	–	–	–	–	–
Minor streams	2	–	12	–	12	12	12	–	12	–	–	–	–	–
Rush Creek														
Above diversion	2	–	12	–	12	12	12	2	12	–	2	–	–	–
Below diversion	2	–	12	12	12	12	12	2	12	–	–	–	–	–
Grant Lake reservoir	2	–	–	–	12	12	12	2	12	–	–	–	–	–
Lee Vining Creek														
Above diversion	2	–	–	–	12	12	12	2	12	–	12	–	–	–
Below diversion	2	–	–	12	12	12	12	–	12	–	–	2	–	–
Walker Creek	2	–	–	–	12	12	12	2	12	–	–	–	–	–
Parker Creek	2	–	–	–	12	12	12	2	–	–	–	–	–	–

Notes: 1 = beneficial uses identified in Lahontan Basin Plan (RWQCB 1987).

2 = beneficial uses identified in draft revised basin plan.

12 = beneficial uses identified in both plans.

– = beneficial use not identified in either basin plan.

Table 3B-2. Mono Lake Mineral Water Quality

Parameter	Unit	LADWP (Median)	Russell	Mason
TDS	g/l	100	53.5[a]	71[a]
Alkalinity	g/l as $CaCO_3$	39.7	--	--
Hardness	mg/l	194	--	--
Electrical conductivity	mS/cm	80.8	--	--
Calcium	mg/l	4	38	--
Magnesium	mg/l	44	184	79
Sodium	g/l	39.3	37.1	36.8
Potassium	g/l	1.8	1.8	1.8
Sulfate	g/l	13.1	12.6	12.9
Chloride	g/l	23.0	22.8	23.0
Silica	mg/l	28	132	--
Iron	mg/l	0.7	--	0.4
Boron	mg/l	474	84	506
Fluoride	mg/l	65	--	63
Phosphate	mg/l	88	--	79
Arsenic	mg/l	17	--	13
Specific gravity	fraction	1.080	--	--
Bromide	mg/l	--	--	52
Iodide	mg/l	--	--	13
Total organic carbon	mg/l	--	--	62
Strontium	mg/l	--	--	156
Lithium	mg/l	--	--	13
Manganese	mg/l	--	--	.02
Aluminum	mg/l	--	--	.05
Copper	mg/l	--	--	.1
Nickel	mg/l	--	--	.002
Tin	mg/l	--	--	.04
Cobalt	mg/l	--	--	.001
Molybdenum	mg/l	--	--	.001

Note: Concentrations have been adjusted to TDS of 100 g/l.

[a] Measured TDS concentrations.

Source: Based on LADWP measurements of lake and evaporation pond samples from 1974 to 1990. Russell (1984) and Mason (1967) analyses are given for comparison.

Table 3B-3. Average Temperatures of Mono Lake Tributaries (^oC)

Location	1987						1988							
	July	August	September	October	November	December	January	February	March	April	May	June	July	August
DFG data[a]														
Rush Creek at Grant Lake reservoir outlet	16.7	17.2	15.6	12.8		1.7	2.2	2.8	4.4	8.3	12.2	15.0	18.9	19.4
Rush Creek at Mono Lake	16.7	17.2	15.0	12.2	6.7	1.1	1.7	4.4	6.1	9.4	14.4	17.2	20.0	19.4

Location	1991			
	July	August	September	October
1991 data[b]				
Rush Creek at Grant Outlet		18.7	16.2	14.6
Rush Creek at Mono Lake	19.0	18.2	15.6	13.4
Parker Creek above diversion	14.5	14.5	12.3	9.7
Walker Creek above diversion	16.1	14.4	11.9	10.2
Lee Vining Creek below diversion		12.0	9.8	8.2
Lee Vining Creek at Mono Lake	15.0	14.4	11.8	9.4

[a] California Department of Fish and Game Stream Evaluation Report No. 91-2, Volume 1. The July 1987 to August 1988 IFIM study was conducted by Beak Consultants. Values in this table were estimated from report graphs of continuous data and converted from ^oF to ^oC.

[b] Calculated averages of continuous data from instantaneous data collected during Jones & Stokes Associates 1991 sampling program.

Table 3B-4. Water Quality Summary of Grant Lake Reservoir Outlet (1940-1991)

Variable	Units	Samples		Mean		Minimum		Maximum	
		LADWP	JSA	LADWP	JSA	LADWP	JSA	LADWP	JSA
Specific conductance	µS/cm	354	10	59	61	40	58	165	63
Total organic carbon	mg/l	2	10	0.9	2	0.8	ND	0.9	4
Color	units	351	10	6	5	0	ND	38	15
Turbidity	NTU	351	10	3.0	1	0.0	1	28	3
Total suspended solids	mg/l	0	10		4		ND		10
Total dissolved solids	mg/l	0	10		37		31		47
Alkalinity (as $CaCo_3$)	mg/l	353	10	18	22	10	20	31	26
Hardness (as $CaCo_3$)	mg/l	354	10	21	24	12	20	41	38
Calcium	mg/l	354	10	6.6	8	0.0	7	12	9
Magnesium	mg/l	353	10	1.0	1	0.0	1	5	1
Sodium	mg/l	354	10	2.7	2	0.0	2	10	3
Potassium	mg/l	345	10	0.7	1	0.0	1	4	1
Sulfate	mg/l	353	10	4.8	4	0.0	3	18	4
Chloride	mg/l	354	10	1.8	2	0.0	1	9.2	2
Silica	mg/l	352	10	6	6	1	5	20	7
Boron	mg/l	210	10	0.04	0	0.00	ND	0.33	0
Fluoride	mg/l	354	5	0.05	0	0.00	ND	0.40	ND
Bromide	mg/l	0	3		0		ND		ND
Ammonia (as N)	mg/l	0	10		0		ND		0
Total Kjeldahl nitrogen	mg/l	350	10	0.22	0	0.02	ND	0.96	ND
Nitrate (as N)	mg/l	342	10	0.06	0	0.00	ND	0.45	ND
Total phosphate	mg/l	0	10		0		ND		0
Dissolved phosphate	mg/l	174	0	0.025		0.000		0.490	
Silver	µg/l	0	6		0		ND		ND
Aluminum	µg/l	0	6		92		ND		230
Arsenic	µg/l	90	6	10	ND	10	ND	20	ND
Barium	µg/l	0	6		ND		ND		ND
Cadmium	µg/l	0	6		0		ND		0
Chromium	µg/l	0	6		ND		ND		ND
Copper	µg/l	0	10		ND		ND		ND
Iron	µg/l	353	10	38	45	0	ND	300	230
Mercury	µg/l	0	6		ND		ND		ND
Manganese	µg/l	0	10		13		ND		39
Lead	µg/l	0	6		ND		ND		ND
Selenium	µg/l	0	6		ND		ND		ND
Zinc	µg/l	0	10		ND		ND		ND

Notes: LADWP sampling 1940-1990. Jones & Stokes Associates (JSA) sampling 1991.

Table 3B-5. Comparison of Average Water Quality for Major Sources of Los Angeles Aqueduct and Los Angeles Water Supply

Water Quality Parameter Source	Unit	Lee Vining Creek (JSA[a])	Walker Creek (JSA)	Parker Creek (JSA)	Rush Creek (JSA)	Grant Lake Reservoir Outlet (JSA)	Big Springs (JSA)	East Portal (JSA)	Mammoth Creek (JSA)	USGS Hot Creek (JSA)	Convict Creek (JSA)	McGee Creek (JSA)	Hilton Creek (JSA)	Crooked Creek (JSA)	Rock Creek (JSA)	Lake Crowley Reservoir Outlet (LADWP[b])	LADWP Tinemaha Reservoir Outlet (LADWP)	USGS Tinemaha Reservoir Outlet (USGS[c])	Owens Valley Ground-Water (LADWP	LA Aqueduct Filtra-tion Plant (LADWP	Colorado River Aqueduct (MWD[d])	California Aqueduct (MWD)
EC	μS/cm	40.0	44.0	54.0	57.0	61.0	206.0	422.0	97.0	506.0	160.0	90.0	29.0	74.0	36.0	325.0	316.0	287.0	288.0	340.0	887.0	536.0
TDS	mg/l	28.0	32.0	37.0	38.0	37.0	151.0	263.0	61.0	325.0	98.0	59.0	21.0	61.0	27.0	–	–	182.0	–	–	556.0	301.0
Alkalinity	mg/l	11.0	12.0	13.0	20.0	22.0	84.0	213.0	44.0	154.0	64.0	31.0	12.0	33.0	14.0	121.0	110.0	96.0	99.0	108.0	130.0	87.0
Hardness	mg/l	15.0	14.0	19.0	21.0	24.0	45.0	181.0	34.0	54.0	70.0	38.0	10.0	21.0	9.0	70.0	76.0	71.0	84.0	87.0	279.0	132.0
Calcium	mg/l	4.9	4.7	6.8	7.3	8.0	6.7	40.0	8.3	12.0	28.0	14.0	3.6	7.1	3.0	20.0	23.0	22.0	23.0	25.0	69.0	29.0
Magnesium	mg/l	0.5	0.6	0.6	0.7	1.0	6.8	18.0	3.2	5.5	0.5	0.4	0.2	0.9	0.3	4.8	4.6	4.0	6.9	6.1	26.0	14.0
Sodium	mg/l	1.7	2.3	1.8	2.1	2.0	25.0	22.0	6.0	81.0	1.4	1.7	1.6	6.6	3.4	41.0	36.0	32.0	27.0	37.0	79.0	54.0
Potassium	mg/l	0.6	0.8	0.8	0.7	1.0	4.2	3.1	1.5	7.9	0.8	0.8	0.6	2.1	0.7	4.3	3.9	3.9	3.1	4.0	4.0	3.0
Sulfate	mg/l	4.8	5.9	7.8	3.6	4.0	6.8	6.7	4.0	26.0	14.0	9.4	<2.0	1.9	2.8	13.0	24.0	23.0	19.0	28.0	–	–
Chloride	mg/l	1.0	1.0	1.0	2.0	2.0	9.0	7.3	1.0	45.0	<1.0	<1.0	<1.0	<1.0	<1.0	19.0	15.0	13.0	18.0	18.0	63.0	70.0
Silica	mg/l	6.7	8.6	8.9	7.8	6.0	52.0	50.0	15.0	55.0	12.0	8.6	6.2	21.0	8.1	24.0	24.0	23.0	29.0	20.0	–	–
Boron	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	0.4	0.27	<0.02	2.0	<0.02	<0.02	<0.02	<0.02	<0.02	0.7	0.5	–	0.6	0.5	0.1	0.25
Fluoride	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	0.4	<0.1	2.0	<0.1	<0.1	<0.1	0.2	<0.1	0.7	0.6	0.6	0.6	0.6	0.3	0.21
Bromide	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	–	–	–	0.14	–	–
TSS	mg/l	4.0	8.0	9.0	6.0	4.0	15.0	9.0	26.0	12.0	5.0	8.0	6.0	8.0	5.0	–	–	39.0	–	–	–	–
Turbidity	NTU[e]	0.4	1.2	1.5	0.5	1.0	0.8	1.1	2.3	1.9	0.4	0.8	0.6	1.1	1.1	3.8	12.0	6.5	–	5.2	–	–
TOC	mg/l	<3.0	3.2	4.5	5.5	2.0	<3.0	<3.0	4.8	4.1	4.4	3.7	6.2	7.3	4.2	2.6	2.2	4.7	–	2.1	–	–
Color	units	4.0	6.0	6.0	6.0	5.0	8.0	5.0	11.0	12.0	3.0	6.0	10.0	35.0	12.0	12.0	22.0	–	3.0	12.0	–	–
TKN[f]	mg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.4	0.4	0.6	0.4	0.3	–	–
Nitrate	mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.61	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.11	0.12	0.11	0.63	0.08	0.75	2.1
Phosphorus	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	0.35	0.04	<0.02	0.26	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	0.09	0.09	0.35	0.07	–	–
Arsenic	μg/l	<4.0	<4.0	<4.0	<4.0	<4.0	17.0	13.0	6.0	224.0	5.0	<4.0	<4.0	<4.0	<4.0	44.0	23.0	24.0	11.0	22.0	3.0	3.0

[a] Jones & Stokes Associates (JSA) 1991 data.

[b] LADWP 1940-1991 data.

[c] U.S. Geological Survey (USGS) 1974-1986 data.

[d] Metropolitan Water District (MWD) 1985-1990 monthly data.

[e] Nephelometric Turbidity Units.

[f] Total Kjeldahl Nitrogen.

Table 3B-6. Water Quality Impact Significance Criteria

Constituent	Criterion	Type	Source of Criteria
Conductivity	900 μS/cm	Recommended MCL for secondary drinking water standard	California Code of Regulations, Title 22, Chapter 15, Article 8
Chloride	250 mg/l	Recommended MCL for secondary drinking water standard	California Code of Regulations, Title 22, Chapter 15, Article 8
Fluoride	1.6 mg/l[a]	MCL for primary drinking water standard	California Code of Regulations, Title 22, Chapter 15, Article 4
Arsenic	50 μg/l	MCL for primary drinking water standard	California Code of Regulations, Title 22, Chapter 15, Article 4
	190 μg/l[b]	EPA ambient water quality criterion	EPA Quality Criteria for Water 1986
Phosphorus (as phosphate)	0.025 mg/l[c] 0.050 mg/l[d]	EPA suggested maximum[e] concentrations	EPA Quality Criteria for Water 1986

[a] Fluoride MCLs are based on annual average of maximum daily air temperatures; the value given is for temperatures between 70.7°F and 79.2°F.

[b] Based on a 4-day average of arsenic not to be exceeded more than once every 3 years.

[c] Value in lake or reservoir not to prevent eutrophication (e.g., Lake Crowley reservoir outflow).

[d] Value in stream at the point of entry to any reservoir (e.g., East Portal outflow).

[e] Values are suggested only and are not yet national criteria.

Table 3B-7. Summary Comparison of Water Quality Effects of the Alternatives

Alternative or Condition	Mono Lake Salinity (g/l)	Parameters of Concern for Drinking Water Supply at the LA Aqueduct				Parameters of Concern for Aquatic Ecosystems in the Upper Owens River Basin			
						East Portal		Lake Crowley Reservoir	
		Conductivity (μS/cm)	Chloride (mg/l)	Arsenic (μg/l)	Fluoride (mg/l)	Arsenic (μg/l)	Phosphate (mg/l)	Arsenic (μg/l)	Phosphate (mg/l)
Point of reference	90	NA	NA	NA	NA	NA	NA	NA	NA
Point-of-reference scenario	108	313	17	23	0.6	9	0.26	47	0.20
No restriction	133*	307	17	23	0.6	8	0.25*	44	0.19*
6,372 Ft	92*	--	--	--	--	--	--*	--	--*
6,377 Ft	86*	--	--	--	--	--	--*	--	--*
6,383.5 Ft	76	--	--	--	--	--	--*	--	--*
6,390 Ft	69	--	--	--	--	--	--*	--	--*
6,410 Ft	54	--	--	--	--	--	--*	--	--*
No diversion	48	350	20	26	0.6	26	0.85*	69	0.29*
Prediversion	48	350[a]	20[a]	26[a]	0.6[a]	0	0	??	??
Regulatory threshold	85[b]	900[c]	250[c]	50[c]	1.6[c]	190[c]	0.050[c]	190[c]	0.025[c]

Notes: -- = not evaluated.
NA = not applicable.
?? = unknown.

No significant adverse impacts identified; see Chapter 3E, "Aquatic Productivity", for significance of salinity effects.

* Exceeds regulatory threshold.

[a] Prediversion values unknown but presumed to be similar to the No-Diversion Alternative.

[b] Federal antidegradation threshold; see text for explanation.

[c] See Table 3B-5.

Table 3B-8. Model Data for Point-of-Reference Condition and No-Restriction and No-Diversion Alternatives

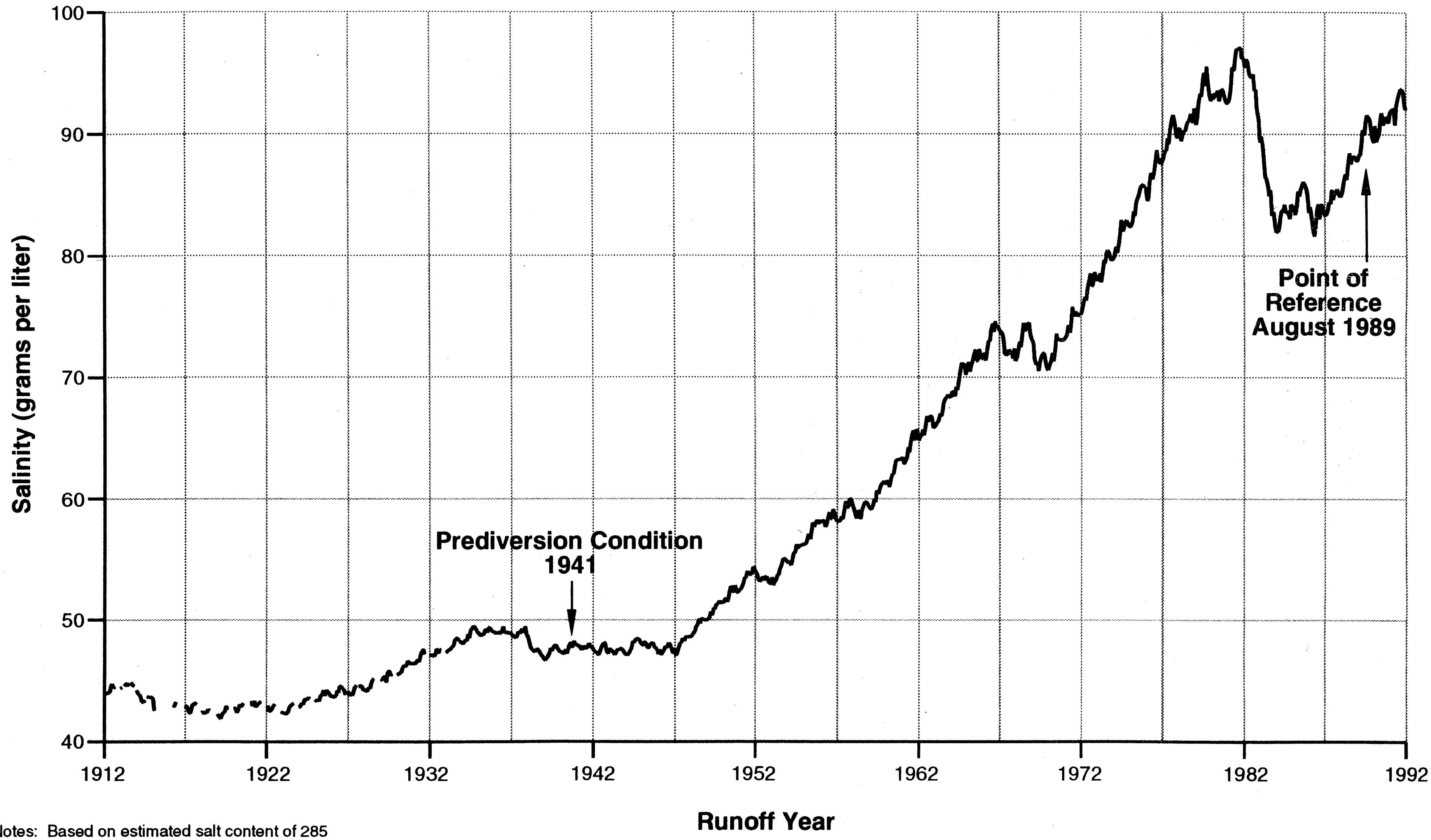
	Point-of-Reference Conditions					Historical Data 1940-1990				
	Conductivity (μS/cm)	Chloride (mg/l)	Arsenic (μg/l)	Fluoride (mg/l)	Phosphate (mg/l)	Conductivity (μS/cm)	Chloride (mg/l)	Arsenic (μg/l)	Fluoride (mg/l)	Phosphate (mg/l)
East Portal outflow										
Mean	160	5.88	8.59	0.22	0.26	175	6.14	10.80	0.21	0.19
Minimum	60	1.85	2.53	0.06	0.06	26	0.60	2.00	0.00	0.01
Maximum	425	17.00	25.50	0.64	0.85	623	14.00	20.00	0.50	2.25
Lake Crowley reservoir outflow										
Mean	308	18.70	46.70	0.74	0.20	325	18.88	45.47	0.73	0.13
Minimum	228	12.49	32.33	0.50	0.12	188	8.50	4.00	0.31	0.00
Maximum	482	43.83	101.64	1.65	0.33	592	45.00	150.00	1.50	0.65
Los Angeles filtration plant inflow										
Mean	313	17.41	23.22	0.56	0.11	334	17.48	22.41	0.59	0.07
Minimum	214	7.77	1.20	0.24	0.04	173	6.00	5.00	0.16	0.00
Maximum	434	26.26	43.37	0.89	0.21	618	47.00	66.00	0.96	0.28

	No-Restriction Alternative					No-Diversion Alternative				
	Conductivity (μS/cm)	Chloride (mg/l)	Arsenic (μg/l)	Fluoride (mg/l)	Phosphate (mg/l)	Conductivity (μS/cm)	Chloride (mg/l)	Arsenic (μg/l)	Fluoride (mg/l)	Phosphate (mg/l)
East Portal outflow										
Mean	154.48	5.63	8.20	0.21	0.25	425	17.00	25.50	0.64	0.85
Minimum	60.45	1.85	2.53	0.06	0.06	425	17.00	25.50	0.64	0.85
Maximum	425.00	17.00	25.50	0.64	0.85	425	17.00	25.50	0.64	0.85
Lake Crowley reservoir outflow										
Mean	292.00	17.65	44.00	0.70	0.19	431	27.14	68.51	1.08	0.29
Minimum	225.00	12.30	31.87	0.49	0.12	246	13.47	36.88	0.55	0.14
Maximum	437.00	43.36	100.53	1.63	0.29	656	46.53	107.95	1.75	0.43
Los Angeles filtration plant inflow										
Mean	307.00	17.10	22.77	0.55	0.11	350	19.56	26.35	0.64	0.13
Minimum	212.00	7.77	1.20	0.24	0.04	222	7.77	1.20	0.24	0.04
Maximum	410.00	24.61	42.43	0.84	0.19	495	30.45	53.89	1.05	0.26

Table 3B-9. Summary of High Arsenic Values under the No-Diversion Alternative Compared with Values under Point-of-Reference Conditions

Date	Arsenic Concentration (μg/l)		
	No-Diversion Alternative	Point-of-Reference Condition	Percent Increase
February 1961	42.95	32.04	34.1
March 1961	48.74	36.35	34.1
April 1961	36.97	43.01	-14.0
December 1961	45.08	33.59	34.2
March 1962	41.80	30.65	36.4
April 1962	47.43	34.83	36.2
April 1965	49.56	35.12	41.1
April 1973	48.52	34.46	40.8
April 1977	45.30	41.46	9.3
December 1977	53.89	43.37	24.3
April 1978	48.70	38.67	25.9
April 1988	47.51	35.70	33.1
December 1988	42.84	34.41	24.5
November 1989	44.71	30.97	44.4
December 1989	49.48	35.45	39.6

Note: High arsenic values defined as >40 μg/l.



Notes: Based on estimated salt content of 285 million tons and lake volumes calculated from bathymetry.

Breaks in the record prior to the early 1930s occur because of intermittent data collection.

Mono-37

Figure 3B-1.
Historical Mono Lake Salinity, 1912 - 1991

Figure 3B-2.
East Portal Conductivity in Relation to Flow, 1940-1991

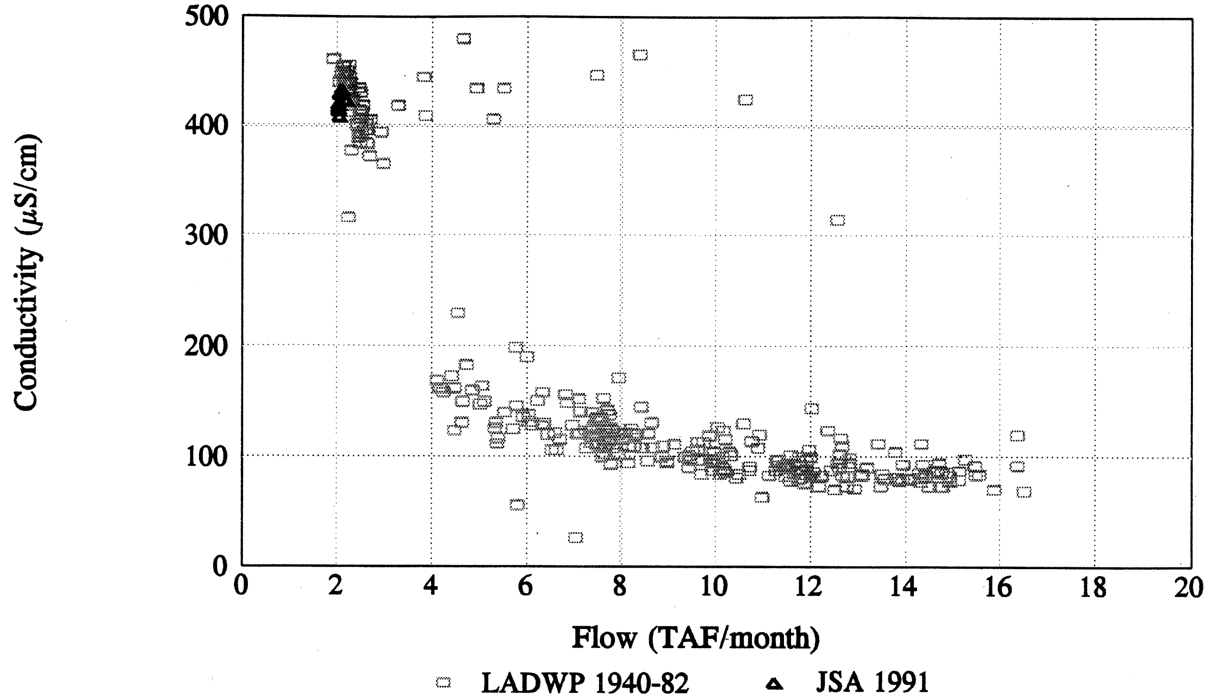
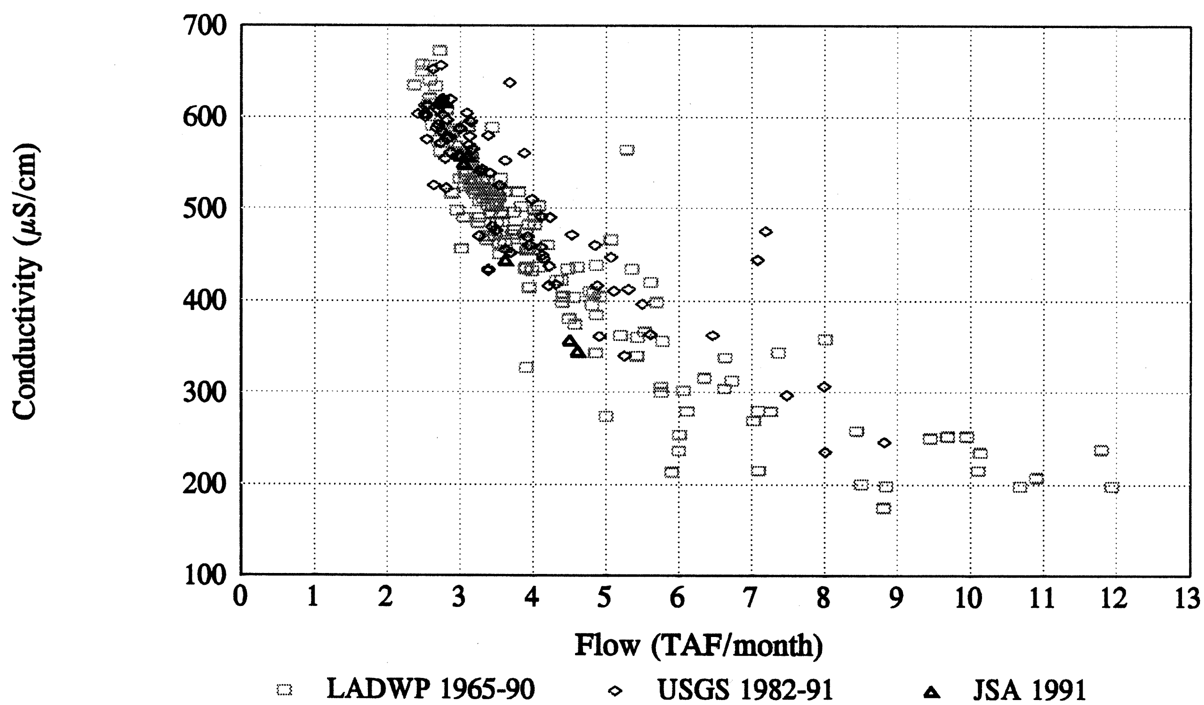


Figure 3B-3.
Hot Creek Conductivity in Relation to Flow, 1965-1991



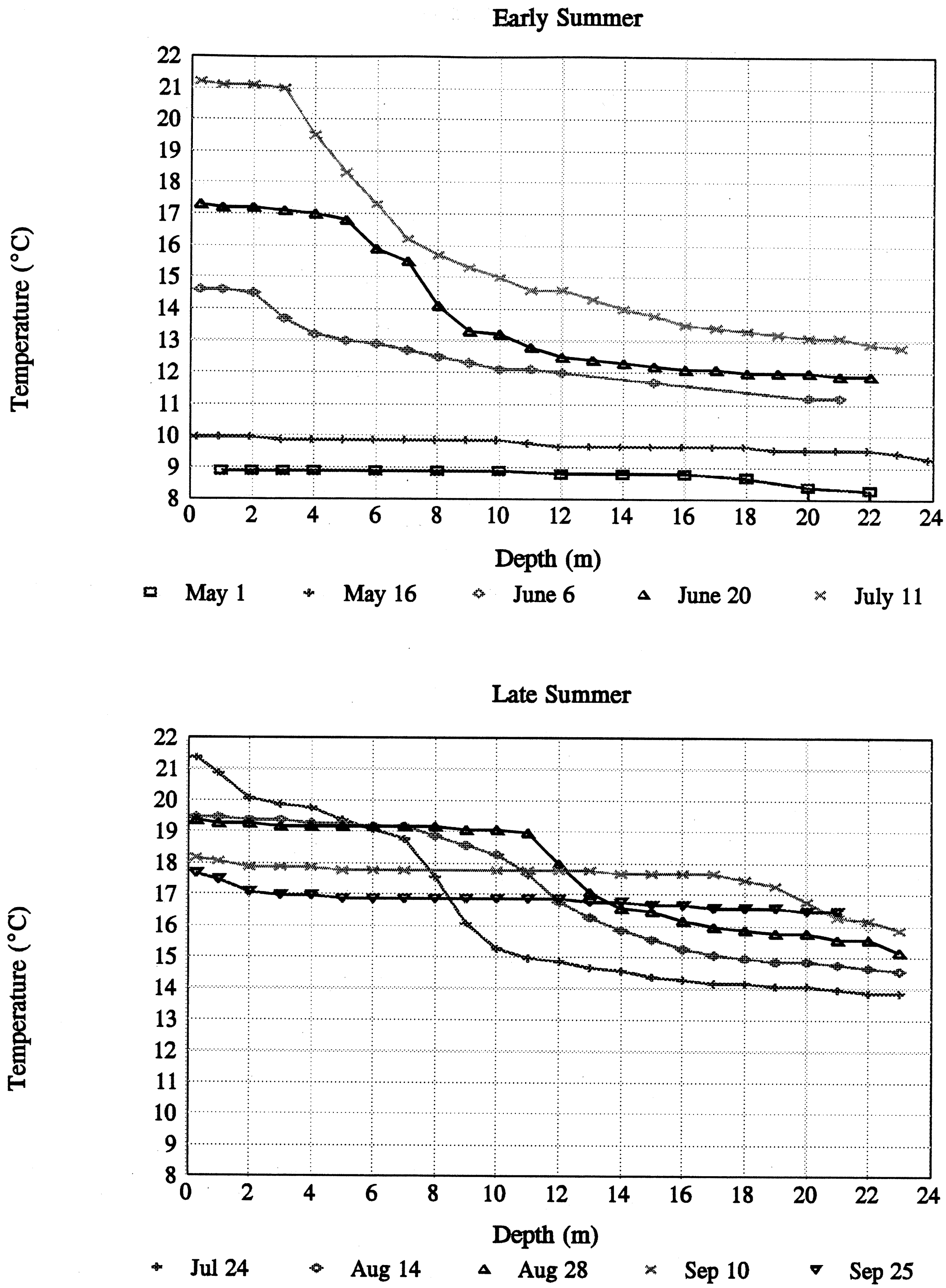


Figure 3B-4.
Crowley Lake Temperature Profiles, 1991

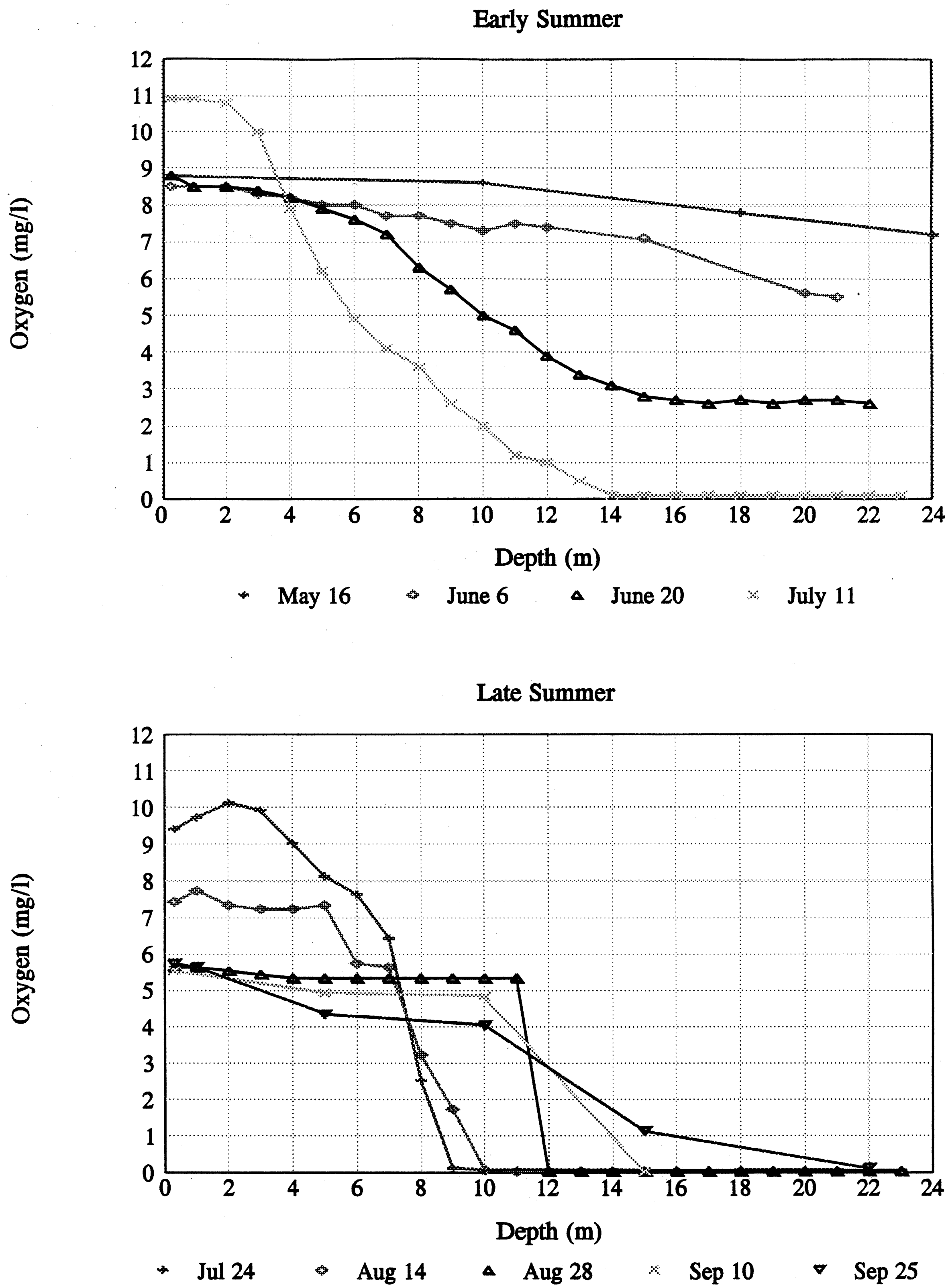


Figure 3B-5.
Crowley Lake Oxygen Profiles, 1991

Figure 3B-6.
Crowley Lake Outlet Conductivity, 1940-1991

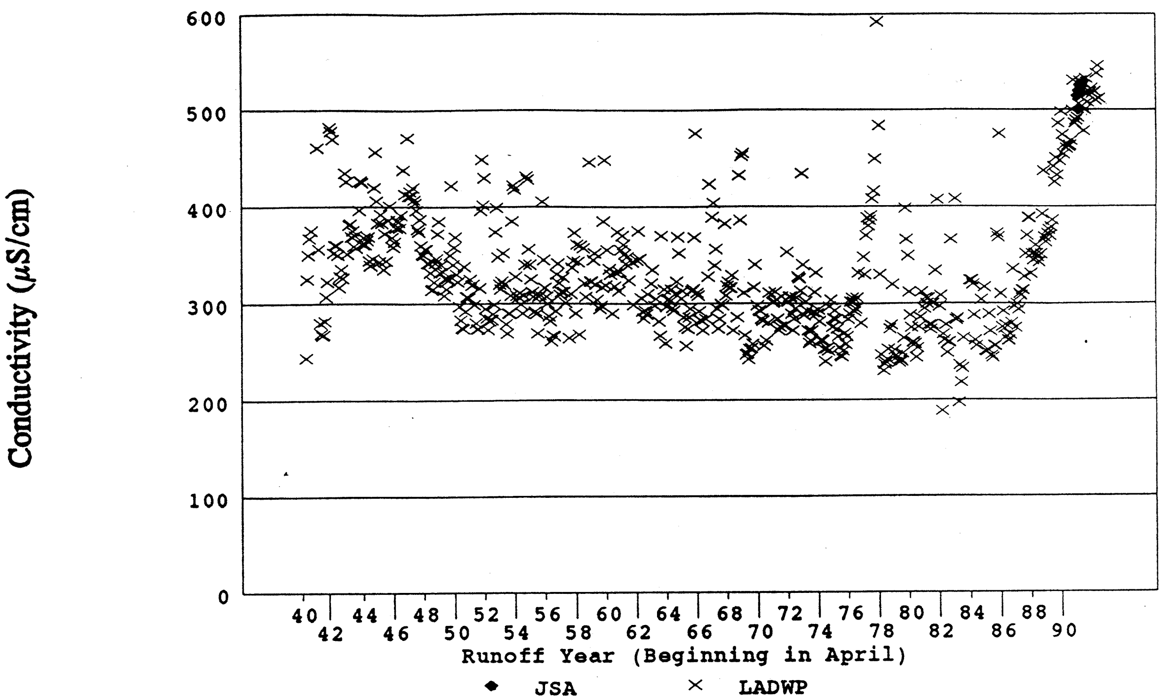
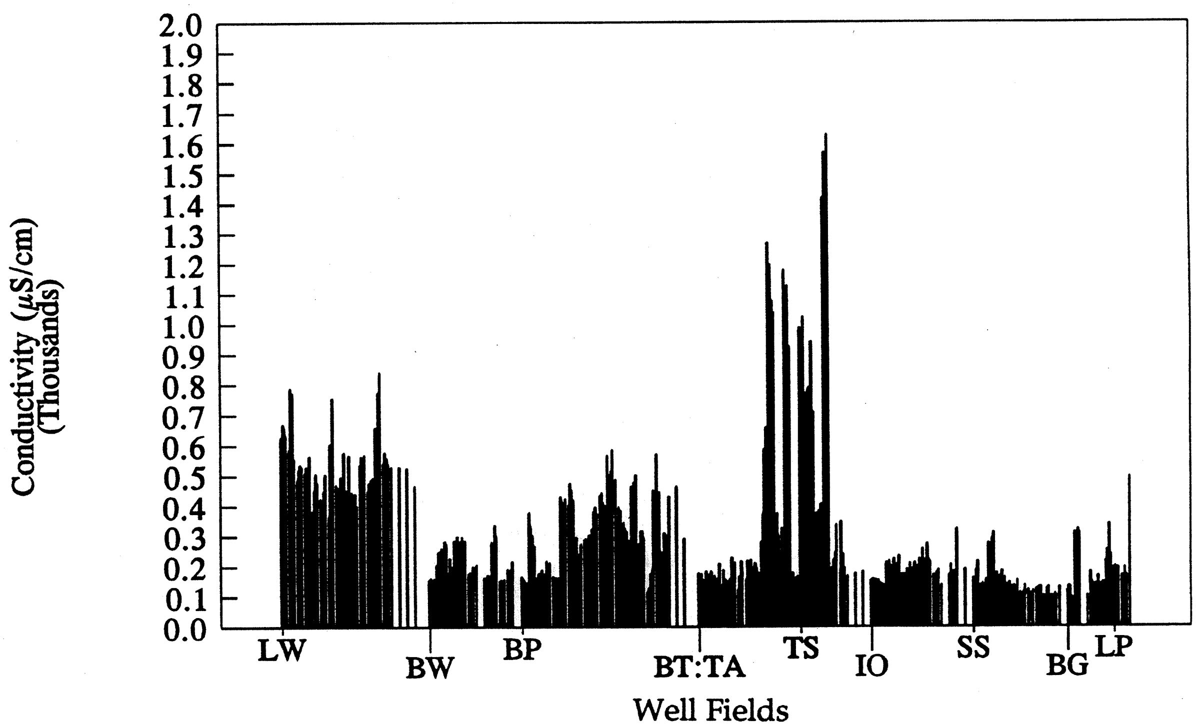


Figure 3B-7.
Conductivity of LADWP Well Water in the Owens River Basin



Note: See text for well field names.

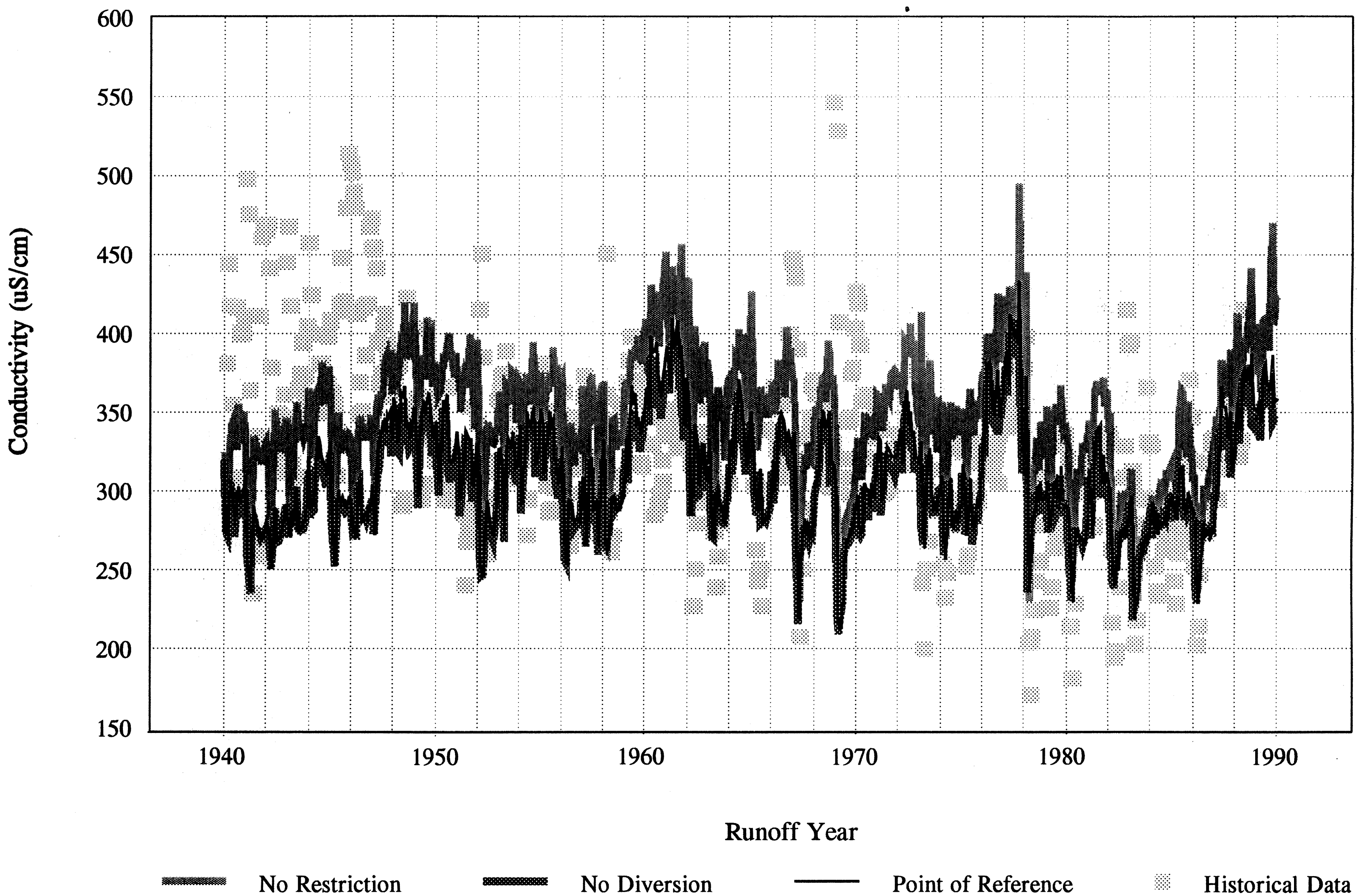


Figure 3B-8.
Predicted and Historical Conductivity
for LA Aqueduct Filtration Plant Inflow from 1940 to 1990

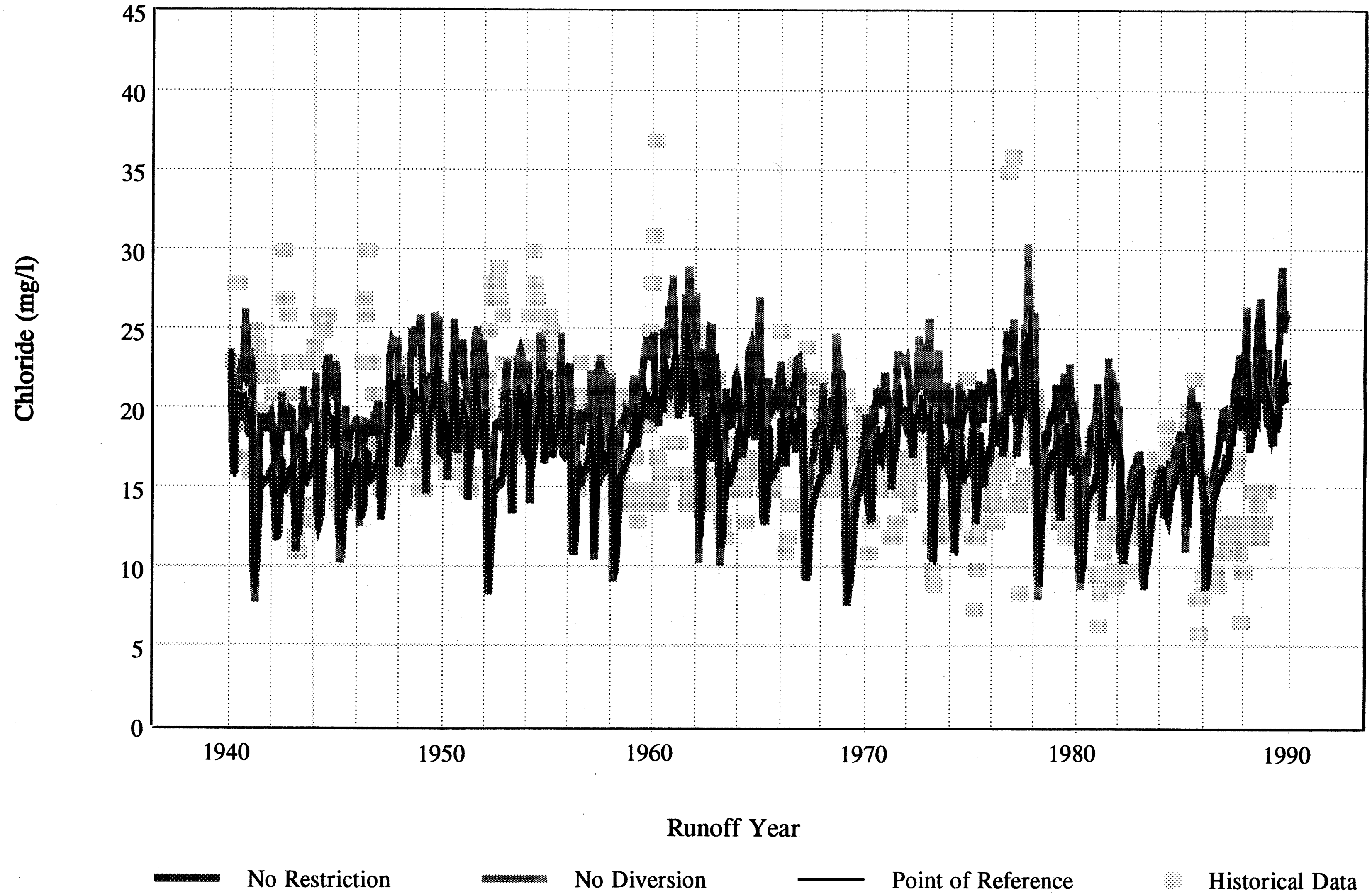


Figure 3B-9.
Predicted and Historical Chloride Concentrations
for LA Aqueduct Filtration Plant Inflow from 1940 to 1990

MONO BASIN EIR
Prepared by Jones & Stokes Associates

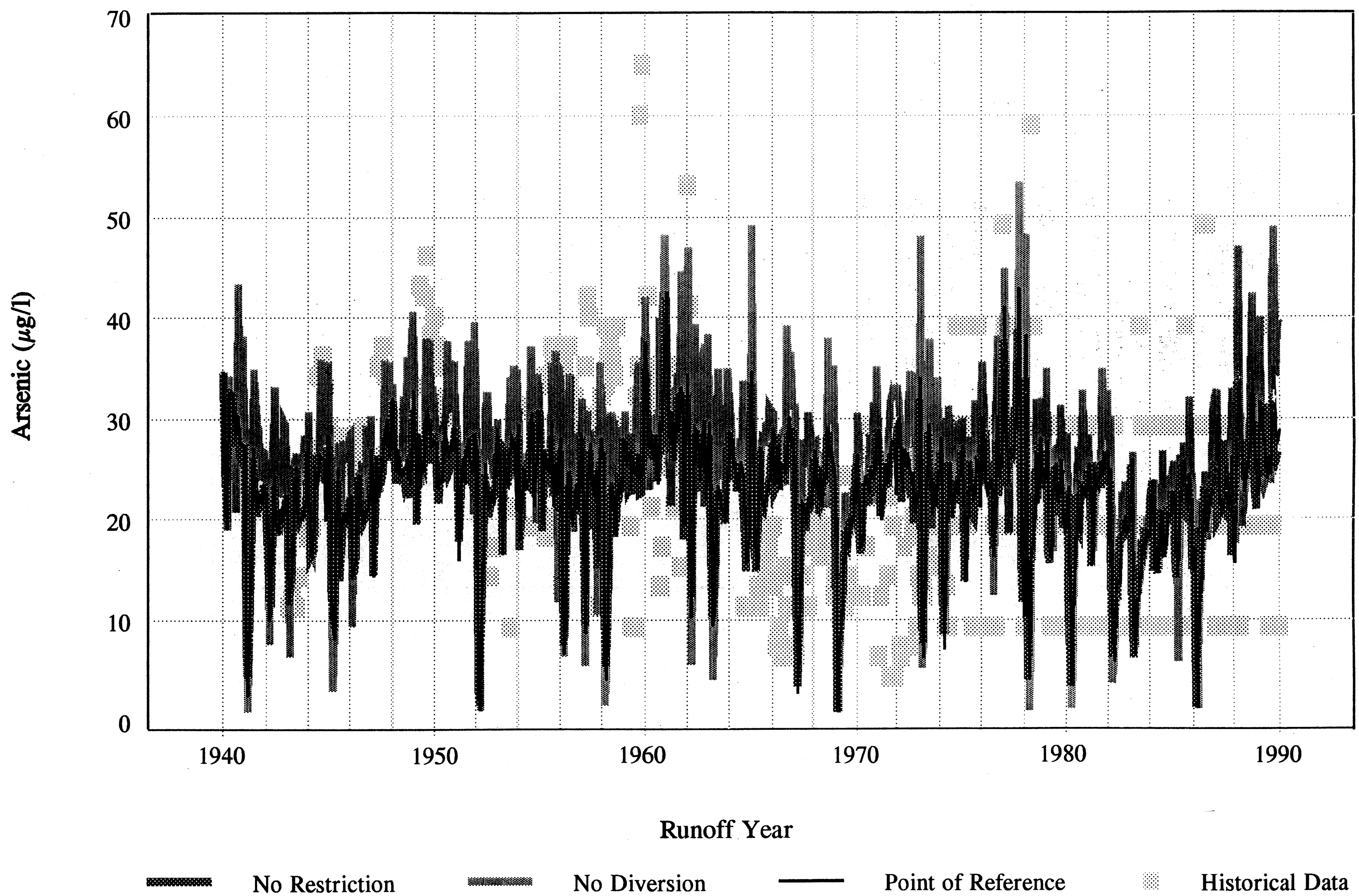


Figure 3B-10.
Predicted and Historical Arsenic Concentrations
for LA Aqueduct Filtration Plant Inflow from 1940 to 1990

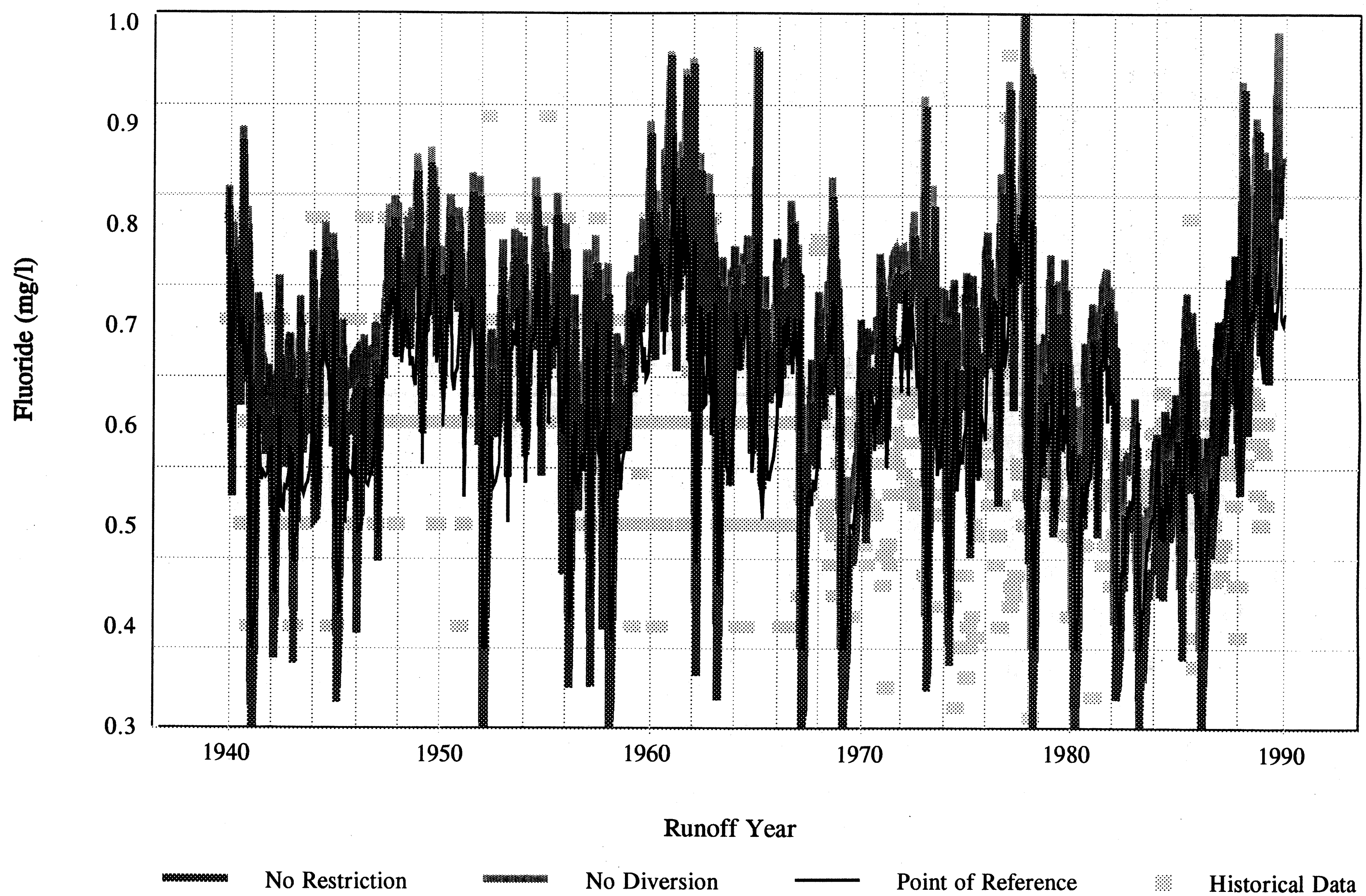


Figure 3B-11.
Predicted and Historical Fluoride Concentrations
for LA Aqueduct Filtration Plant Inflow from 1940 to 1990

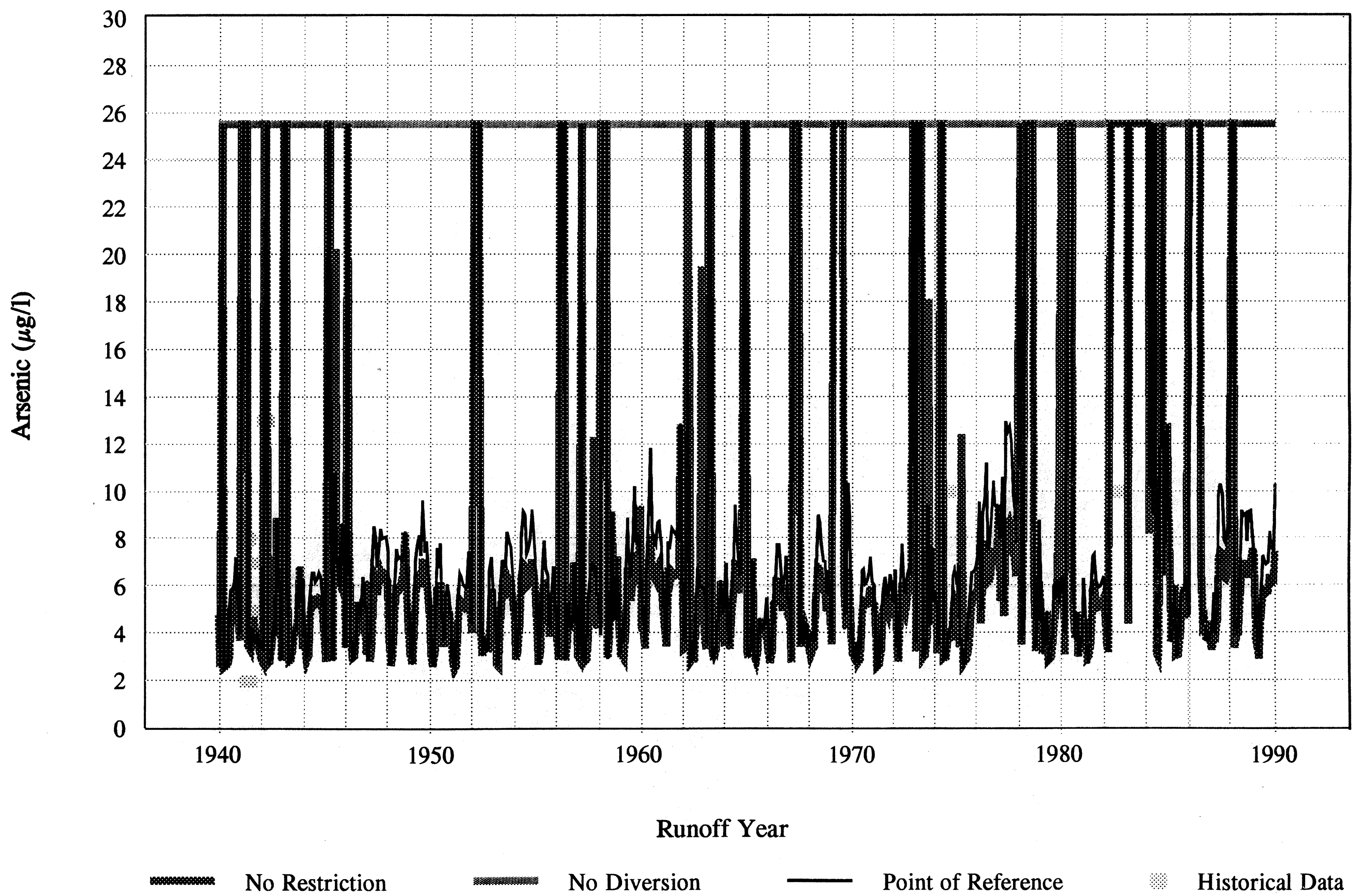


Figure 3B-12.
Predicted and Historical Arsenic Concentrations
for East Portal Outflow from 1940 to 1990

MONO BASIN EIR
Prepared by Jones & Stokes Associates

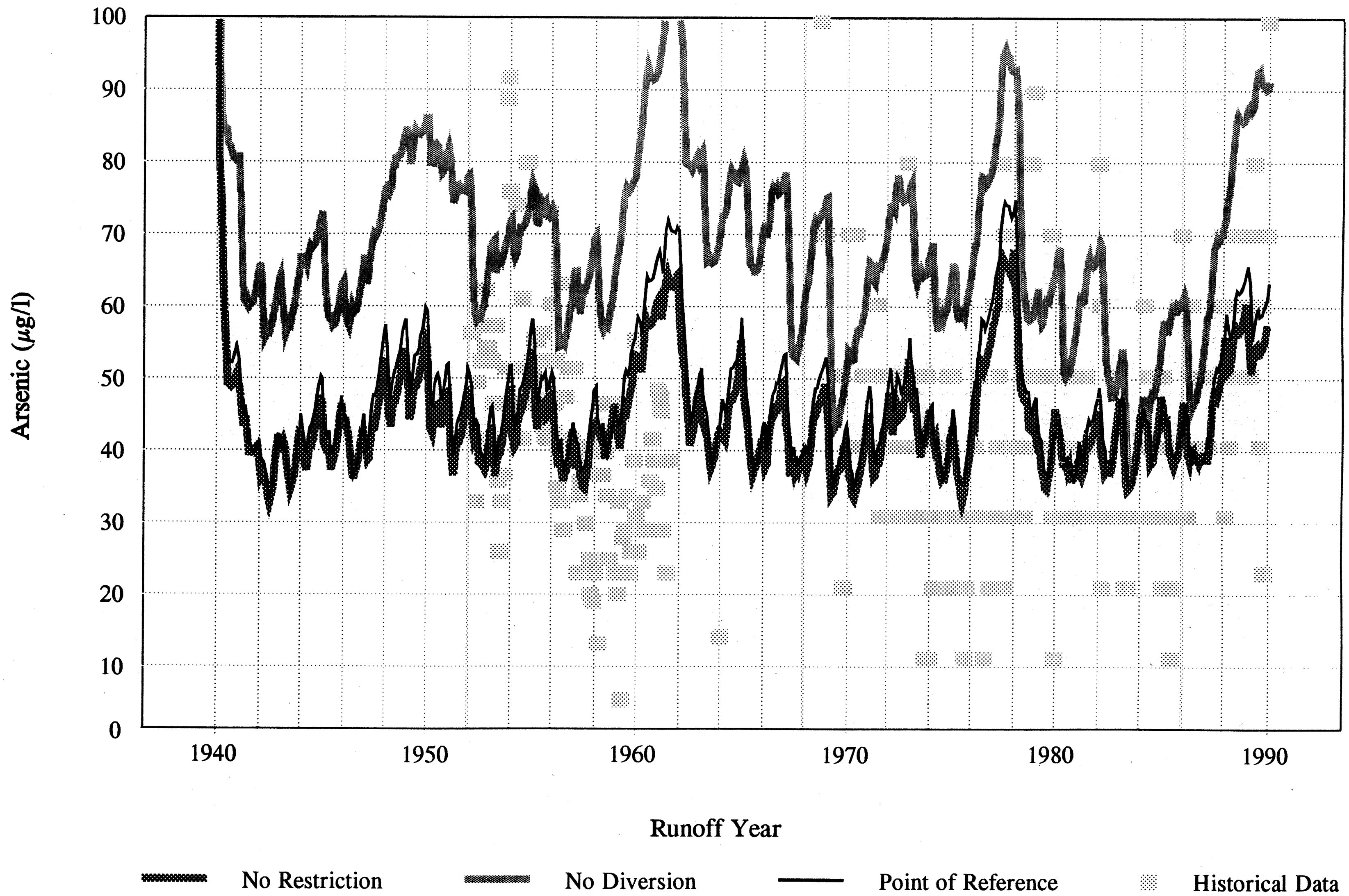


Figure 3B-13.
Predicted and Historical Arsenic Concentrations
for Lake Crowley Reservoir Outflow from 1940 to 1990

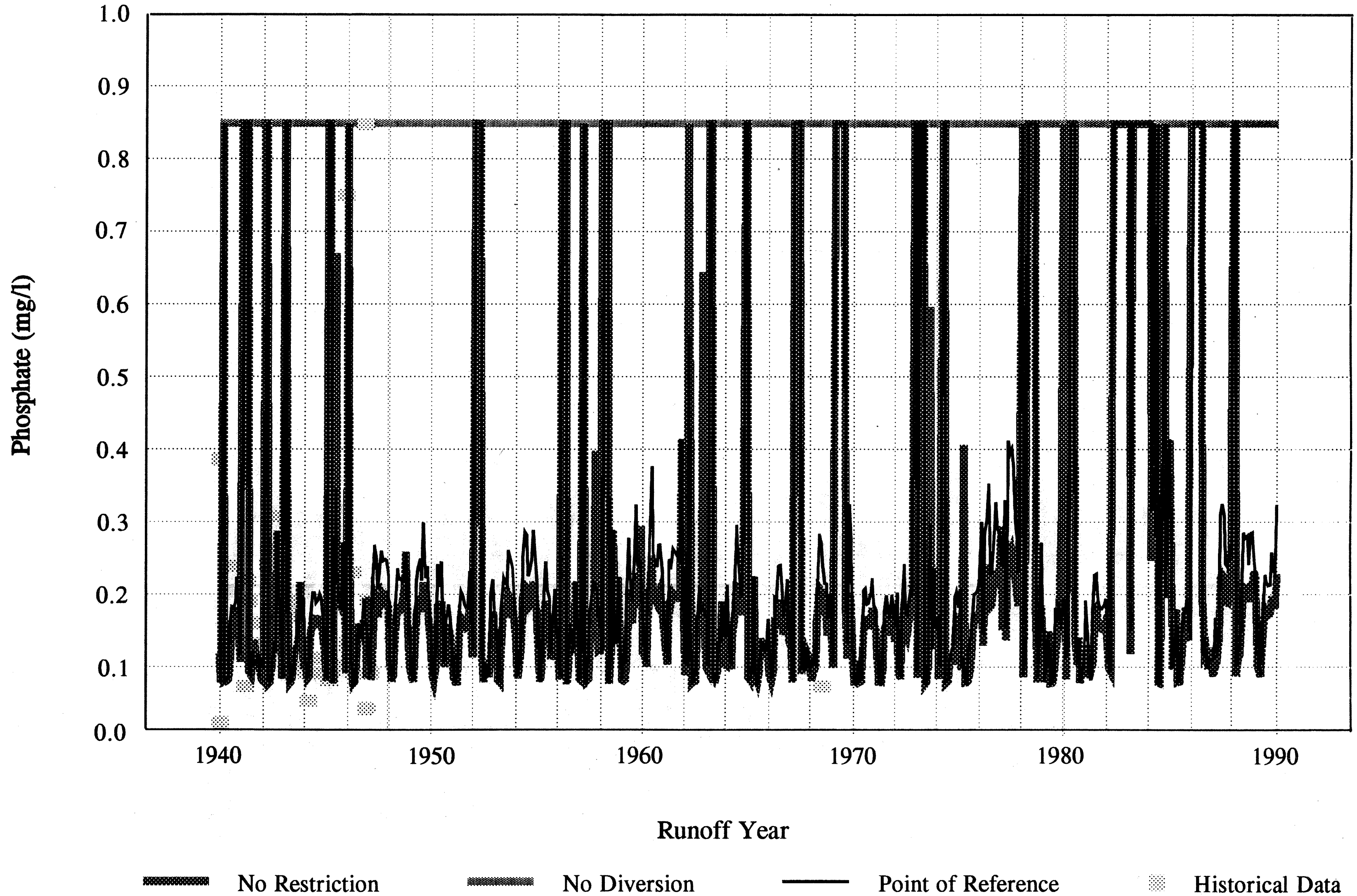


Figure 3B-14.
Predicted and Historical Phosphate Concentrations
for East Portal Outflow from 1940 to 1990

MONO BASIN EIR

Prepared by Jones & Stokes Associates

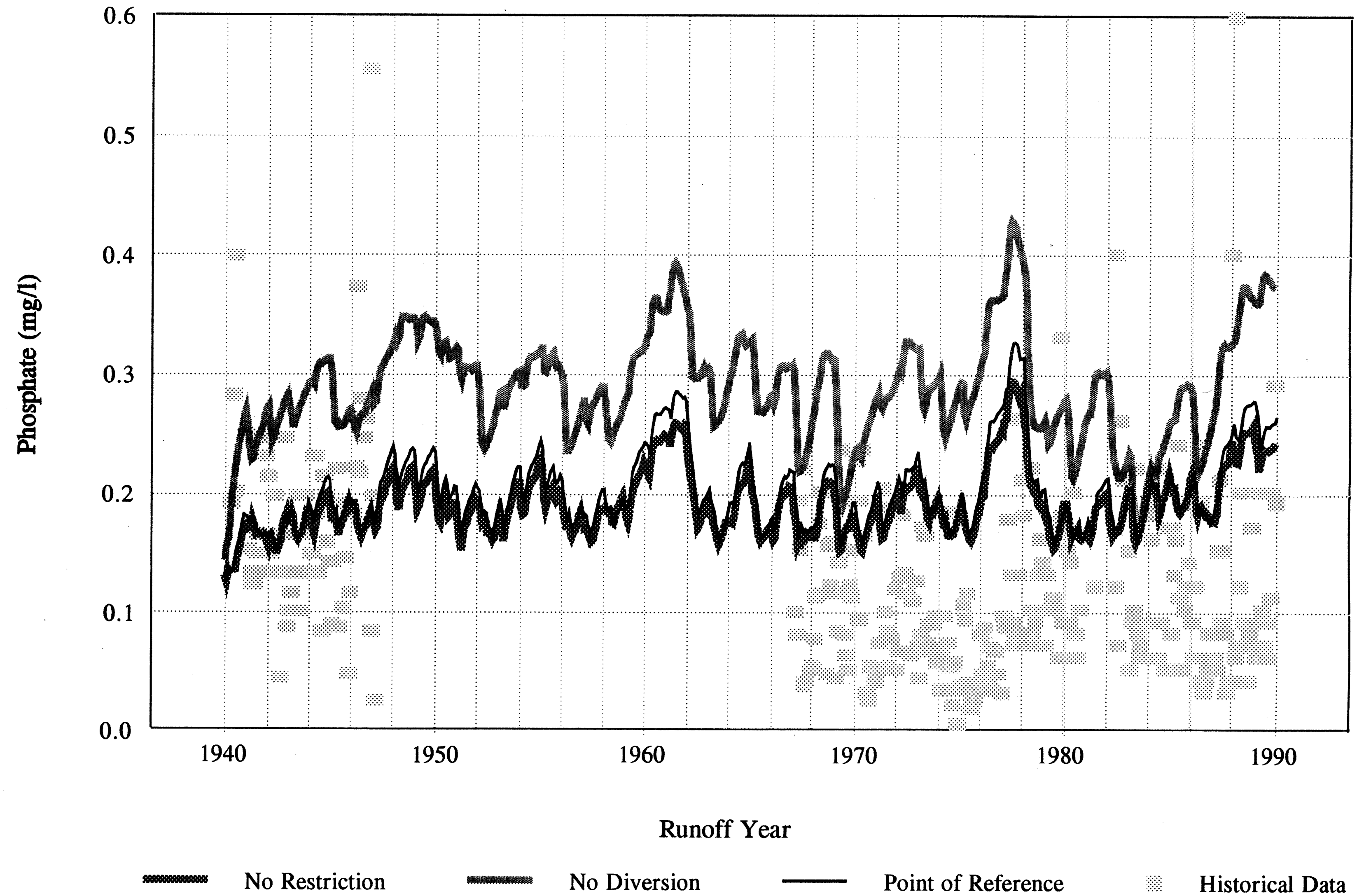
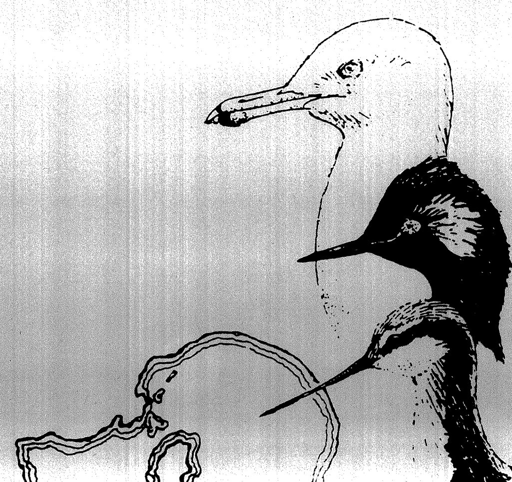


Figure 3B-15.
Predicted and Historical Phosphate Concentrations
for Lake Crowley Reservoir Outflow from 1940 to 1990

MONO BASIN EIR
Prepared by Jones & Stokes Associates

Chapter 3C. Environmental Setting, Impacts, and Mitigation Measures - Vegetation



Chapter 3C. Environmental Setting, Impacts, and Mitigation Measures - Vegetation

This chapter addresses vegetation in lake-fringing wetlands, along the tributary streams, and along the Upper Owens River to Lake Crowley reservoir (Figures 1-3 and 1-4). Relative effects of the EIR alternatives on vegetation downstream of the reservoir cannot be distinguished and are therefore not addressed. Effects on vegetation from pumping of groundwater in the Owens River basin also are not considered here because, as noted in Chapter 2, all alternatives incorporate pumping constraints reflecting the recent agreement between Inyo County and the City of Los Angeles.

Several appendices provide support for analyses and conclusions in this chapter:

- Appendix F describes the vegetation/substrate classification system used in the mapping and analyses of vegetation and applicable to the riparian vegetation along the tributary streams and the Upper Owens River and to the lake-fringing wetlands. Appendix F also provides a table of common and scientific names of plant species mentioned in this chapter.

- Appendix P describes in detail historical changes in and the impact analyses for riparian vegetation along the diverted tributary streams. Appendix P also includes a review of existing scientific literature pertinent to the ecology of riparian vegetation in Mono Basin, providing the basis for some assumptions used in the analyses.

- Appendix Q describes in detail similar information for the lakebed wetlands.

These appendices should be considered as integral parts of the assessments of this EIR.

This chapter and the appendices draw information from the general body of scientific literature, as well as from several auxiliary reports prepared for this EIR:

- Stine's (1991) study of prediversion riparian vegetation and geomorphic changes along the tributary streams,

- Stromberg and Patten's (1992) studies of streamflow effects on cottonwood tree growth along the diverted tributary streams,

- Balance Hydrologic's (1992b) assessment of groundwater profiles and streamflow responses along the diverted tributary streams,

- Stromberg and Patten's (1991) evaluation of the response of willows to streamflow augmentation along the Upper Owens River,
- Stine's (1993) study of lake-fringing wetlands before and during the diversion period, and
- Balance Hydrologic's (1992b) evaluation of groundwater conditions affecting the lake-fringing wetlands.

Vegetation acreages reported in this chapter are from maps prepared by SWRCB consultants except where noted otherwise (see Appendices P and Q for descriptions of vegetation mapping methods).

PREDIVERSION CONDITIONS

Sources of Information

Information on prediversion hydrology and geomorphology is drawn from Stine 1991 and DFG's four fishery resource reports for the tributary streams (EBASCO Environmental 1991c; Beak Consultants 1991, Aquatic Systems Research 1992). Information on the prediversion extent and character of riparian vegetation along the four diverted tributary streams was obtained primarily from aerial photographs taken in winter 1929-1930 and summer 1940. Testimony from the streamflow hearings, several historical photographs, and research by Stine (1991) provided additional information on the character of the riparian zone on the creeks.

The prediversion character and extent of lake-fringing wetlands is based on aerial photographs (dated 1930 and 1940) and Stine's (1993) interpretation of historical accounts and aerial photographs.

The prediversion character and extent of the Upper Owens River meadow and woody riparian vegetation is based on analysis of aerial photographs (August 1944), a DFG report in preparation, and consultations with knowledgeable individuals.

Assumptions about the prediversion status and distribution of special-status plants in Mono Basin and Long Valley are based on information about the current status of these plants obtained from DFG (Natural Diversity Data Base 1991), Inyo National Forest (Parker pers. comm.), U.S. Bureau of Land Management (BLM) (Primosch pers. comm.), and LADWP (Novak pers. comm.).

Tributary Streams

Hydrology and Geomorphology

The distribution of riparian vegetation is tied closely to substrate conditions allowing the availability of unconfined water at relatively shallow depth throughout most of the growing season. For this reason, most riparian vegetation is primarily found along the basin's perennial streams, but shallow groundwater flow toward the ultimate base level of the surface of Mono Lake in places gives rise to additional patches of riparian vegetation.

Geomorphic Setting. The diverted tributary streams originate in bedrock basins of the high Sierra Nevada and flow through glacially-altered terrain to discharge onto the depositional piedmont above the Mono Basin floor (Figure 3C-1). The present diversion points occur near where glacial moraines give way to distributory fluvial piedmont deposits (the Grant Lake reservoir diversion of Rush Creek and the Lee Vining Creek diversion are above the lowermost glacial moraines; the Parker and Walker Creek diversions are below them).

Pumice Valley is an eroded lakebed of Pleistocene "Lake Russell". On the west, it is intermingled with recent alluvial fan and Pleistocene delta and moraine alluvium where Rush Creek and two of its tributaries, Walker and Parker Creeks, emanate from the confining moraines that extend from bedrock canyons above. On the east (in the vicinity of U.S. Highway 395 [U.S. 395]), before becoming confluent, these three streams descend steeply into canyons they cut in the lakebeds until reaching a resistant bedrock sill at The Narrows. This post-Pleistocene vertical incision of the former top of the lakebeds (at about 7,080 feet elevation) is approximately 400-500 feet at this point.

Below the Narrows, Rush Creek flows through a more gently sloping canyon, the bottomlands, incised deeper into the Pleistocene lakebeds and now filled with stream alluvium (from a drier period when the lake fell before rising to historical elevations). Much of the alluvium is from the glacial outwash periods. Part of it, however, consists of pumice and other blast deposits from Panum Crater, which is adjacent to the bottomlands.

The lower reaches of Lee Vining Creek are in a canyon similarly incised into the lakebeds, through which the creek descends below U.S. 395. Above the highway, the creek descends steeply from the lowermost moraine of glaciation that carved the canyon of Lee Vining Creek. The LADWP diversion is upstream of the moraine in the more gently sloping canyon reach where relatively shallow fluvial deposits overlie bedrock.

Hydrologic Setting. As described in Chapters 2 and 3A, the tributary streams have relatively constant baseflows throughout the year from groundwater inflows in their upper watersheds (although flows are somewhat regulated by powerhouses on Rush and Lee Vining Creek tributaries). For 1-2 months in late spring and summer, snowmelt is considerable and streamflows increase about threefold to eightfold. In winter, snow and ice buildup can diminish streamflows. Occasional summer thunderstorms can briefly cause increased flows, especially on the smaller streams (Parker and Walker). In the prehistorical period, these streams probably all flowed perennially in most years and likely charged overflow channels during snowmelt. Occasional channel avulsions (relatively rapid change in the location of a stream channel during flood) in the alluvial fan environments undoubtedly occurred.

The tributary streams below the LADWP diversions are generally "losing" streams (although Lee Vining Creek is still gaining above U.S. 395). Losing streams percolate water to the groundwater table lying below the elevation of the channel bottom; losing reaches are typical of arid Great Basin streams emanating from mountain ranges into alluvial basin environments. "Gaining" reaches occur in more mesic environments where a water table rising away from the stream drains into the streamflow.

Riparian vegetation can occur along both losing and gaining reaches. In rapidly losing reaches the riparian corridor will be relatively narrow; along slowly losing or gaining floodplain reaches wide corridors, such as the Rush Creek bottomlands, may develop. In a losing reach, persistent streamflow continuing to recharge a shallow water table through most of the summer is generally needed for a riparian community to become established or survive.

Persistence of Summer Flows. Before LADWP diversions, Rush, Parker, Walker, and Lee Vining Creeks were diverted for flood irrigation of pastureland by local ranchers. As a result, some reaches of these streams were dewatered from time to time.

Inferences from Synoptic Flow Measurements and a No-Diversion Simulation. Flows estimated in this report for the No-Diversion Alternative, which do not include local irrigation diversions, are sufficient in all years to overcome channel losses estimated in DFG's recent studies of the four streams (Table 3C-1) with one exception. The data suggest that Walker Creek would be dry somewhere below its upper reaches 2-4% of years in March, April, and November, even if no diversions occurred.

Considering channel losses, a diversion of about 3 cfs, however, would have been sufficient to dewater Walker Creek in May and August of "dry" years (the driest 20%). Diversions of 9 cfs from Parker Creek would have caused stream dewatering in May of dry years. Diversions of 23-27 cfs from Rush Creek could have caused dewatering in July and August of dry years. In the driest years of record (driest 2%), however, diversions of only 12-14 cfs from Rush Creek would have dewatered the stream.

Inferences from Historical Data and Testimony. Historical information indicates that some reaches of the diverted streams were largely or completely dewatered from time to time in the pre-DWP-diversion period. Diversion of Parker and Walker Creeks began in the 1860s when Cain Ranch was first established and, by the 1930s, most of their flow was annually diverted from April through September. Dewatering of reaches occurred during the drought of the late 1920s and 1930s, although an amount of water sufficient for ranch domestic needs still flowed in the Parker Creek channel at the ranchhouse during this period (McAfee, Court Testimony, Streamflow Hearings Volume 2). Intermittent use of these channels to convey irrigation waters, as well as return flows from extensive irrigation near them, however, prevented significant vegetation loss (Stine 1991).

During the 1920s and 1930s, the historical period of maximum irrigation, an average of about 50% of the annual flow of Rush Creek was diverted into three major irrigation ditches from near Grant Lake dam and the old highway bridge:

- nearly 19,000 af/yr into the A-Ditch originating in the first major overflow channel below the dam, conveyed eastward to Pumice Valley;
- more than 7,000 af/yr into the B-Ditch from the channel about 1/4 mile upstream of the old highway bridge, also conveyed to Pumice Valley; and
- about 4,700 af/yr into the C-Ditch from near Grant Lake dam north to Cain Ranch.

These diversions caused dewatering of Rush Creek between the B-Ditch and Parker Creek or The Narrows in nearly 50% of the months in 1930-1935 (Stine 1991), which probably corresponded to the entire growing season. As discussed subsequently, in this particular reach, substantial riparian vegetation losses probably occurred before LADWP diversions began.

Conversely, the substantial spreading of the irrigation waters over the generally permeable Sierran piedmont, which grades into stratified former lakebeds having relatively impermeable horizontal layers that gave rise to an abundance of springflow from canyon walls, ensuring continuous streamflow and riparian survival in lower Rush Creek. Large amounts of the water distributed over the highly permeable Pumice Valley returned to Rush Creek at natural springs located along the base of the high bluffs on the east side of the Rush Creek bottomlands. Other natural springs near the mouths of Parker and Walker Creeks, and particularly those on the west side of Rush Creek at The Narrows, had their flows increased by irrigation on Cain Ranch with water from Rush, Parker, Walker, and Bohler Creeks.

The Ney and Jamison ditches diverted water from Lee Vining Creek below U.S. 395 to irrigate pastures on the west and east sides of the creek, respectively, near County Road. The Farrington and Rogers ditches diverted water above U.S. 395 to pastures between Lee Vining and Horse Creeks. The Lee Vining ditch diverted water above U.S. 395 to the Lee Vining town area. The O-Ditch irrigated meadows upstream from the Lee Vining ranger station (Stine 1991). Although these early diversions were substantial, they apparently did not dewater the stream channel (Stine 1991) and did not result in dewatering of habitats or major die-off of riparian vegetation.

Channel Stability. Fluvial landforms of the tributary streams were formed in the Pleistocene Epoch and reflect higher runoff conditions of this wetter period. The prehistorical channels were therefore probably quite stable carrying the reduced flows of the recent epoch.

Grazing was introduced into the basin more than 80 years before the LADWP diversions began. In certain periods, grazing levels were very high (see Chapter 3G, "Land Use"). Introduction of domestic livestock probably initiated a watershed disturbance and a process of channel adjustment. Decreases in vegetation and increases in surface compaction undoubtedly caused higher rates of runoff and initiated some channel incision and bank instability.

Because the ranching diversions were apparently not large enough to cause major vegetation die-offs, stream channels probably continued to be relatively stable and little-incised through the onset of LADWP diversions. Indeed, some reaches of the recently rewatered channel of Parker Creek, preserved without major flow since early in the diversion period, appear largely undisturbed.

Shallow Groundwater Zones. Before the period of stream incision during the LADWP diversions, the floodplain surfaces of lower Rush and Lee Vining Creeks were within a few vertical feet of stream surfaces, providing more primary habitat for riparian vegetation. Accordingly, xeric habitats in these bottomlands were less extensive in the prediversion period, although prediversion topographic data to measure this effect does not exist.

Seasonal Floodchannel and Overbank Flows. Before channel incision, flood channel and overbank flows in the bottomlands were probably common during snowmelt, promoting germination and recruitment in the primary riparian habitat. Also, the mouths of several flood channels and distributary channels along Rush, Parker, and Walker Creeks, now filled, may have been open before channel incision, allowing seasonal inflow and resulting riparian regeneration. Although the ranching diversions might have been used to divert some floodflows, such management seems unlikely. The recurrence period of such overbank flows (bank-full stage) is typically 2 years.

The mouths of prehistorical distributary channels of Parker and Walker Creeks where they debouched from their moraines were at the present locations of each of the LADWP diversions. No longer functioning as overflow channels, they were probably first altered by the early ranching diversions, but may have continued to carry flows during periods of high runoff in the prediversion period.

Riparian Vegetation

Definition and General Characteristics. Riparian vegetation consists of trees and shrubs occurring on the banks and floodplains of streams and around springs. Riparian vegetation requires shallow groundwater throughout the growing season and generally also requires seasonally high flows for successful reproduction of plants adapted to this habitat. Riparian vegetation is dominated by plants that cannot grow in the locally adjacent uplands because of inadequate groundwater and surface water during the growing season. Riparian vegetation includes both obligate riparian plants (i.e., plants that occur only in riparian sites) and facultative riparian plants (i.e., plants that are restricted locally in association with streams but in areas of wetter climate are not restricted to streams).

Riparian vegetation in healthy condition is characterized by a dense, multilayered canopy of trees, shrubs, and herbs with a mosaic pattern of variation in species dominance, tree age, canopy height, and canopy density. These characteristics provide many ecological and social benefits. Benefits to aquatic life include bank stabilization, refuge from predators and floods, food production (insects and other invertebrates), shading, and nutrient cycling. Benefits to terrestrial wildlife include nesting, feeding, and resting habitat; protection from predators and storms; and corridors for daily and seasonal migration. Benefits to the physical environment include nonpoint source pollution abatement, chemical and energy cycling, flood abatement, and geomorphic stabilization. Benefits to society include opportunities for recreation and scientific study.

The prediversion extent of riparian vegetation along the tributary streams is shown in Table 3C-2. Maps and reach-by-reach descriptions of this vegetation are given in Appendix P.

Rush Creek. Riparian vegetation conditions on Rush Creek were altered before the LADWP diversion period by construction of Grant Lake reservoir, irrigation diversions to Pumice Valley and Cain Ranch, and the emergence of irrigation water at springs in the Rush Creek bottomlands.

Grant Lake reservoir was initially constructed in 1915 and raised in 1926. From 1926 to 1940, Rush Creek entered Grant Lake reservoir at the spillway elevation of approximately 7,093 feet. Grant Lake reservoir had already inundated an unknown amount of riparian and meadow vegetation before LADWP raised the dam 38 feet in 1940 to its current spillway elevation of 7,131 feet in 1940. Raising the dam eliminated several acres of riparian vegetation at the dam site and in the enlarged drawdown zone. During this time, many Jeffrey pines were removed by logging in the reach between the dam and U.S. 395. (Stine 1991.)

As noted previously, in the prediversion period water was diverted from Rush Creek at three locations between Grant Lake reservoir and U.S. 395. Although the effect of these diversions on riparian vegetation along the main channel is uncertain, they may have contributed to a general scarcity of riparian vegetation in 1940 between the old highway bridge and the confluence with Parker Creek.

Vegetation associated with the springs along lower Rush Creek benefitted indirectly from the irrigation. Even the drought of the late 1920s and early 1930s had little adverse impact on riparian vegetation below The Narrows, because of water gained from springs supported by the heavy irrigation (Stine 1991) and geomorphic conditions favoring shallow groundwater.

Altogether, about 271 acres of woody riparian vegetation and 131 acres of meadows grew along Rush Creek in 1940 (Table 3C-2) (Appendix P). About 64% of the cottonwood- or willow-dominated vegetation along the creek grew in the reach between The Narrows and

County Road. The largest meadows occurred in this reach and near the mouth of the creek. The overall condition and vigor of the vegetation appear to have been good to excellent in 1940, with relatively dense canopies evident in the 1930 and 1940 aerial photographs. The width of the riparian strip varied from less than 100 feet in narrow, V-shaped gullies through the moraine below Grant Lake reservoir and the delta canyon below U.S. 395, to as much as 1,200 feet in the broad, level reach of the Rush Creek bottomlands. A reach-by-reach description of prediversion riparian vegetation along Rush Creek is given in Appendix P.

Parker Creek. By 1940, approximately 80 years of irrigation and grazing had significantly altered the extent and condition of riparian vegetation along Parker Creek. The principal alterations were probably a major expansion of meadows into areas previously occupied by sagebrush scrub and a lesser expansion of riparian scrub along irrigation supply and runoff collection ditches. Relatively small amounts of willow or mixed riparian scrub may have been eliminated in the lower portions of the meadows east and west of Cain Ranch Road. Another major effect in later years may have been suppression of willow recruitment caused by the absence of overbank flows and the consumption of palatable young plants by sheep (Stine 1991).

At the time LADWP began diversions, Parker Creek supported approximately 58 acres of woody riparian vegetation (Table 3C-2), about 93% of which was willow scrub. Most occurred along the main channel, but some had become established along major irrigation ditches and probably depended on irrigation for continued vigor. Canopy cover in the willow scrub and mixed riparian scrub was mostly moderate to dense along active channels and sparser in areas off the main channels. Most of this vegetation appears to have been relatively vigorous (with dense canopies casting clear shadows) in the December 1929 and June 1940 aerial photographs.

Extensive meadows (presumably of mostly rush series vegetation) surrounded the stream and riparian vegetation from the present location of the diversion pond to U.S. 395. Patches of sagebrush scrub occurred among patches of riparian vegetation at the base of the moraines on the west side of Cain Ranch. Sagebrush scrub surrounded the narrow riparian strip in the canyon below the present location of U.S. 395.

Walker Creek. As on Parker Creek, the riparian vegetation on Walker Creek had been significantly altered by approximately 80 years of irrigation and grazing activities before 1940. The effects of these activities on Walker Creek vegetation were similar to those described above for Parker Creek.

Between the present location of U.S. 395 and the present LADWP diversion site, Walker Creek flowed through two roughly parallel channels. The south channel was the main channel and the north channel, naturally a distributory overflow channel, was supplied with water diverted from both Walker and Bohler Creeks. The secondary channel appears to have received water from Bohler Creek approximately 0.45 mile upstream from Cain Ranch Road. Both channels supported roughly equal amounts of woody riparian vegetation.

At the time LADWP began diversions, Walker Creek supported approximately 50 acres of woody riparian vegetation (Table 3C-2). About 85% of this vegetation was willow scrub. Most occurred near the banks of the main and secondary channels, but some had established along irrigation ditches and probably depended on irrigation for continued vigor. The condition of this vegetation was similar to that described above for Parker Creek.

Meadow and sagebrush scrub vegetation along Walker Creek had a distribution similar to that described for Parker Creek.

Lee Vining Creek. Riparian vegetation along Lee Vining Creek had been minimally altered before 1940. Road crossings existed at the present locations of County Road, U.S. 395, Highway 120, and ranger station crossings. A hydroelectric diversion dam existed immediately above the Highway 120 crossing, and a powerhouse was located at the present-day Southern California Edison (SCE) substation site.

From the LADWP diversion site to U.S. 395, about 30 acres of forest (mostly conifer-broadleaf) and 5 acres of willow scrub grew along the main channel and adjacent meadows.

Below U.S. 395, approximately 69 acres of woody riparian vegetation (mostly cottonwood-willow forest and conifer-broadleaf forest) existed in the Lee Vining Creek floodplain. About 6 acres of irrigated pasture and unirrigated meadow and 2 acres of sagebrush scrub also existed within the floodplain below U.S. 395. Another 8.4 acres of woody vegetation (mostly quaking aspen forest) occurred above the floodplain, along the sides of the delta canyon. About 40 acres of irrigated pasture occurred outside the floodplain on the west side of the creek and several more acres on the east side of the creek.

Altogether, about 112 acres of woody riparian vegetation occurred along Lee Vining Creek below the LADWP diversion (Table 3C-2).

Other Creeks. Several other streams are direct or indirect tributaries to Mono Lake but are not diverted by LADWP. These creeks would be indirectly affected by the alternatives, through deposition or incision in their lower reaches depending on the adopted lake management levels.

Bohler Creek. Bohler Creek (north of Walker Creek) on Cain Ranch supported several acres of mixed riparian and willow scrub in scattered patches and strands similar to those of Walker Creek. By 1940, the main channel of Bohler Creek was obscured by diversion of the entire flow into irrigation channels. At the present site of U.S. 395, Bohler Creek entered a narrow canyon similar to that of Walker Creek. A few small, scattered patches of coyote willow or mountain rose grew along the creek in this canyon but did not provide significant acreage of riparian habitat. Several large patches of willow scrub occurred where the Bohler Creek canyon entered the Rush Creek canyon about 0.4 mile below The Narrows. These willows may have been sustained by groundwater originating in the portion of Cain Ranch watered by Bohler Creek.

Horse Creek. Horse Creek (between Bohler and Lee Vining Creeks) was diverted for pasture irrigation in Upper and Lower Horse Meadows, near U.S. 395, and possibly near the lakeshore in Horse Creek Bay. The historical main channel of Horse Creek was probably the southern of the two ravines (about 1,000 feet apart) crossed by U.S. 395. Vegetation on Horse Creek in 1940 was probably similar to that of today, with a few acres of dense willow scrub on main channels near the irrigated pastures. Short narrow strands of willow scrub may have occurred in one or both of the ravines for 0.2-0.5 mile below the highway.

Post Office Creek. This very steep stream crosses U.S. 395 at Tioga Lodge, 1.5 miles north of Lee Vining. Diversions for domestic and other uses were relatively small. Early photographs of Tioga Lodge indicate that willow and mixed riparian scrub extended down the creek to near the lakeshore.

DeChambeau Creek. DeChambeau Creek (south of Mill Creek) supported quaking aspen forest, willow scrub, and mixed riparian scrub from the mountain slopes above U.S. 395 to the vicinity of the present-day Mono Lake County Park parking lot. Water was diverted for pasture irrigation above and below the highway. Flows may have been supplemented with water diverted from Mill Creek.

Mill Creek. Mill Creek (in Lundy Canyon) supported conifer-broadleaf forest and cottonwood-willow forest from above U.S. 395, through the deep canyon below the highway, and down the delta to about the 6,420-foot elevation. The general composition and character of the vegetation was probably very similar to that on Lee Vining Creek. Distant views of the Mill Creek delta from near the Mono Inn are shown in photographs by Burton Frasher of boat races during Mark Twain Days in 1930, 1939, and 1940. These photographs show a tall, multilayered canopy of cottonwoods and conifers on lower Mill Creek. Mill Creek was partly diverted at Lundy Lake for power production beginning in 1911 and at various locations below Lundy Lake for irrigation beginning in the late 1800s.

Wilson Creek. Wilson Creek (north of Mill Creek) was an ephemeral stream with little riparian vegetation before it was augmented with water that had passed through the Mill Creek powerhouse (beginning in 1911). Smaller amounts of water diverted from Virginia Creek to irrigate Conway Ranch also ended up in Wilson Creek. The increased flow caused significant channel incision. The augmented flows probably increased riparian vegetation along the channel north of Highway 31, but riparian vegetation was probably minimal below the highway.

Lake-Fringing Wetlands

Definitions

For this assessment, the term wetland is based on the U.S. Fish and Wildlife Service (USFWS) definition (Appendix Q); DFG has adopted the same definition. This concept of wetland encompasses the range of groundwater-dependent habitats that could be affected by EIR alternatives. This definition includes some dry meadow habitats that do not meet the U.S. Environmental Protection Agency (EPA) and U.S. Army Corps of Engineers (Corps) jurisdictional definition for the Clean Water Act (33 CFR 328.3). Dry meadows at Mono Lake are dominated by plants that depend on deep groundwater and do not occur at sites that are saturated, flooded, or ponded at the surface during the growing season.

Lake-fringing wetlands form at springs, seeps, and lagoons around the edge of Mono Lake. Based on the above wetland definition, lake-fringing wetlands include unvegetated lagoons and those alkali flats that under normal climatic conditions are saturated at the surface for a long duration during the growing season.

Wetland Functions

Important functions of lake-fringing wetlands include providing habitat (food, water, cover) for wetland-dependent plant and wildlife species, including some special-status species and migratory birds; detaining and stabilizing sediment; transforming and cycling nutrient; and supporting wildlife food chains. Lake-fringing wetlands are highly productive from a plant biomass standpoint. (High productivity may result from the presence of biogenic lakebed deposits from prior lake highstands.) Wetlands are valued as pasturage and are well suited for waterfowl management. These functions translate into social values, including biodiversity reserves, livestock range, hunting and recreational opportunities, and resources for research and education.

Geohydrologic Processes Affecting Lake-Fringing Wetlands

Eighteen lake-fringing wetlands can currently be delimited at Mono Lake based on geohydrology (Figure 3C-2). Wetlands existed at most of these locations before water export began in 1941. The 18 wetlands are grouped into six georegions based on location, water source, sediment lithology, and response to lake level fluctuation (Table 3C-3). The geohydrology of the lake-fringing wetlands is described in Appendix Q and summarized below.

Wetlands develop where groundwater is discharged to the soil surface or exists in shallow subsurface aquifers. Vegetated wetlands develop where fresh groundwater inflows are available to sustain hydrophytic vegetation and flush salts and phytotoxins (e.g., boron and arsenic) from lakebed sediments ringing the lake.

Mono Lake is the regional sink for groundwater that originates from relict lake water in the lakebeds of former high stands or from ongoing precipitation and streamflow in the watershed. Rangeland irrigation has at times also contributed to groundwater discharge along the lake's west shore (Stine 1993). Groundwater reaches Mono Lake along one of two paths: water reaches the lake through shallow aquifers or faults that convey water downslope to the shoreline via gravity, and artesian water upwells from deeper, pressurized aquifers and reaches the lake through terrestrial or underwater springs.

Groundwater flowing only under the influence of gravity is guided to the lake by impervious lakebeds or the underlying denser, saline nearshore groundwater that is influenced by the high salinity of Mono Lake. Artesian water is trapped in deeper lakebeds that are dead-end or confined aquifers pressurized from precipitation and infiltration in distant, higher-elevation recharge zones. Faults and other structural discontinuities provide pathways where pressurized water escapes to the surface, forming springs or seeps. Water from terrestrial artesian springs can reinfiltrate shallow aquifers and move toward the lake as shallow groundwater, in addition to flowing over the surface to the lake.

Four types of springs and seeps discharge groundwater to lake-fringing wetlands; each type differs in water source, underground pathway, and response to lake level fluctuation (Appendix Q):

- The unconfined nearshore water table and shallow, confined aquifers discharge upland groundwater in arched bands around the lakeshore from the faces of low wave-cut scarps formed by shoreline erosion or from the surface of nearly flat-lying sediments due to capillary rise.

- Fractured-rock gravity-flow springs, restricted to the base of the Sierra Nevada, discharge groundwater that has moved through the complex pathway of intersecting faults of the eastern Sierra Nevada.

- Deltaic artesian springs originate in confined aquifers deep within the deltas of Lee Vining, Rush, Mill, and Wilson Creeks.

- Deep-fracture artesian springs originate in groundwater in the deep sediments accumulated in Mono Basin.

Most lake-fringing wetlands are sustained by two or more of these water sources.

Lagoons with brackish water form around the lakeshore behind shoreline berms of sediment deposited by longshore currents of the lake and associated aeolian processes (Appendix Q). In prediversion times, they had developed best along the northern shoreline and on the Rush, Lee Vining, and Mill Creek deltas. Lagoons form when Mono Lake stands high enough for shallow groundwater to surface and lakewater to infiltrate the berms. Fresh water from upslope catchments also discharges into the lagoons. Groundwater is consistently less saline than Mono Lake water; fresh surface water and shallow groundwater dilute the lake water, forming brackish rather than saline conditions.

The alkali lakebed habitat is a prominent feature of the contemporary Mono Lake shoreline, but was practically nonexistent before diversions began. It develops on relicted lakebed where old lake deposits from prior highstands are exposed and a process called efflorescence is operative. Efflorescence at Mono Lake occurs when shallow, moderately saline groundwater underlies gently sloped relicted lakebed. The saline groundwater is drawn to the surface by capillary action and evaporates, continually reforming a salt residue that can develop into a thick powder or crust between occurrences of wind and rainstorms. Gentle water table slopes and moderate to slow permeability prevent the water table from draining rapidly (Appendix U).

Effects of Habitat on Vegetation

Wetland vegetation includes riparian scrub, marsh, wet meadow, and alkali meadow types (described in Appendix F). Relicted lakebeds in drier topographic positions support an array of scrub and herbaceous vegetation types. Nonwetland areas exposed for decades develop rabbitbrush, greasewood, or sagebrush scrub. Recently exposed lakebed supports herbaceous vegetation. Mono Lake's extreme salinity and alkalinity prevent vegetation from becoming established within the lake. Lagoons and alkali flats are too saline and alkaline to support vegetation (Stine 1993, Groeneveld 1991a, 1991b). Lakebed exposed by lake recession is initially too saline for vegetation because of the high lakewater salinity.

Lakebed Leaching. Springs and seeps above the shoreline support wetland vegetation, which can invade the shore zones following lake regression after inhibitory saline-alkali compounds are leached.

Wetland vegetation varies according to the volume, seasonality, and quality (i.e., salinity and alkalinity) of water, and substrate texture and chemistry. As described, variations in site hydrology are complex. Soil chemistry variations are also complex because of the complex geology and hydrology of the Mono Lake shoreline.

Coarse-textured stream deposits of granite and metamorphic rock make up surface sediments of the west shore. The northeastern shoreline and the surface of Paoha Island are covered with fine-textured, highly saline-alkaline lakebed sediment, overlaid in some areas by a veneer of wind-blown sand, primarily from Mono Craters. The southern shoreline is covered by fine-grained ash ejected from Mono Craters, interbedded with coarse-grained, wind-blown sand. Slowly permeable or impermeable, clayey lakebed sediment from prior Mono Lake highstands or weathered volcanic ash are interbedded as subsurface layers in all regions.

Sediment texture and salinity, shoreline slope, and the seasonal duration and volume of groundwater inflow determine substrate leaching rates. Wetter sites, common on the lake's west side, have been exposed to the greatest degree of salt leaching and support vegetation more typical of freshwater wetlands. As the degree of leaching decreases, vegetation types shift toward more salt-tolerant plant associations, such as alkali meadows.

Common Wetland Habitat-Vegetation Relationships. Each wetland supports a mosaic of plant associations (i.e., series). Wetlands are interspersed with unvegetated tufa towers, sandy beaches and berms, lagoons, and alkali flats.

Relationships between vegetation type and groundwater depth in the vicinity of Mono Basin have been documented by Sorenson et al. (1989), Lee (1912), and Ecosat Geobotanical Surveys, Inc. (1990). Marshes form in areas of permanent or semipermanent shallow flooding at springs, along drainages, and in ponds behind littoral embankments. Marshes are typically encircled by wet meadow or alkali meadow. Wet meadows develop in well-leached soil having a shallow water table. Alkali meadows form in areas of limited substrate leaching and shallow water table where efflorescence maintains elevated surface salinity and alkalinity. Dry meadows occupy well-drained porous soil underlain by deeper groundwater.

Some lake-fringing wetlands, especially along the Sierran front, support willow or mixed scrub vegetation, generally on well-leached soil. Rabbitbrush and greasewood scrub, which are not wetlands, develop on lakebed sediment underlain by deeper groundwater than is found under dry meadows.

Wetland Species Richness and Diversity. Vegetated lake-fringing wetlands are typical of the western Great Basin but have relatively low species richness, possibly because of their young age. The gradual process of vegetation change (succession) is influenced by the length of time a site is exposed above the lake, degree of salt flushing, and rates of plant immigration from distant wetlands. Recently formed wetlands and those widely separated from established wetlands are dominated by one or few plant species. Many of the larger wetlands support vast areas of one plant species, such as the three square marsh or Nevada bulrush alkali meadows.

Some less prevalent wetland types, such as mixed alkali meadow and mixed wet meadow, have considerably higher plant species richness and diversity. The more diverse types are associated with: well-established wetlands that existed before LADWP diversions, saline-alkali soils that have complex surface relief and drainage, and wet meadows below the Sierran front exposed to a constant influx of plant propagules from wetlands along tributary streams.

Prediversion Wetland Extent and Distribution

Before diversions, the Mono Lake shoreline supported about 615 acres of wetlands (Figure 3C-2, Table 3C-4), including 260 acres of brackish lagoon and 356 acres of marsh, wet meadow, alkali meadow, and wetland scrub habitat (their relative extent could not be distinguished using historical aerial photographs [Stine 1993]). Vegetated prediversion wetlands were recorded at 14 of 18 current sites; the other four sites supported only lagoons.

These area estimates include little if any dry meadow because the early aerial photographs do not provide the resolution required to discern this sparsely vegetated habitat. Evidence indicates dry meadows were of limited extent under prediversion conditions.

Wetland area was limited before diversions began because the relatively steeper shoreline minimized the area exposed to springs and seeps. Many of the springs supporting wetlands during the point of reference were underwater and forming tufa. Almost no efflorescent alkali flats were present in the prediversion period.

North Mono Shorelands. Over 200 acres of lagoons dominated shorelines of Mono Lake in the prediversion period. Most of the lagoons were east of Sulfur Springs (the dune lagoons). The 23-acre lagoon at the DeChambeau embayment did not develop until the late 1940s after the lake dropped 5 feet below the prediversion level of 6,417 feet. About 2 acres of vegetated wetland are visible on the prediversion aerial photographs, although additional narrow bands of vegetated littoral springlines likely existed just above the shoreline (Stine 1993). Irrigation at DeChambeau Ranch likely enhanced wetlands at the DeChambeau embayment, but relatively fresh groundwater does reach this site (Balance Hydrologics 1993a). Irrigation also likely maintained a narrow band of wetlands at Bridgeport Creek.

East and South Mono Shorelands. This area supported 92 acres of meadow and marsh vegetation scattered at five relatively small wetlands; no lagoons were located there. Excluding wetlands that received groundwater from upslope rangeland irrigation, Warm Springs and Simon's Spring were the largest of the prediversion lake-fringing wetlands. Knowledgeable individuals believe a narrow lagoon about 1 mile long existed at Simon's Spring, but it is not visible on historical photographs (Stine 1993). This possible lagoon is not shown or reported in Figure 3C-2 or Table 3C-4.

Sierran Deltas. The Rush Creek delta supported 38 acres of natural lagoon wetland, and the Wilson and Lee Vining Creek deltas and Lee Vining tufa wetlands supported 60 acres of vegetated wetland.

Existing lagoons on the Rush and Lee Vining Creek deltas were modified and new lagoons were developed for waterfowl hunting soon after diversions began, by diversion of natural streamflow (Stine 1993).

The Wilson Creek delta supported a small willow scrub and meadow-marsh complex along the wave-cut delta face at the 6,428-feet highstand. Wilson Creek flows were augmented with water from Mill and Virginia Creeks in the early 1900s and may, in part, be responsible for the wetlands (Stine 1993).

Sierran Front. This region supported 201 acres of vegetated wetlands at the Horse Creek embayment, the county marina, and Mono Lake County Park. Groundwater originating as upslope pasture irrigation is believed responsible for sustaining most or all of the prediversion wetlands at these sites (Stine 1993). Extensive tufa-cemented beachrock along the shoreline from the county marina to Mono Lake County Park precluded shoreline vegetation establishment during this period (Stine 1993).

Mono Islands. Paoha Island supported a small area of lagoon and meadow-marsh wetlands. About 5 acres of unvegetated lagoon formed in several small craters and cinder cones and behind a large slump on the south shore. Hot Spring Cove supported a minor meadow-marsh wetland.

Upper Owens River

Geomorphology and Vegetation Distribution

The Upper Owens River is divided for analysis purposes into three discrete reaches reflecting landform, geology, soil, and vegetation differences. The uppermost "Portal" reach extends from the East Portal (river mile 20.5) east to the upper end of Long Valley (river mile 17) at the confluence with McLaughlin Creek. The "Middle" reach extends from McLaughlin Creek to the confluence with Hot Creek at river mile 7.5. The lowermost "Hot Creek" reach extends from the Hot Creek confluence to Lake Crowley reservoir.

Portal Reach. The Portal reach is confined. The south edge of the canyon is delimited by narrow colluvial aprons at the base of a basalt bluff. Groundwater springs and seeps from the base of the basalt bluff. The northern edge is defined by bedrock hills and alluvial fans of the Bald Mountains. The river along this reach meanders across a relatively narrow floodplain. Low and high floodplain terraces distinguish marsh and meadow habitats from dry meadow and Great Basin scrub. Willow scrub is spotty along this reach and is mostly restricted to low terraces, except at disturbed sites below the East Portal and along the basalt bluff springline.

Middle Reach. In the Middle reach, the stream flows through recent alluvium at the upper end of Long Valley. Although ancient lakebed deposits have eroded from this area, the soils are both saline and alkaline. The flat-bottomed valley is from 0.5 to 1 mile wide and contains low terraces with marsh and wet meadow habitat and high terraces with dry and alkali meadows. Along this reach, water from the Owens River is diverted into either two or three parallel channels that distribute water across the floodplain. Shallow groundwater and saline-alkali soil lead to efflorescent crust formation at some sites along this reach.

Hot Creek Reach. In the Hot Creek reach, the stream flows over recent alluvium and past remnants of the ancient lakebed that form high terraces in the lower portion of Long Valley (Bailey 1989). The 3- to 4-mile-wide valley is traversed by numerous meandering river channels and diversion ditches. Hot Creek enters from the west in three main canals; the southern channel is diverted into several irrigation ditches that interconnect across the valley bottom before joining the Owens River. Soils are highly saline and alkali, strongly affecting the vegetation composition of wetlands. Efflorescent crusts also form along this reach.

Hydrologic and Hydraulic Conditions

Near the beginning of Mono Basin exports, channel sinuosity of the Upper Owens River ranged from 1.57 to 2.09 along diversion-augmented reaches, and was 1.75 along the unagumented reach from Alpers Ranch downstream to the East Portal, as measured on 1944 aerial photographs. Sinuosity is determined by calculating the ratio of actual channel length to linear distance along the general trend of the valley.

Sandbar and sandy and gravelly riverbanks were probably exposed above water during summer more frequently than they are now. Undercut riverbanks were common aquatic habitats. Channel avulsions (sudden relocations) were presumably infrequent; this assumption is based on the low number documented for the reach above the East Portal during the diversion period (see "Environmental Setting" below).

In normal years, average monthly flows ranged from about 50 to 80 cfs and in no years did monthly flows exceed 180 cfs before flow augmentation (see Chapter 3A, "Hydrology"). Base flow rarely dropped below 50 cfs because of relatively constant groundwater inflows from Big Springs. Before flow augmentation, the Upper Owens River apparently experienced overbank flooding during the June-July runoff peaks. Extensive irrigation of the Upper Owens River floodplain began decades before LADWP's augmentation of flows began in 1941. Summer irrigation withdrawals may have been nearly as extensive as current withdrawals, which have virtually dewatered the stream in very dry periods (Table 3A-9).

Floodplain Vegetation

The Upper Owens River flowed through a valley that supported a mosaic of willow scrub, marsh, and meadow vegetation similar in character and overall extent to the present condition. Location and extent of vegetation are controlled by elevation above the floodplain and soil texture, salinity, and alkalinity. The valley's low and intermediate terraces support willow scrub; marsh; and wet, alkali, and dry meadow wetlands (Table 3C-5) flanked by dry meadow and sagebrush and rabbitbrush scrub on high terraces and alluvial fans.

Wet meadow and alkali meadow were likely the predominant habitats of the Portal and Hot Creek reaches, respectively. Most willow scrub was restricted to the Portal reach. It is unclear why willow cover is limited along the Portal reach and nearly absent along the two lower reaches (only a few shrubs exist). Willows were apparently not removed by landowners (Arcularius, Brown, and Rossi pers. comms.). A 1920s photograph of the Inaja property shows a lack of willows (Rossi pers. comm.). However, photographs from the late 1800s of Crooked Creek, a tributary to Lake Crowley reservoir with saline-alkali soil, reveal willow growth (Groeneveld pers. comm.). Additionally, willows flourish along the lower Owens River where it passes through saline-alkali soil. These observations indicate that substrate chemistry is probably not responsible for the dearth of willows. Upper Owens River vegetation may be influenced by ice dams that form periodically during spring runoff. Temporary ice dams impound water that, when released, forms torrents that can shear off woody vegetation and may be partially responsible for the scarcity of willow scrub (Groeneveld pers. comm.).

In 1991, abundant 1- to 2-year-old willow seedlings had established along steep portions of the riverbank inaccessible to livestock on Arcularius and Inaja Ranches. The seedlings inhabited sands and gravels of the riverbank exposed after the river dropped with the curtailment of water exports in 1989. Livestock consume willows and hamper regeneration by trampling and foraging. Willows are especially sensitive to late-season grazing when they are attempting to build carbohydrate reserves for the next season's growth. Long-term, year-round livestock grazing may be partially responsible for the limited prediversion extent of willow scrub.

Near the beginning of diversions, the Portal reach supported 16 acres of willow scrub (based on canopy extent measured on the 1944 aerial photographs), but wet meadows were more abundant. Narrow marshes fringed the river channel and occupied the low terraces and abandoned river channels (i.e., oxbows). The Middle reach supported limited willow growth (< 1 acre) and was dominated by wet and alkali meadow with marsh along the river and adjacent low terraces and oxbows. The Hot Creek reach was predominantly alkali meadow, possibly with limited marsh along the river's edge and low terraces and oxbows.

Special-Status Plants

Definitions of Special-Status Plants

Special-status species are plants and animals that are legally protected under state and federal Endangered Species Acts or other regulations, and species that are considered sufficiently rare by the scientific community to qualify for such listing. Special-status plants are species in the following categories:

- plants listed or proposed for listing as threatened or endangered under the federal Endangered Species Act (50 CFR 17.12 [listed plants] and various notices in the Federal Register [proposed species]);
- plants that are Category 1 or 2 candidates for possible future listing as threatened or endangered under the federal Endangered Species Act (55 Federal Register 6184, February 21, 1990);
- plants listed or proposed for listing by the State of California as threatened or endangered under the California Endangered Species Act (14 CCR 670.5);
- plants listed under the California Native Plant Protection Act (Cal. Fish and Game Code, Section 1900 et seq.);
- plants that meet the definitions of rare or endangered under CEQA (State CEQA Guidelines, Section 15380);

- plants considered by the California Native Plant Society (CNPS) to be "rare, threatened, or endangered in California" (Lists 1b and 2 in Smith and Berg 1988);

- plants listed by CNPS as plants about which more information is needed to determine their status and plants of limited distribution (Lists 3 and 4 in Smith and Berg 1988), which may be included as special-status species on the basis of local significance or recent biological information; and

- plants listed as sensitive by the local U.S. Forest Service region (Forest Service Manual 2670) or U.S. Bureau of Land Management resource area.

Special-Status Plants in Mono Basin and Long Valley

No data are available on the distribution and status of currently designated special-status plants in Mono Basin and Long Valley in 1940. The 1992 status, known distribution, and habitat of each special-status plants known to occur in Mono Basin and Long Valley is described under the "Environmental Setting" section of this chapter. The following assumptions about the status of these plants in 1940 are based on knowledge of current distributions and habitats.

Long Valley Milk-Vetch. All current populations probably existed in 1940, along with several populations that were probably eliminated by road construction or overgrazing.

Mono Milk-Vetch and Mono Lake Lupine. These two plants have nearly identical habitats and distributions. All current populations probably existed in 1940, along with several populations that were probably eliminated by road construction or overgrazing.

Tonopah Milk-Vetch and Bodie Hills Draba. All current populations probably existed in 1940. Some may have been in better condition before subsequent years of grazing.

Mono Buckwheat. All current populations above elevation 6,420 feet probably existed in 1940. Some may have been in better condition before subsequent years of grazing. Several additional populations may have existed. Two currently known populations were not present because they occur below the 1941 lake level of 6,417 feet.

Utah Monkeyflower. Populations were probably present in Mono Lake County Park and Old Marina areas in 1940 but may have been in slightly different locations because of differences in lake level and spring flow.

Conclusion. No populations of special-status plants are likely to have occurred in riparian, meadow, or pasture habitats below the diversion points on the tributary streams or along the Upper Owens River in 1940. This assumption is based on the fact that no special-status plants known or expected to occur in Mono Basin presently occur in these habitats. Utah monkeyflower may have occurred in lake-fringing wetlands at or near the Old Marina and Mono Lake County Park.

ENVIRONMENTAL SETTING

Sources of Information

Tributary Streams

Information on riparian hydrology and geomorphology is drawn from Stine 1991, Kondolf 1988, and DFG's four fishery resource reports for the tributary streams. Information on the 1989 extent and character of riparian vegetation was obtained primarily from recent color aerial photographs (1:2,400 scale for Rush Creek in August 1987 and 1:12,000 scale for all four creeks in July 1990), detailed topographic maps (1:1,200 scale based on May 1991 aerial photographs), and field surveys conducted from fall 1990 through fall 1991. Additional information relating to ecological conditions and processes was obtained from available literature and knowledgeable individuals. Acreages reported below are from maps prepared by SWRCB consultants.

Lake-Fringing Wetlands

Information on the point-of-reference character and extent of lake-fringing wetlands is based primarily on field-based vegetation mapping and assessment prepared by SWRCB consultants (Appendix F) (Jones & Stokes Associates 1993), geohydrologic reconnaissance with Scott Stine and Barry Hecht, and evaluations by Stine (1993) and Balance Hydrologics (1993a). This information was supplemented with vegetation mapping by Dummer and Colwell (1985) and Hargis (NAS 1986) and various geohydrologic and ecologic studies (see Appendix Q).

Upper Owens River

Information on the point-of-reference character and extent of meadow and woody riparian vegetation along the Upper Owens River is based on the field surveys, 1990 aerial photographs (1:2,500-scale), DFG's recent fisheries study (EBASCO et al. 1992), Stromberg and Patten's (1991b) study of the relationship between streamflow and the Upper Owens River willow density and growth, preliminary soil maps (U.S. Soil Conservation Service n.d.), and consultations with local residents and other knowledgeable individuals (e.g., Arcularius, Brown, Rossi, Groeneveld, and Reed pers. comms.).

Assessment of habitat changes from prediversion to the point of reference was based on a comparison of aerial photographs from 1944 (1:12,672-scale) and 1990. The large-scale, black-and-white photographs from 1944 provided limited ability to discern marshes, wet meadows, and dry meadows. Change in willow scrub extent was based on the EBASCO et al. (1993) report for stands along the river edge and on SWRCB consultant's comparison of 1944 and 1990 aerial photographs for willows on the floodplain away from the river's edge.

Assessment of stage and discharge changes for this period is based on historical flow data and stage discharge relationships developed by EBASCO et al. (1993). Changes in the location and condition of the Upper Owens River channel from prediversion to the point of reference were based on DFG (in press) and evaluations conducted by SWRCB consultants.

Special-Status Plants

Information on the current status and distribution of special-status plants in Mono Basin and Long Valley was obtained from DFG (Natural Diversity Data Base 1991), Inyo National Forest (Parker pers. comm.), BLM (Primosch pers. comm.), and LADWP (Novak pers. comm.). Although no focused surveys were conducted for special-status plants, the plants were sought out during other riparian and wetland vegetation field surveys.

Tributary Streams

Hydrology and Geomorphology

Geomorphic Changes. Geomorphic conditions along the tributary streams were altered by streamflow reductions during the LADWP diversion period. Low runoff during dry periods, in conjunction with increased water exports, resulted in the prolonged dewatering of major reaches, causing substantial die-off of riparian vegetation along Rush and Lee Vining Creeks. On Lee Vining Creek, a major fire in the early 1950s consumed much of the dead vegetative matter. Major floods in 1967 and 1969 in these streams, exacerbated by continuing diversion of Lee Vining Creek to Rush Creek in the 1967 event, caused major channel and floodplain erosion and deposition, channel avulsion, and channel incision throughout the bottomland reaches and reaching extreme proportions on the relicted lands. (Stine 1991.)

By this period, the lake surface had been lowered 28 feet by the diversions, lowering the base levels of the streams and promoting the rapid headward erosion of the channels during peak flows. High runoff in 1980, 1982, and 1983 caused further channel incision and widening of the early incisions. By the point of reference, along the lowermost reaches these streams had incised deeply and begun to erode new floodplains as much as 17 and 30 feet below the former floodplains of Lee Vining and Rush Creeks, respectively (Figure 3C-3). The major incision of Rush Creek extends upstream of the lake to just upstream of the culvert crossing. In the mid-bottomlands, incision measures only a few feet, although just below The Narrows deeper incision is also present. The incised channel drained shallow adjacent groundwater from several riparian habitats and converted them to xeric condition.

Persistence of Summer Flows. In the growing season during the diversion period, Rush and Lee Vining Creek streamflows were eliminated with increasing frequency below the diversions. In April 1947, the average monthly flow in Lee Vining Creek at County Road near the lake was reduced to less than 3% of previously recorded flow. In 1948, complete diversion of Rush, Parker, and Walker Creeks occurred and was sustained for 4 consecutive years.

Increased aqueduct capacity and resultant reductions in Cain Ranch irrigation in 1970 probably had a great effect on the springs in Rush Creek bottomlands shortly thereafter. Cessation of Pumice Valley irrigation via the A- and B-Ditches caused springs along the east wall of the bottomlands to cease flowing. Springs on the west side of the bottomlands most likely diminished as irrigation of Cain Ranch lands was reduced. (Stine 1991.)

In the years after the complete diversion of Parker and Walker Creeks in 1948-1952, substantial flows resumed, particularly during snowmelt. Overall 40-50% of the annual flows remained instream. Some of this was irrigation water conveyed in the stream channels supplemented by releases from the Lee Vining conduit sand traps. Stream channels were commonly dry for long periods of the growing season, however.

In 1985 and 1986, continuous flows were restored to Rush and Lee Vining Creeks by court order. In 1991, after the point of reference, continuous flows were likewise restored to Parker and Walker Creek. The minimum required releases at that time were at least marginally sufficient to overcome estimated channel losses (Table 3C-1):

- Rush Creek - minimum release flow 19 cfs, net flow 4-8 cfs;
- Lee Vining Creek - minimum release flow 5 cfs, net flow 1 cfs;
- Walker Creek - minimum release flow 6 cfs, net flow 5 cfs; and
- Parker Creek - minimum release flow 9 cfs, net flow 8 cfs.

The marginality of the Lee Vining Creek flow at the point of reference suggests less-than-full wetting of the creek channel bottom, which would have constrained the width of the primary riparian habitat in many areas.

Required minimum flows in Rush and Lee Vining Creek today are considerably higher than the point-of-reference minimum flows. Current minimum release flows in Rush Creek of 40 cfs and in Lee Vining Creek of 35 cfs imply net instream flows of 26-28 and 28 cfs, respectively.

Channel Stability. Little of the current stream channel system is considered highly stable as it was in the prehistorical period, but most of it appears to be moderately stable. With a few exceptions, ongoing severe bank erosion is not apparent and incision events have not recently occurred.

The potential maximum incision, or fall of lake surface, has increased from 28 feet during the floods of the 1960s to 41 feet at the point of reference. Lesser floodflows in the early 1980s caused some further incision when the potential maximum incision was only 1-2 feet less than at the point of reference. Thus, these streams may be in equilibrium with lake levels of the early 1980s, or about 6,375 feet elevation, but it is equally likely that the recurrence of extremely high flows would cause further incision while the lake stood at this level.

Studies of channel conditions recently conducted for the Restoration Technical Committee (RTC), established by the El Dorado County Superior Court, suggest that, under current conditions (which include the presence of some recent fish habitat installations by RTC consultants), flows damaging to streambeds may occur above the following streamflows (Trihey pers. comm.):

- Rush Creek - 350 cfs,
- Lee Vining Creek - 250 cfs,
- Parker Creek - 23 cfs, and
- Walker Creek - 15 cfs.

Without diversions, the annual high flow would exceed these thresholds during most years in Parker and Walker Creeks, an average of every 3-4 years in Lee Vining Creek, and about 6% of years in Rush Creek.

These data indicate that all these creeks, without overflow channel relief, are potentially unstable in the event of fairly frequent floodflows. Parker, Walker, and Lee Vining Creeks are considered especially susceptible, but damaging flows in Rush Creek recur at an average interval of less than 20 years.

Shallow Groundwater Zones. During the diversion period, the extent of shallow groundwater zones diminished in reaches where incision occurred, because the deepening channel and lowering water surface draws water tables down a similar amount (see "Water Depth Model" in Appendix P). In the Rush Creek and lower Lee Vining Creek bottomlands, several areas of former floodplain now have water tables below the depth usually needed to support robust woody riparian vegetation (Figure 3C-3).

In the deeply incised reaches, channel widening is now creating a new floodplain near the water table; evidence of this effect is the abundant distribution of willow seedlings in the lower reach of Rush Creek. This incised floodplain is considerably narrower, however, than the former floodplain.

Seasonal Floodchannel and Overbank Flows. During the diversion period, seasonal high flows from snowmelt became increasingly infrequent until only occasional, large, and often destructive flows occurred, especially in Rush and Lee Vining Creeks. When the minimum streamflows in effect at the point of reference were imposed by the court, no provision was made for regular seasonal high flows. Variations in runoff, however, suggest that high flows capable of substantial floodchannel recharge (approximately 180-200 cfs in

Rush and Lee Vining Creeks) occur an average of once every 4 years under the point-of-reference diversion management.

Under current conditions, little overbank flow occurs during high release periods (Figures 3C-4, 3C-6, and 3C-8), primarily because of channel incision. Overbank flow that does occur is limited to the new, narrow, incised floodplains in the middle and lower Rush Creek bottomlands and lower Lee Vining Creek.

In addition, very little overflow or distributary channel recharge occurs. This is due both to incision and the presence of artificial plugs or stream deposits in the channel mouths. Incision makes it difficult to recharge several of the channels but, with minor excavation of fill material (Table 3C-6), several channels would be recharged during flows similar to the interim seasonal high flows now required (Figures 3C-5, 3C-7, and 3C-9). A considerable length of overflow channel could be seasonably wetted under the point-of-reference streamflows.

Riparian Vegetation

The extent of riparian vegetation at the point of reference is shown in Table 3C-2. Maps and reach-by-reach descriptions of this vegetation are given in Appendix P.

Rush Creek. Riparian vegetation on Rush Creek changed little from 1941 to 1947 because high runoff enabled flows to continue despite diversions to Los Angeles and local pastures. Runoff was low from 1948 to 1951, resulting in increased diversions out of Mono Basin and sharply curtailed irrigation to Pumice Valley and flow down Rush Creek. Vestal (Stine 1991) recalled that many of the remaining pines below U.S. 395 died during this period. Releases to Rush Creek and groundwater recharge from irrigation were highly variable during the 1950s (Stine 1991). Cottonwoods and willows began to decline above The Narrows during this period, but little loss is evident below The Narrows in an August 1954 aerial photograph.

Releases to Rush Creek were consistently low from 1960 to 1965, leading to rapid loss of riparian vegetation in many areas; however, springs continued to support vegetation locally in parts of the bottomlands. Extreme floods occurred in 1967 and 1969, as described previously. Without riparian vegetation to stabilize the stream banks and reduce water velocities, the channel was severely scoured, and large amounts of live and dead vegetation and topsoil were removed. (Stine 1991.)

Little to no water was released to Rush Creek through most of the 1970s, and no irrigation occurred in Pumice Valley. Groundwater dropped below the reach of riparian plants in many areas because of channel incision and inadequate recharge from streamflow or springs. Most of the riparian vegetation that survived the floods of the late 1960s died or was severely degraded during the 1970s from lack of water. High runoff forced the release of uncontrolled flows to Rush Creek again in 1980, 1982, and 1984, causing further damage to the riparian zone (Stine 1991, Kondolf 1988).

In 1985, continuous low flows were returned to Rush Creek to maintain the trout population. These flows, with an absence of scouring floods, have promoted a modest recovery of riparian vegetation along portions of Rush Creek. Some large cottonwoods that were severely stressed, but not dead, have recovered much of their vigor. Many thousands of willow and cottonwood seedlings have appeared on wetted gravel bars, especially near the mouth of the creek.

In 1989, Rush Creek (including the abandoned channel above the Return Ditch) supported approximately 135 acres of mature woody riparian vegetation, 33 acres of newly establishing riparian vegetation, and 40 acres of meadows (Table 3C-2). This represents a loss of about 50% of prediversion woody riparian vegetation, but the establishing vegetation is replacing one-quarter of the loss. Seventy percent of the prediversion meadowlands were lost.

The mature woody vegetation is predominantly willow scrub (47%) and mixed riparian scrub (43%). About 25% of the woody riparian vegetation has 10-50% cover and about 75% has 50-100% cover. Approximately 89 acres of mature woody vegetation (66% of all remaining below the diversion) still occurs in the bottomlands between The Narrows and the ford.

Because no fires have occurred in the Rush Creek riparian zone, large amounts of dead wood remain in areas unscoured by floods. Riparian vegetation dominated by dead wood and severely stressed riparian plants (41 acres in 1989) is characterized as decadent. Mature, establishing, and decadent riparian vegetation totaled about 209 acres on Rush Creek in 1989.

Since 1989, several minor channel modifications have been implemented to improve fish habitat as part of the interim stream restoration program. A temporary grazing moratorium to promote riparian vegetation recovery began in 1991.

Parker Creek. As described previously, little or no water flowed in the main channel of Parker Creek below the LADWP diversion dam after 1947 (Stine 1991).

In the 1960s, a gravel road was constructed on the west side of Parker Creek from U.S. 395 to quarries on the west side of Rush Creek just below the mouth of Parker Creek. The road and Rush Creek gravel operations have caused minimal disturbance to Parker Creek.

In the early or mid-1960s, several hundred feet of Parker Creek were filled with what became known as "the Parker plug", centered about 0.4 mile below U.S. 395. Gravel was pushed into the dry channel as part of a quarrying operation conducted by California Department of Transportation (Caltrans) on the east side of the creek. In 1990, the gravel plug was removed and channel restoration began. Additional channel restoration and rewatering began on Parker Creek in 1990.

Parker Creek in 1989 supported approximately 49 acres of woody riparian vegetation, 9 acres fewer than in the prediversion period (Table 3C-2), of which about 91% is willow scrub. Most of this vegetation is in highly stressed condition. Most of the willows contain many dead branches, have only sparse foliage on the live branches, and are competing for groundwater with the more drought-tolerant mountain rose. Willow seedlings are absent and suckers are infrequent. New willow growth accessible to sheep is usually lost to browsing. Mountain rose growing alone or among clumps of dead willows generally has sparser foliage with a more yellowish color than rose on rewatered portions of Rush Creek.

Extensive rush-dominated meadows surround the stream and riparian vegetation from the LADWP diversion site to U.S. 395. Patches of sagebrush scrub occur among patches of riparian vegetation at the base of the moraines on the west side of Cain Ranch. Sagebrush scrub occupies most of the canyon below U.S. 395.

Walker Creek. Between 1940 and 1989, the changes described for Parker Creek also occurred on Walker Creek. Channel restoration and rewatering began in 1990.

Walker Creek in 1989 supported approximately 43 acres of woody riparian vegetation, or 7 acres fewer than in the prediversion period (Table 3C-2). About 61% of the woody riparian vegetation is willow scrub, and 34% is mixed riparian scrub. The condition of this vegetation is similar to that described for Parker Creek.

Meadow and sagebrush scrub vegetation along Walker Creek has a distribution similar to that described for Parker Creek.

Lee Vining Creek. Vegetation along Lee Vining Creek declined rapidly when high runoff ceased after about 1947. Pasture irrigation on lower Lee Vining Creek also ended at about this time. The vegetation was most severely affected from the lakeshore to a narrow point in the canyon 0.45 mile downstream from U.S. 395. Fire consumed much of the dead riparian vegetation and some of the remaining live vegetation in the early 1950s (apparently 1951, 1952, or 1953) (Stine pers. comm.).

The stream was nearly or completely dewatered most years until 1969, when a major flood caused severe channel widening, migration, and incision, as previously described. Modest recovery in riparian vegetation has occurred along portions of Lee Vining Creek in response to continuous low flows and an absence of floods since 1986.

Lee Vining Creek supports approximately 60 acres of mature woody riparian vegetation, a loss of about 50% during the diversion period (Table 3C-2). Approximately 44 acres, 63% of which is conifer-broadleaf, occurs between the LADWP diversion and 0.45 mile below U.S. 395. Only 16.2 acres of mature woody riparian vegetation (mostly in small, scattered patches) occurs in the lower portion of the creek.

Since 1989, several minor channel modifications and limited revegetation have been implemented to improve fish habitat as part of the interim stream restoration program. A temporary grazing moratorium to promote riparian vegetation recovery began in 1991.

Other Streams. Other streams tributary to Mono Lake have been affected by lowering of the lake level, even though they are not diverted by LADWP.

Bohler Creek. Most of the water in Bohler Creek below the aqueduct road is diverted for pasture irrigation at the north end of Cain Ranch. The main channel and irrigation ditches support about the same amount of scattered mixed riparian and willow scrub as occurred in 1940. Riparian vegetation is essentially absent in the Bohler Creek canyon east of U.S. 395 (as it was in 1940), and the willow scrub near the mouth of the canyon appears to have about the same extent and condition it had in 1940.

Horse Creek. Most of the water in Horse Creek below Lower Horse Meadows is diverted for pasture irrigation immediately above U.S. 395. Dense coyote willow scrub occurs along the main channel of Horse Creek (the northern of two ravines crossed by U.S. 395) from about 1,000 feet above to about 100 feet below the highway. Scattered coyote willow and mountain rose extend another 1,800 feet downstream. Smaller amounts of willow and rose occur along some of the irrigation ditches and the historical main channel (which crosses the highway 1,000 feet south of the current main channel).

Post Office Creek. Approximately 27 acres of willow scrub occur on the small Post Office Creek delta below the 1940 lake level of 6,417 feet. Above U.S. 395, the creek supports a narrow but mostly continuous strand of willow and cottonwood-willow vegetation. Additional willows and cottonwoods grow at several small hillside seeps above the creek.

DeChambeau Creek. DeChambeau Creek and associated springs support extensive willow scrub thickets below the road to Black Point. About 8 acres of willow scrub occur below the 1940 lake level of 6,417 feet. Native and non-native cottonwoods and poplars occur along the main channel and irrigation ditches almost to U.S. 395. Intermittent to continuous willow scrub, cottonwood-willow, quaking aspen, and conifer-broadleaf habitats follow the stream above the highway.

Mill Creek. Most of the water in Mill Creek is diverted for power production (by Southern California Edison [SCE]), pasture irrigation, and domestic use above U.S. 395. Vegetation above the highway is relatively intact and vigorous, comprising a nearly continuous strand of willow scrub, cottonwood-willow, quaking aspen, and conifer-broadleaf habitats. From U.S. 395 to about 5,000 feet below it, cottonwoods, willows, and Jeffrey pines are numerous, but the riparian habitat is degraded by channel incision and dewatering. From about 5,000 feet below the highway to the Black Point road, only scattered, degraded patches of willow, cottonwood-willow, and mixed riparian vegetation remain. The channel is severely incised because of the lake level lowering, and the former riparian zone is dominated by scoured cobbles and sagebrush scrub.

Below the Black Point road, two diverging channels have incised the Mill Creek delta. Numerous black cottonwoods, some mountain rose, and some coyote willow persist on high ground between the delta channels. Most of these plants appear to be severely stressed by lack of water. The lowest trees occur at or near the 6,420-foot elevation, just above the mouth of the creek in 1940. A few widely scattered vegetative sprouts of black cottonwood occur in the channel of Mill Creek, and coyote willows grow near the lakeshore at seeps at the base of the Mill Creek delta.

Wilson Creek. Wilson Creek supports scattered small to locally large patches of willow scrub from the irrigated pastures of Conway Ranch downstream to about Highway 31 (the road to Hawthorne, Nevada). Willow scrub patches are few and widely scattered as streamflows diminish in the increasingly permeable substrates between Highway 31 and the road north of Black Point. The channel of Wilson Creek continues south from the road crossing to enter Mono Lake between Mill Creek and Black Point. Almost no riparian vegetation occurs along the usually dry segment of Wilson Creek below the road north of Black Point; however, lake-fringing wetlands near the mouth of Wilson Creek are probably supported in part by groundwater that originated as surface flow in Wilson Creek.

Lake-Fringing Wetlands

Geohydrologic Changes

Over the diversion period, geohydrologic conditions affecting the lake-fringing wetlands changed for several reasons:

- as the lake level has declined, the base level controlling water table depths and shallow groundwater inflow from basin sediments has fallen;
- the newly exposed beach slopes for the most part are more gently sloping;
- the exposed lakebeds tend to be fine-grained sediments, diminishing the lake-shore extent of beach rock and coarse sand substrates;
- the lower lake surface elevation has exposed some springs and reduced the hydrostatic pressure on other underwater springs; and
- longshore drift of sediment along the northern shoreline has diminished, ending processes that form and maintain large lagoons.

Although the lake surface fell 41 feet overall, three major lake transgression episodes (rising lake levels) actually occurred during the diversion period. Each transgression changed the nearshore topography through wave erosion. (Stine 1993.)

The flatter beach slopes now provide more wetted area at spring and seep discharges, creating relatively extensive wetlands or alkali flats at some sites. Some springs that discharged underwater before the beginning of diversions became terrestrial, creating new vegetated wetlands. Some terrestrial artesian springs along faults have diminished as hydrostatic pressures on underwater springs from the same aquifer have been reduced.

New springlines have formed at the upper edge of the wave-cut terraces at elevations of 6,409 feet; 6,390 feet; and 6,381 feet; these wave-cut terraces were created during the highstands of 1952, 1967-1969, and 1982-1983, respectively. These new springlines caused older upslope springlines to cease flowing as the water table fell, converting wet meadow and marsh habitat to dry meadow or rabbitbrush scrub habitat. At some sites, the newer springlines did not sap water from the older, higher springlines because of abundant groundwater inflows or the presence of impermeable layers underlying the wetlands, which protected them from water table drainage.

The large lagoons of the prediversion period drained as the lake level and nearshore water table lowered beneath their bottoms. New lagoons have formed in places along the new shoreline, but they are smaller and less numerous. As the falling lake surface lost contact with Black Point, the rate of longshore sediment transport and creation of littoral embankments was greatly reduced, so that the formation of large lagoons at the point-of-reference lake elevation is unlikely. Moreover, the induced high water table in the tributary stream deltas that supported prediversion wetlands has been lost as the lake has regressed from the flatter upper delta surfaces to the steeper delta fronts.

Large, continuous, gently sloping efflorescent alkali flats up to 3/4-mile wide have formed around most of the eastern shoreline of the lake, especially below the 6,390-foot elevation. The combination of lowered base level for groundwater inflow and the gentle slope of the relicted lands has brought saline groundwater near the ground surface over wide expanses of these alkali flats. The efflorescence is facilitated by the fine-grained texture of the exposed lakebeds combined with the presence of salt-laden groundwater and lakebed sediments. Efflorescence only occurs at alkali lakebeds underlaid by shallow groundwater. Groundwater has drained from some of the point-of-reference alkali lakebeds, although these still have residual salt crusts and fine-grain, salt-laden lakebed sediment.

Wetland Changes during the Diversion Period

The extent and condition of lake-fringing wetlands has changed substantially since diversions began, principally because of the geohydrologic changes discussed above. Vegetated and alkali lakebed wetlands expanded onto the newly exposed lakebed, resulting in a 14-fold increase in areal extent of vegetated wetland over prediversion conditions (Figure 3C-10; Table 3C-4). Excluding the acreage of dry meadow, an eightfold increase in the area of marsh, wet meadow, alkali meadow, and wetland scrub occurred through the diversion period.

Nearly 5,500 acres of alkali lakebed existed in 1989 where none existed before diversions began. Salt efflorescence now dominates expansive flats along the north, west, and south shorelines and on Paoha Island (Figure 3C-3). Some portion of this area does not currently qualify as wetlands because groundwater has drained. While the area of vegetated wetlands increased, a nearly complete loss of lagoon acreage occurred, for the reasons previously described.

Wetlands changed in several ways. Some wetlands dried at their upper edges or were converted from wet to dry meadows. In fact, over 2,300 acres of the current wetlands are saltgrass dry meadow, nearly 40% of which has less than 10% plant cover. These changes generally coincided with the expansion of wet meadows and marshes at lower elevations as wetlands moved downslope with the receding lake. Others merely expanded while the upper edge remained static. Most wetlands underwent a net increase in areal extent and habitat diversity. Although artificial irrigation in areas upslope of the Sierran front and Sierran delta wetlands has diminished over the diversion period, the extent of wetlands generally increased as a result of the exposure of previously submerged freshwater springs and lakebed sediment conducive to vegetation establishment.

Although many habitat-specific wetland functions and values are the same as under prediversion conditions, some functions have been enhanced because of greater area. Low numbers and diversity of general wildlife use (see Chapter 3F, "Wildlife") indicate that the principal value of increased area of vegetated wetlands is increased habitat for wetland-dependent plant species. Dry meadows have the least value in this regard.

North Mono Shorelands. As a result of the lake level decline, about 1,440 acres of lakebed developed vegetation along the northern shoreline of Mono Lake, which included about 560 acres of sparsely vegetated dry meadow. Additional changes attributable to diversion include the disappearance of the numerous large lagoons and emergence of nearly 3,400 acres of alkali lakebed. The bottom of the former dune lagoons now are barren and salt-encrusted, while the DeChambeau lagoon supports annual forb or dry meadow vegetation. Irrigation at DeChambeau Ranch likely enhanced groundwater flow to the DeChambeau embayment wetland (Stine 1993), but natural groundwater inflows do reach this wetland (Balance Hydrologics 1993a).

East Mono Shorelands. Vegetated wetlands in this area increased from nearly 80 to 1,725 acres (including 740 acres of dry meadow). The net increase of nearly 990 acres of wet meadow, alkali meadow, and marsh wetland is a result of the increased area of gently sloped lakebed and the creation of new springlines that accompanied the decline in lake level. Alkali lakebed increased from 0 to about 1,420 acres as a result of the lower lake level.

East Mono Shoreland wetlands dried at their upper edges after diversion began as a result of groundwater drainage that converted meadows and marshes to dry meadow or rabbitbrush scrub with dry meadow understories. Tufa groves at Simon's Spring became terrestrial and are surrounded by extensive marshes and several linear, vegetated ponds that formed behind old beach berms. Excluding areas with dry meadow, Warm Springs and East Beach are predominantly alkali meadow and marsh. Ponds and lagoons formed at Simon's Spring during the lake regression but have since dried because of the continued decline in lake level or filled in with marsh vegetation.

South Mono Shorelands. At the point of reference, the South Mono Shorelands support more than 1,110 acres of vegetated wetlands, of which about 840 acres are dry meadow. The wetlands developed after the gently sloped lakebed and underwater springs were exposed. Narrow lagoons at South Tufa and South Beach dried because of the lower groundwater base level and curtailment of upslope irrigation (Stine 1993). Natural groundwater at South Tufa continued to sustain extensive alkali meadow and marsh after the end of upslope irrigation. Alkali lakebed increased to 18 acres.

Sierran Deltas. Lowered lake level has resulted in a net increase of more than 275 acres of vegetated wetland over the 60 acres that existed before diversions. Wetland extent increased because suitable lakebed was exposed along with previously underwater springs. In contrast, natural lagoons on the Rush Creek delta and the 45-acre Lee Vining Creek wetland were drained by the lowered groundwater base level and the stream incision that coincided with lake level decline. In addition to these losses, about 50 acres of artificial ponds built to attract waterfowl to the Rush Creek delta shortly after diversions began were eliminated by the declining lake level. Today, the Wilson Creek delta wetland supports one of the richest assortment of plant species around the lake. Sixteen acres of alkali lakebed have developed within areas encompassed by the Sierran delta region since diversions began.

Sierran Front. The extent of vegetated wetland increased from about 200 to 560 acres along the Sierran Front, including about 260 new acres of marsh, meadow, and riparian scrub, and 100 acres of dry meadow. This increase occurred despite the end of irrigation above the Horse Creek embayment and the county marina. The extent of vegetated wetlands increased because the receding lake exposed fine-grained sediment conducive to vegetation establishment below the tufa-cemented beach rock from the county marina to the Mono Lake County Park. Today, the county park wetland supports the highest diversity of marsh and wet meadow species of Mono Lake's lake-fringing wetlands.

Mono Islands. Prediversion lagoons on Paoha Island all desiccated as a result of lower lake level. In contrast, meadow and marsh wetlands at Hot Spring Cove on Paoha Island increased from 1 to 3 acres from exposure of more lakebed and the formation of a wave-cut terrace. About 600 acres of alkali lakebed became exposed on Paoha Island; about 500 acres on the west shore have a very sparse greasewood scrub cover on lands otherwise classified as alkali lakebed.

Upper Owens River

The valley bottom of the Upper Owens River supports a mosaic of willow scrub, marsh, and meadow vegetation similar in character and extent to prediversion conditions (Table 3C-5). Meadow habitat still predominates. The Portal reach supports about 4 acres of willow scrub, and Middle reach supports a couple of scattered willows. Livestock grazing throughout the river floodplain is heavy and is probably similar to prediversion conditions.

Changes in Hydrologic and Hydraulic Conditions

Mono Basin exports substantially augmented streamflows in the Upper Owens River (Table 3C-7). Over the 1940-1989 period, the average flow was triple that of the prediversion period. Even under the point-of-reference scenario, where basin exports are reduced, average monthly streamflows in normal years would increase from 49-79 cfs to 120-246 cfs, an average annual increase of 177%. High flows did and would peak higher and be sustained longer. Whereas average monthly flows probably never exceeded 180 cfs at any time in the prediversion period, over the diversion period they often exceeded 300 cfs. Even under the point-of-reference scenario, they would exceed 200 cfs by June in 2 out of 3 years, and be sustained over this level for 8 months during wet years. In fact, flows over 300 cfs would be sustained 5-6 months during wet years.

The construction of new diversion canals during the diversion period modified the river's floodplain. Three new irrigation canals were built in addition to the "north diversion" on the Inaja Ranch downstream of the East Portal. LADWP funded construction of the north diversion to address landowner claims of flooding, channel, and fishery damage that began shortly after the onset of flow augmentation. The north diversion was built through highly erodible sediment, however, and large flow releases have caused it to deepen and widen (Reed pers. comm.). Water was allocated to the north diversion based on streamflow and water temperature. Flows in excess of 300 cfs were shunted to the north diversion, but it also conveyed water when total flows were below 300 cfs. (The amount diverted was intended to maintain water temperature at the Hartman Bridge below 70°F for the fishery [Reed pers. comm.].)

Other floodplain changes during the diversion period included the armoring of river-banks on the John Arcularius and Inaja Ranches. Rock rip-rap was used to reduce bank erosion and prevent channel avulsions.

Effects of Changes during the Diversion Period

Stage-Discharge Relationship. Because prediversion channel depths are unknown, the change in river stage relative to floodplain elevations due to flow augmentation cannot be completely known. Stage-discharge relationships recently obtained for the Upper Owens River (DFG in press), applied to averaged June-July prediversion and point-of-reference streamflows (no-diversion and point-of-reference simulations), indicates that relative river stage has increased an average of 0.3-0.5 feet during dry years, 0.5-0.7 feet during average runoff years, and 1.4-1.8 feet during wet years. This increased river stage would promote a similar increase in the elevation of the floodplain aquifer under adjacent terraces, expanding the riparian habitats an indeterminate amount. Effects of higher river stage could easily have been nullified, however, if flow augmentation also caused the channel to deepen.

River Channel Morphology and Stability. Landowners and researchers assert that flow augmentation has altered channel and floodplain morphology by widening and deepening channels and straightening the river course (Stromberg and Patten 1991b; Arcularius, Brown, and Rossi pers. comms.). EBASCO et al. 1993 has documented channel avulsions occurred sometime after land surveys during the late 1800s and documented a widening and straightening of the river channel. The large increase in streamflow would be expected to have caused important floodplain and habitat changes based on established general relationships between discharge and a river's sediment transport capability, erosion potential, and channel and floodplain morphology.

Ongoing bank sloughing is apparent below the East Portal, and the channel is therefore gradually widening. The bank sloughing is probably more related to rapid reductions in flow augmentation, causing unsupported, saturated banks to collapse, than it is to increased scouring forces of the augmented flows.

Notions of altered morphology can be evaluated by comparing aerial photographs from 1944 and 1990 for portions of the Upper Owens River above and below the East Portal. The reach above the East Portal is a control reach because its flows were not augmented. Aerial photographs were used to measure channel length, sinuosity, and meander cutoffs, but their limits of resolution precluded a comparison of channel widths or the presence or absence of point-bar habitat.

No meander cutoffs occurred along the control reach, but 54 were documented from the East Portal to Lake Crowley reservoir (Table 3C-8). Evaluation by the SWRCB consultants showed that sinuosity remained nearly constant in the control and Portal reaches, increased in the Middle reach, and decreased in the Hot Creek reach, resulting in negligible changes in river channel length. DFG maintains, however, that channel length decreased by 3.6 miles along the augmented reach since 1944 (EBASCO 1993). This discrepancy could be due to use of different analysis methods, which cannot be assessed without a detailed description of the DFG methodology. DFG also documented a net decrease in the number of meanders along the augmented reach.

The data suggest that flow augmentation may have destabilized the channel relative to prediversion conditions. Although channel stability decreased with flow augmentation, the channel did not appreciably straighten, except in the most downstream reach affected by Hot Creek. The data are for only a 45-year interval, which probably is not long enough for the channel and floodplain to have equilibrated to augmented flows.

Channel changes may not have been caused solely by flow augmentation. Channels and floodplains respond to cumulative watershed changes. Road building, logging, grazing, and other activities in the Upper Owens River watershed have probably increased peak runoff and sediment loads, contributing to bank erosion and other channel morphology changes. Regardless, landowners below the East Portal recall that distinct changes coincided with flow augmentation in 1941 and its elimination in 1989. The limited change documented along the control reach, combined with the need to construct the north diversion to protect the main channel, supports the connection between flow augmentation and channel changes and instability of the last 50 years. This conclusion is further supported by the fact that only minor avulsions occurred in the reach diverted by the north diversion (DFG in press).

Meadow and Marsh Wetlands. Aerial photograph examination does not reveal any noticeable difference in the overall extent of meadow and marsh habitat along the Upper Owens River between the early diversions and point of reference (Table 3C-5). Evidence of drier habitats under prediversion conditions converting to wetter meadows and marshes, because of the stage increases associated with augmented flows, are not visible on the available imagery. Neither are conversions to drier habitats, as could result from channel incision. The process of channel avulsion has probably had little net effect on the extent of meadow and marsh wetlands. Channel meanders that were abandoned during avulsions have increased the amount of marsh habitat at the expense of meadow and marsh eliminated at the location of the new channel.

Operation of the north diversion and new irrigation canals likely increased the proportion of wet meadow and marsh habitats because it increased the area of wetter habitat along the outer edge of the floodplain. Conversion to wetter habitats is beneficial to wetland-dependent plants and wildlife and increases the amount and quality of wildlife and livestock forage.

Willow Scrub. The extent of willow scrub habitat below the East Portal diminished by 75% while along the control reach areal extent declined by 26% during the diversion period. These lands are under multiple ownerships, however, and differing land use and grazing may explain this difference. None of the landowners ever physically removed willows (Arcularius and Rossi pers. comms.). The 4 acres below the East Portal in 1990 are not all remnants of the 1944 stand, although some of the same shrubs were present in 1944 and 1990.

Factors that could account for the reduction in willow scrub include direct removal, livestock grazing, and flow modification. Livestock grazing rates remained essentially unchanged during this period but could at least partially account for a gradual demise of willow scrub that may have begun before water exports.

Flow augmentation could decrease the extent of willow scrub habitat if higher flows during summer submerged gravel bar and riverbank habitat, favored sites for willow seedling germination (McBride and Strahan 1984). Augmented summer flows could drown recently established seedlings, eliminate plants via bank erosion, or reduce plant vigor or increase their susceptibility to disease because of higher water tables (Dionigi et al. 1985).

Recent studies suggest that augmented Owens River flows may be partially responsible for decline in the extent of willow scrub (Stromberg and Patten 1991b). These researchers found statistically significant differences in the density of juvenile willows and in canopy extent of mature willows when comparing the control and augmented reaches. The augmented reach had fewer juvenile willows in the river-edge recruitment zone and lower canopy area of mature plants. The density of juvenile willows increased with increasing elevation of the floodplain terrace supporting them, and willows along the augmented reach had lower annual growth rates (as measured by growth ring thickness). Annual willow growth rates decreased with increased flow volume. Other relationships revealed by their study were not statistically significant but suggest a relationship with flow augmentation; these included the higher proportion of dead to live plants, lower density of mature plants, and increased distance of live plants from the stream along the augmented reach as compared with the control reach.

Stromberg and Patten's study indicates that flow augmentation could limit seedling establishment and retard the growth of mature willows. Their study indicates that seedling establishment along the augmented reach may be limited by:

- an absence of seedling habitat because flow augmentation has converted the river to a degrading system with vertical banks and without depositional features, such as point bars,

- seedling removal during river bank erosion, or

- waterlogging of riverbanks and terraces because of the higher river stage.

Possible mechanisms for observed adverse effects on mature plants include increased saturation, and thus reduced oxygenation, within the root zone (Dionigi et al. 1985). Relationships between growth rate and willow vigor was not studied along the Upper Owens River. However, cottonwood (a close relative of the willow genus) was studied along the tributary streams, and vigor increased with increasing annual growth increment (Stromberg and Patten 1991b).

Although livestock grazing may have limited the extent of willow scrub under pre-diversion conditions, flow augmentation appears to have exacerbated this effect by limiting the habitat for seedling establishment and possibly reducing the vigor of established plants. Limited recruitment of young willows during the analysis period indicates that the existing willows are aging without providing replacement stock to maintain the current condition. The skewing of the age class distribution to older, possibly less productive plants exposes the population to risk of local extirpation if the remaining plants die before new individuals establish.

Special-Status Plants

Special-status plants known to occur in Mono Basin and Long Valley are listed in Table 3C-9.

Special-Status Plants in Mono Basin

Six special-status plants are known to occur below the 7,000-foot elevation in Mono Basin: Mono buckwheat, Utah monkeyflower, Mono milk-vetch, Mono Lake lupine, Tonopah milk-vetch, and Bodie Hills draba (Natural Diversity Data Base 1991, Parker pers. comm.). None of these plants is known or expected to occur along the tributary streams.

Mono buckwheat occurs at several locations around Mono Lake. Populations near DeChambeau Ponds, Goat Ranch Road, Kirkwood Spring, Sulfur Pond, and south of Simon's Spring occur above the 1940 lake level of 6,417 feet. Populations near Danburg Beach, DeChambeau Ponds, Warm Springs, Simon's Spring, and the mouth of Rush Creek occur near or below the 1941 lake level.

Utah monkeyflower is reported from Mono Vista Spring and the site of the old Marina north of Lee Vining. It may occur at additional freshwater springs on the west side of the lake. Both known sites are near or below the 1941 lake level of 6,417 feet.

Mono milk-vetch occurs in small valleys filled with pumice sand in the Mono-Inyo Craters area. All known populations in Mono Basin are several miles south of the lakeshore or tributary streams. Mono Lake lupine has nearly the same distribution and habitat as Mono milk-vetch. The known population nearest to the lake or tributary streams is at Panum Crater.

Tonopah milk-vetch is scattered throughout the northeastern portion of Mono Basin between the Bodie Hills and Cowtrack Mountain. The mapped location nearest to Mono Lake is over 4 miles from the eastern lakeshore.

Bodie Hills draba is known from hillsides north of Black Point (above 7,200 feet) and occurs throughout the Bodie Hills.

Special-Status Plants in Long Valley

Three special-status plants are known to occur in Long Valley between the East Portal and Lake Crowley reservoir: Long Valley milk-vetch, Mono buckwheat, and Mono milk-vetch (Natural Diversity Data Base 1991, Primosch and Novack pers. comms.).

Long Valley milk-vetch is known from many small to large scattered populations west and east of the Upper Owens River and Lake Crowley reservoir from near Whitmore Hot Springs and Watterson Canyon to the north end of LADWP land. The plants are generally on dry ground among sagebrush scrub.

Mono buckwheat is known from about 15 populations within the same area occupied by Long Valley milk-vetch. The plants generally occur in sagebrush scrub, on roadsides, or in other dry sites.

Mono milk-vetch is known from a few sites near the west side of upper Long Valley directly east of Lookout Mountain. The plants occur in sandy sites surrounded by sagebrush scrub.

IMPACT ASSESSMENT METHODOLOGY

Impact Prediction Methodology

Tributary Streams

Approach. Project impacts and cumulative impacts on tributary stream riparian vegetation were assessed by:

- describing vegetation and influences on vegetation under prediversion (1929-1940) and point-of-reference (1989) conditions;
- identifying impact mechanisms when or where these mechanisms may result in substantial changes in riparian vegetation acreage or condition;
- predicting streamflow during germination and growing periods and lake level conditions under each EIR alternative (from Chapters 2 and 3A);
- predicting the effects of each alternative on growth of riparian vegetation, using the identified impact mechanisms, predictions of hydrologic conditions, observations of recent vegetation recovery in response to court-ordered flows, and three streamflow dependent models: a riparian vegetation width model, a cottonwood growth rate model, and a water table depth model; and
- predicting residual losses of riparian vegetation relative to prediversion conditions for each alternative.

Methods and results of vegetation mapping are described in Appendix P. Methods and results of the riparian vegetation width model, cottonwood growth rate model, and water table depth model are also described in the appendix. Background information obtained from a literature review is summarized in the appendix section "Results of Riparian Vegetation Literature Review".

Impact Mechanisms. Impacts on riparian and wetland vegetation along the tributary streams could result from changed groundwater availability, floodplain wetting during seed germination periods, bank erosion from flooding, channel incision caused by lake level declines, and inundation by rising lake waters. Past impacts on vegetation along the streams have resulted primarily from loss of streamflow and shallow groundwater, loss of springflow, overgrazing, gravel quarrying, facilities construction, and channel incision and abandonment of overflow channels resulting from major flooding after lake level declines.

The following modeling concepts were adopted to assess overall effects on tributary stream vegetation under each alternative

Total Streamflow. As described in Appendix P, Taylor (1982) and Stromberg and Patten (1992) developed models relating mean annual streamflow to riparian zone width and cottonwood growth rates. Patten and Stromberg's tree-ring data show a strong correlation between annual streamflow and growth. The model therefore provides a relative measure of biomass productivity under the alternatives, but not of the extent (acreage) of habitat.

Taylor developed data from a number of losing streams on the east side of the Sierra Nevada to correlate average annual streamflow with riparian corridor width. However, use of this model assumes that alternative streamflows in a given stream system are equivalent to the characteristic flows in different-size stream systems, which obviously ignores site-specific topographic and other factors.

Application of the Taylor model to the diverted tributary streams frequently results in acreage predictions that cannot possibly develop in these particular stream corridors (Appendix P). Nonetheless, a direct relationship between mean annual streamflow and riparian vegetation extent and vigor is assumed to generally operate in assessing the alternatives.

Shallow Groundwater. The extent of shallow water table is the primary factor affecting the habitat available for riparian vegetation. The variation in shallow water table extent among the alternatives is primarily a function of streamflow because streamflow largely controls water table depth along losing streams.

If flow releases are not sufficient to overcome channel losses (principally infiltration) and stream dewatering occurs during the growing season, water tables along dewatered reaches will lower and damage riparian vegetation or eliminate its habitat. Estimated channel losses for each diverted tributary stream were presented in Table 3C-1, and these can be compared to the simulated release flows of the alternatives to estimate locations or durations of channel dewatering.

When streamflow is persistent, water table depths will be sensitive to streamflow stage, as revealed by test hole data along the diverted tributary streams (Appendix P). The acreage of a shallow water table for each alternative can therefore be estimated from stage-discharge data for each stream, estimated groundwater profiles from test hole observations and channel loss studies, and detailed topography of the stream corridors, as described in "Water Table Depth Model" in Appendix P.

Primary riparian habitat can be approximately represented as areas having water tables averaging within 5-1/2 feet of the ground surface during the growing season, based on test hole data from areas of different vegetation types in the Owens Valley (Appendix P). Areas with such water tables would experience increased vigor, diversity, or extent of riparian vegetation compared with areas of deeper water tables where more xeric vegetation types (e.g., sagebrush scrub) would tend to dominate.

Streamflows in Parker and Walker Creeks apparently benefit riparian vegetation along lower Rush Creek where there emerge springs that appear to be fed in part by water from these creeks. This phenomenon is difficult to model, but the effect among the alternatives is similar because the absence of connected overflow channels along these streams limits the rate at which runoff infiltrates the alluvial body.

A range of predicted riparian acreages for each alternative has been developed. The low values represent a scenario in which all suitable riparian habitat from point-of-reference streamflows is considered to be currently occupied by riparian species. Thus, all acreage increases in the future would be the result of stream stage changes. Because substantial die-off of vegetation occurred along these streams where they were dewatered, however, it is likely that some areas of xeric plant types now have suitable groundwater conditions for riparian expansion.

The high values assume considerable expansion of riparian vegetation even with no streamflow increases from the point-of-reference flows. Acreages are derived from the total area estimated with the model to have a shallow water table; these estimates could be improved considerably through additional water table depth observations.

The predicted minimum and maximum estimates of riparian acreage have both been adjusted for lake inundation effects of each alternative, which are considerable. Values approximately midway between the minimum and maximum estimates were used in wildlife habitat value assessment, based on an independent, field-based preliminary estimate of future conditions (Chapter 3F, "Wildlife").

Lake Level Rise. Inundation would result in loss of all existing riparian vegetation and would inhibit the establishment of new riparian vegetation below the normal highstand elevation of each alternative. The acreages of establishing and mature woody riparian vegetation below the simulated normal maximum lake elevations were estimated from maps of vegetation in 1989, and these acreages are considered as nonhabitat. Some riparian vegetation may in fact temporarily reestablish in the zone of fluctuation after the lake level drops for a prolonged period. Most of vegetation that would be inundated is willow scrub that is currently becoming established in the newly incised floodplains near the mouths of Rush and Lee Vining Creeks.

Stream Erosion. Two approaches to estimating potential for riparian vegetation losses due to stream erosion are appropriate. First, the potential for stream incision, in addition to that responsible for major habitat losses in the diversion period, can be estimated directly from lake levels under the different alternatives. Normal minimum levels can be compared to reference lake elevations selected to best approximate the lake level with which existing incision is in equilibrium.

Increased incision could occur on Rush and Lee Vining Creeks under the No-Restriction and 6,372-Ft Alternatives, causing changes in topography not accounted for in the groundwater model. Additional incision would both remove riparian vegetation and cause lowering of adjacent water tables.

Second, the potential for vegetation losses from bank erosion can be examined through comparison of the level and frequency of higher flows under each alternative with estimated streamflow thresholds for channel erosion. Thresholds estimated by the Restoration Planning Team can be used.

Changes in bank erosion may occur under some alternatives; however, the acreage of affected habitat cannot be quantified. Although the near-term effect may be to eliminate several acres of mature and establishing riparian vegetation, this may be balanced by long-term establishment of riparian plants on new bars and floodplain surfaces.

Potential for Riparian Recruitment. Full occupancy of available riparian habitat and continued stand vigor depend on frequent stream overflows onto floodplains and into floodchannels to promote periodic recruitment of riparian seedlings. Observations made during high flows in spring 1991 have been used to establish threshold runoff rates needed to provide substantial recharge of overflow channels; relatively little overbank flooding occurs at these flows, largely because of closure of overflow channels and past stream incision. Predicted frequencies of various streamflows during snowmelt for each alternative can be compared to these thresholds to predict frequency of potential recruitment.

On Rush Creek, incision along much of the main channel and blockages in all but one overflow channel constrain the area available to riparian recruitment. Opportunities for riparian recruitment on Lee Vining Creek are greater because incision is less pronounced and several floodchannels have been rewatered already. No floodchannels are connected to the main channels of Parker and Walker Creeks. Opening of additional overflow channels or planting would be required for the recruitment potential to be realized.

Lake-Fringing Wetlands

Approach. Resource condition, functions, and values were predicted for each alternative based on the geohydrologic and vegetation response to lake level change. The principal hydrologic data used for this analysis were simulated lake levels existing during the dynamic equilibrium that occurs after lake level has stabilized and during a prolonged drought. These data were applied to the new contour map (Appendix G) and vegetation map (Jones & Stokes Associates 1993) prepared by SWRCB consultants to assess vegetation impacts of the alternatives.

Determination of Lake Level Assessment Elevations. Lake level will fluctuate after reaching dynamic equilibrium as a result of runoff fluctuation (Chapter 2). Rises in lake levels eliminate wetlands within and immediately above the water line. Falls in lake levels are followed by the recolonization of newly exposed lakebed. Thus, the character and extent of lake-fringing wetlands under dynamic equilibrium varies over the short term in response to lake level change and vegetation colonization rates.

Each alternative involves highstands several feet above the target minimum lake level. For each alternative, the elevation selected to represent the lower edge of the emerged terrestrial zone, or "assessment elevation", was defined as the elevation that would be exposed and vegetated more than 50% of the time after dynamic equilibrium. Delayed colonization after reemergence, due principally to soil salinity, is accounted for by discounting the first 5 years of each period of emergence.

The selection of the 5-year colonization period was based on the observed establishment of vegetation within 3-5 years after reexposure of relicted lakebed above the 6,380-foot elevation during the 1982-1986 highstand (Stine pers. comm.). Recolonization below this elevation is inhibited by salinity and alkalinity of substrate and groundwater (Balance Hydrologics 1993a), except for the high discharge Sierran front, where leaching extends lower (Groeneveld 1991a).

Geohydrogical Responses to Lake Level Fluctuation. The character, extent, and value of individual lake-fringing wetlands is governed by geohydrologic characteristics: spring/seep type, substrate type, drainage, water quality, and landform type. These factors are influenced by past and present lake level. As described in the "Prediversion Condition" section, the 19 lake-fringing wetlands can be grouped into seven georegions based on geohydrology (Appendix Q). Each georegion encompasses several wetlands, and each wetland supports several different habitats (i.e., series, see Appendix F).

Changes in wetland extent were determined separately for each wetland site by determining which processes operated at the site and predicting their effects on wetland location and extent. Predictions were based on historical conditions under similar lake levels, site topography and landform, and the landforming processes expected to occur in the future.

The geomorphic processes under the influence of lake level and determining wetland extent are habitat inundation, springline formation, springline desiccation, reactivation of deep-water springs, lagoon formation, and drainage incision. Each of these processes is described below.

Habitat Inundation. This process applies to all but the No-Restriction Alternative. The assessment elevation was overlaid on the point-of-reference vegetation map to determine the area that would be inundated under each alternative.

Springline Formation. As described previously, shallow groundwater discharges along springlines at the base of scarps that are formed by erosion during episodes of lake level rise. New wave-cut platforms that are eroded during highstands eliminate older platforms at lower elevations, so that the eroded head scarp thereby becomes the new littoral springline in most instances. The locations of the future springlines were estimated for each alternative using normal maximum elevations predicted through the LAAMP simulations.

Springline Desiccation. The springlines formed by future highstands will drain groundwater from upslope areas. At wetlands with limited groundwater inflow, older springlines upslope of the new springlines will be desiccated. These locations were identified and approximate affected acreages accounted for.

Reactivation of Deep-Water Springs. Several faults passing under Mono Lake give rise to springs that discharge artesian groundwater from deep aquifers. Spring locations along these faults do not fluctuate with lake level, but the groundwater discharge at any vent is influenced by lake level; most active springs are found near the shoreline. Dormant springs above the lakeshore can be reactivated when the pressure on submerged springs is increased by rising lake level. These locations were identified and estimates of affected habitat were used in the assessment.

Lagoon Formation and Reformation. Lagoons form behind embankments deposited at the Mono Lake shoreline. Small, linear lagoons have developed at some wetlands, and larger lagoons developed on the Rush and Lee Vining Creek deltas and around the northern shorelands when the lake stood above 6,400 feet. Evidence suggests that these large lagoons would reform if the lake stood at elevations above 6,400 feet again.

Drainage Incision. Gravity induces streams to incise until they reach an equilibrium grade with the landform through which they pass, determined by flow regime, the type and amount of suspended sediment, and bed and bank characteristics. Mono Lake is the base level for all drainages across the relicted lakebed and throughout the basin. Drainages incise following lake regressions as they attempt to reestablish their equilibrium grade. Incision lowers groundwater levels in adjacent terraces. If creeks passing through or draining wetlands become incised, they drain groundwater from adjacent areas, either desiccating the wetland or converting it to a drier wetland habitat type. Terraces subject to drainage incision were identified and considered as nonwetland habitat.

Assumptions. The following assumptions were used to predict geohydrologic and geomorphic responses to the lake level regime of each alternative at dynamic equilibrium:

- Unconfined groundwater discharge will continue in the future at the same locations observed in the past.
- The process of downslope migration of springs/seeps that occurred from 1941 to the point of reference is reversible.
- A new wave-cut platform will form during transition periods to lake levels higher than recent highstands. The location of the scarp will be the normal maximum elevation for the alternative. New littoral springlines will form at the new scarp at locations around the lake where they have existed in the recent past.
- The same number of active littoral springlines that existed under historical conditions at the same or similar lake level will be active in the future.

- Historically active but presently dormant artesian springs will reactivate if lake level rises to levels associated with earlier periods of activity.

- Wetland extent will be similar to that observed under historical conditions when the lake was at the same or similar elevation, taking into account differences caused by the new littoral springlines and reactivated springs.

- Lagoon location and extent will be the same as documented in historical aerial photographs and maps under the same or similar lake level.

- Lakebed below the 6,381-foot elevation will remain unvegetated except along the Sierran front and other documented locations where groundwater amounts are sufficient to leach the inhibitory saline-alkali compounds.

- No new sources of groundwater will develop from the irrigation of new areas upslope of the lake.

- Wetland extent will diminish substantially if the lake drops below 6,368 feet because of creek and drainage incision, except for wetlands protected by grade control structures.

Historical aerial photographs (dated 1941, 1952, 1956, 1968, 1972, 1973, and 1974), Stine (1993), published literature (Appendix Q), and anecdotal observation were interpreted using the above assumptions to predict the geohydrologic response of each wetland under each alternative.

Vegetation Response to Geohydrologic Changes. The objective of the lake-fringing vegetation assessment was not to predict the absolute condition of lake-fringing wetlands under each alternative but to provide a relative basis for comparing alternatives. Absolute predictions are impossible to make because of the number of variables that influence lake-fringing wetlands. Time-dependent successional and climatic processes are difficult to separate from the effects of lake level change.

Predicting the type and extent of wetland vegetation was based upon historical conditions under similar lake levels and the observed condition at the point of reference, after correcting for changes in spring/seep locations and the new lake level. Corrections were not made for succession or sediment leaching because of the complexity of their inter-relationships and the inability to make accurate predictions without additional data.

The character and extent of wetlands under each alternative was inferred from a review of historical aerial photographs (dates cited above), published and unpublished literature, and anecdotal observations, using the following assumptions:

- Inundation by Mono Lake permanently kills wetland vegetation.

- Lands within 10 vertical feet of the assessment elevation will support dry meadow unless wet enough to support other wetland types.
- Marshes will form where the surface is saturated or inundated most of the year.
- Wet and alkali meadows will form where the water table stands within 5 feet of the surface.
- Desiccated meadows and marshes will convert to dry meadow.
- Unvegetated alkali lakebed will develop at locations where observed in the past under similar lake levels.
- The extent of dry meadows and riparian scrub on lakebed areas more than 10 feet above the assessment elevation will not change over time.
- Land below the assessment elevation will be in a state of early succession (due to periodic short-term inundation) with the same vegetation as observed below the 6,390-foot elevation at the point of reference.
- Vegetation types and extent that existed under historical lake levels will become reestablished under similar managed lake levels, subject to changes caused by the creation of the new wave-cut platforms.
- Dry meadows at the point of reference that occupy historical wetland locations will reconvert to meadow or marsh under alternatives that cause the reactivation of the springs and seeps that supported them.
- Alkali flats below the 6,381-foot elevation will remain unvegetated.

Procedure. Habitat type and extent under each alternative was determined by annotating the point-of-reference vegetation/substrate map (Appendix Q) with new littoral springlines, springs, and seeps, and overlaying it with the topographic contours, including the assessment contour. Wetland habitat types and boundaries were inferred from historical conditions and adjusted to reflect physical changes and the creation of new littoral springlines using the above assumptions.

Lake-fringing wetland type was predicted at the subformation level. Habitat-type predictions at the series level were infeasible because of the lack of information relating series to geohydrology and lake level. Detailed, site-specific breakdown of predicted habitat extent, by habitat type and alternative, is provided in Appendix Q.

Upper Owens River

The available data provide for the assessment of vegetation impacts from three perspectives: channel stability, extent and quality of meadow and marsh wetlands, and extent and sustainability of willow scrub.

Channel Stability

Background. Channel stability refers to the frequency and magnitude of changes in channel configuration and location. Stability is important because channel changes affect the type and quality of instream and bank habitats and influence overbank flooding.

Changes over the 1940-1989 period indicate that this period of flow augmentation coincided with one of decreased channel stability (see "Environmental Setting"). Without flow augmentation, Upper Owens River flows are relatively constant, with moderate increases during the spring runoff because most flow volume is constant inflow from Big Springs. With augmentation, flows increased threefold. Landowners reported that the period of greatest instability coincided with flow releases exceeding 300 cfs, or rapid decreases in flow augmentation (Arcularius, Rossi, and Reed pers. comms.). These landowners also report that the channel widened and deepened during this period. Rapid declines in flow have caused vertical, saturated banks to collapse into the river because they are no longer supported by high water level in the channel (Arcularius, Rossi, Reed, Edmonson, and Smith pers. comms.).

Impact Assessment Assumptions. The following assumptions were used for the impact assessment:

- Watershed perturbations (e.g., road building, resort development, logging, and grazing), which influence channel stability, will remain the same as before the point of reference.
- Flows above 300 cfs substantially destabilize the channel by increasing rates of bank erosion, channel avulsions, and flooding.
- With the exception of the No-Restriction Alternative, flows below the East Portal will not exceed 300 cfs, and no ramping criterion exists.
- Flow decreases exceeding 10% of total volume over a 24-hour period potentially result in bank erosion.
- The frequency, duration, and magnitude of flows exceeding 200 cfs contribute to channel instability, as measured by the number of meander cutoffs and extent of bank erosion.
- Flow augmentation causes channel widening and deepening.

- After dynamic equilibrium is reached, the Upper Owens River channel would eventually achieve a new equilibrium grade and sinuosity under any alternative. Although overbank flooding and meander cutoffs would continue to occur, their frequency would stabilize around a new lower mean.

Impact Assessment Methods. Predictions of channel stability under the alternatives were based on the changes that occurred during the diversion period; relative magnitudes, durations, and frequencies of peak flows and ramping schedules; and relationships between discharge, channel stability, and floodplain morphology.

Extent and Condition of Meadow and Marsh Wetlands

Background. The type and condition of meadows and marshes on the Upper Owens River floodplain are controlled largely by water table depth, which is determined by river stage, irrigation, and groundwater inflows. Natural groundwater inflows occur from below the basalt mesa south of the river and from alluvial fans at the foot of the Bald Mountains. The importance of river stage is evidenced by the fact that low terraces and oxbows that supported wet meadows and marshes before the point of reference were converted to drier habitats during the 1986-1992 drought after the court-ordered suspension of Mono Basin exports (Arcularius pers. comm.). Information to characterize water table profiles and floodplain topography, which is available for the Mono Basin streams, is not available for the Upper Owens River, preventing detailed analysis of stream stage effects.

Nearly 2,000 acres of the river floodplain are irrigated by water diverted from the Owens River and Hot Creek. In August 1990, after 3 years of drought and a summer with no Mono Basin exports, irrigation appeared widespread on the aerial photographs, leading to the conclusion that the irrigation system and amount of water available are adequate to irrigate this area in low runoff years.

During extreme drought, however, the flows are more limited and river stage is even lower. Under extreme drought conditions, the ability to divert water for range irrigation is limited by the capability of structures to divert water and the amount of water available (Table 3A-9). When the recent drought became extreme in summer 1991, some landowners erected temporary dams in the river to raise the river stage so that water would flow into their diversion ditches (Canaday, Smith pers. comms.).

Impact Assessment Assumptions. The following assumptions are used to assess changes in the extent and productivity of floodplain meadows and marshes:

- Irrigation practices (i.e., patterns of water distribution) and natural groundwater inflow have much greater effect on the extent and productivity of the floodplain's meadows and marshes than do riverflows and river stage.

- Loss of meadow and marsh wetlands or their conversion to drier habitats because of changes in river stage would only affect terraces immediately adjacent to the river and unexposed to artificial irrigation or groundwater inflows. Losses would be significant only when the river stage (during normal years) were more than 1 foot below the point-of-reference condition.

- Impacts of extreme droughts would be similar to those observed during 1991-1992.

- If river stage drops below the point-of-reference level, wet meadow and marsh on low terraces and old meander scars would convert to dry meadow or low-productivity wet meadow, and wet meadow on high terraces would convert to dry meadow or sagebrush scrub. Exceptions are where wet meadow or marsh on low terraces and old meander scars will convert to alkali meadow or sagebrush scrub.

Impact Assessment Methods. Predictions of the extent and type of meadow and marsh vegetation along the river floodplain under the alternatives are based on changes observed during the prediversion to point-of-reference period, stage-discharge relationships developed at selected points by DFG (EBASCO et al. 1993), point-of-reference channel and floodplain condition, and soil type.

River stages for the different alternatives were based on stage-discharge measurements and equations developed by DFG (EBASCO et al. 1993) at 28 transects grouped into three reaches: "Inaja", "below Benton", and "Hot Creek". Estimated wet, normal, and dry year flows for June through August under each alternative were used to calculate river stage for each transect. For each reach, the calculated stages at each transect were averaged separately for wet, normal, and dry seasons for each alternative.

Predicted changes in the extent and condition of meadow-marsh vegetation are necessarily qualitative because of the unavailability of detailed contour mapping and water table data. Groundwater inflow or channel losses and the effects of irrigation and river stage on shallow groundwater along this stream are unknown.

Willow Scrub Extent and Sustainability

Background. Decline in the extent and vigor of willow scrub and low rates of willow reproduction corresponded along the Upper Owens River with the period of augmented basin export flows (see "Environmental Setting" section of this chapter). Optimal willow growth rates occurred under moderate flows at the high end of the natural flow regime, which overlaps the low end of the augmented flow regime; increasing augmentation appears to suppress growth (Stromberg and Patten 1991b).

Although this study indicates that average annual flows influence willow growth rate, the biological significance of this change is largely unknown; however, a direct relationship between growth increment and cottonwood vigor was documented for streams tributary to Mono Lake (Stromberg and Patten 1992). It is therefore concluded that willow biomass production, if not extent, increases with increasing annual flow volume.

Limited willow reproduction was also correlated with the augmented flows. Under the typical augmented flow regime, there is little above-water sand bar habitat (Arcularius, Rossi pers. comms.). The limited number of willow seedlings (Stromberg and Patten 1991b) and steady decline in extent of willow scrub may result from the absence of suitable habitat for seedling germination (McBride and Strahan 1984), but livestock probably play an important role also because they trample and consume seedlings and mature plants.

Impact Assessment Assumptions. The following assumptions were used to predict willow scrub impacts:

- Livestock grazing rates will be relatively unchanged.
- Within-channel willow seedling habitat will be limited or nonexistent under alternatives with augmented flows because gravel bar habitat is submerged.
- Declining trends in extent of willow scrub that occurred before the point of reference will continue under alternatives with augmented summer flows because of the combined effects of livestock grazing and flow augmentation; rates and magnitude of declines in extent will increase with increasing levels of flow augmentation.
- Although areas affected by overbank flood scour and abandoned meanders can provide habitat for willow establishment, these do not, under augmented flow regimes, provide adequate willow seedling habitat to provide for replacement of plants that die.

Impact Assessment Methods. The extent of willow scrub under each alternative was predicted through extrapolation of changes documented during the diversion period and predictions of willow productivity and rates of decline in extent based on the above assumptions. Willow growth rates were predicted using Stromberg and Patten's model (1991b, 1992) relating annual growth increment to mean annual discharge, which was obtained from the hydrologic simulations of each alternative.

Special-Status Plants

Approach. Impact predictions for special-status plants were based on available information on locations and habitats of each species and assumptions about the potential for streamflow or lake level changes to affect each species or its habitat.

Impact Mechanisms. Impacts on special-status plants in the project area would result primarily from grazing practices and changes in lake level. Past impacts on special-status plants have resulted primarily from grazing. The following observations were made regarding impacts on special-status plants:

- No state-listed or federally listed or proposed threatened or endangered plants would be affected by any of the alternatives.

- No special-status plants in Mono Basin or Long Valley occur in riparian zones affected by the project.

- Two plants listed in the California Native Plant Society (CNPS) inventory of rare and endangered plants (Smith and Berg 1988) could be affected by changes in lake level.

  - Mono buckwheat has become established in some former lakebed and marsh sites since 1940. Some of these populations could be reduced in area at lake levels above about 6,400 feet.

  - Utah monkeyflower may have become established at sites below the 1940 lake level of 6,417 feet. These populations could be reduced in area at lake levels above about 6,400 feet. Changes in spring activity with higher lake levels could allow new populations to become established at higher elevations.

- All special-status plants in Mono Basin and Long Valley were probably more abundant in 1940 than today but have not been adversely affected by changes in streamflow or lake levels.

Criteria for Determining Impact Significance

Criteria for determining the significance of impacts on riparian and wetland vegetation and special-status plants are based on state and federal regulations, resource agency policies, and the judgment of professional resource managers and scientists.

Legal Framework

Riparian and Wetland Vegetation. Riparian and wetland communities are recognized by many state and federal resource agencies, conservation organizations, and independent scientists as having especially high biological values. These communities are also recognized as having been reduced in area and quality by a variety of causes in many locations. Several agencies have policy statements regarding the importance and sensitivity of riparian or wetland resources or the adequacy of various mitigation methods (The Conservation Foundation 1988, National Audubon Society 1992, Abell 1989, California Department of Fish and Game 1985, Warner and Hendrix 1984.) Section 404 of the Clean Water Act discourages activities that would discharge fill material into wetlands and other jurisdictional waters of the United States, requiring federal permits for such activities.

Impacts leading to substantial reduction or degradation of riparian and wetland vegetation may be considered significant under CEQA because of the widely recognized importance of these resources.

Special-Status Plants. Federally listed threatened or endangered plant species are protected under the federal Endangered Species Act (50 CFR 17.11-12). State-listed rare, threatened, or endangered plants are protected under the California Endangered Species Act (California Administrative Code, Title 14, Section 670.5).

Under CEQA, substantial adverse effects on rare and endangered species are considered significant impacts. Species that meet broad CEQA criteria for rare and endangered must be considered even if they are not listed under the state or federal Endangered Species Acts (State CEQA Guidelines 1989).

Significance Criteria

Impacts on riparian and wetland vegetation are considered significant if they met one or more of the criteria described below. Impacts are considered beneficial if they would increase the extent of riparian or wetland vegetation or improve vegetation conditions. Significance criteria for impacts on wildlife, fisheries, visual resources, or recreation resulting from impacts on vegetation are discussed in other chapters.

Tributary Streams. Impacts on hydrology supporting riparian vegetation were considered significant if they would result in:

- dewatering of any stream reach or more than minor (10%) decrease in extent of shallow groundwater,
- more frequent channel erosion or deeper channel incision, or
- less frequent spring overflow conditions compared to the point-of-reference condition.

Impacts on growth of riparian vegetation were considered significant if they would result in:

- a more than minor (10%) reduction in acreage of woody riparian or meadow and wetland vegetation in a reach or group of reaches along any tributary stream,
- a substantial qualitative reduction in the condition (e.g., survival, vigor, cover, density, or native species diversity) of woody riparian or meadow and wetland plant communities in a reach or group of reaches along any tributary stream, or

- a substantial qualitative reduction in the functions (e.g., population regeneration, nutrient cycling, bank stability, or other functions normal to self-sustaining riparian plant communities) in a reach or group of reaches along any tributary stream.

Changes in condition were considered beneficial if they would result in measurable net increases in the extent or quality of native riparian or wetland vegetation. Benefits were characterized as minor or major.

Lake-Fringing Wetlands. Loss of dry meadows is not considered a significant impact because the habitat does not support important wildlife species or other important ecological functions in the Mono Basin, large portions of the habitat at Mono Lake have less than 10% plant cover, the soil does not become saturated to the surface by groundwater, and most importantly, the dry meadows and the species they support are common locally and throughout the Intermountain West.

Likewise, the loss of unvegetated alkali lakebed is not considered a significant impact from an ecological perspective because the few wildlife species that utilize the habitat are not limited locally by the extent of this habitat, and the habitat does not support ecosystem functions of importance to adjacent habitats. Use by the snowy plover is an important exception, however; effects on this species are described in Chapter 3F, "Wildlife".

The combined loss of marsh, wet meadow, alkali meadow, and riparian scrub habitats fringing Mono Lake is considered significant if:

- more than 10% of the total acreage of marsh, meadow, and riparian scrub would be eliminated when total wetland area exceeds 1,000 acres;

- more than 5% of the total acreage of marsh, meadow, and riparian scrub would be eliminated when total wetland area measures 500-1,000 acres; or

- more than 1% of the total acreage of marsh, meadow, and riparian scrub would be eliminated when total wetland area is less than 500 acres.

These losses are considered significant because of the local and regional scarcity of these wetland types, the extent of historical regional losses from groundwater pumping and agricultural and rangeland conversion, threats facing the remaining occurrences from grazing and groundwater pumping, and the habitat's importance to dependent plant and wildlife species.

Upper Owens River. Vegetation impacts are considered significant if the following would occur:

- flow regimes decrease stability of the creek channel;

- meadow, marsh, and undercut riverbank habitat is eliminated or permanently converted to low-quality wet meadow, dry meadow, or sagebrush scrub;

- the extent of willow scrub is reduced;

- the extent of habitat available for willow seedling establishment is reduced; or

- annual growth increment of willows declines by more than a minor amount (10%) relative to the point-of-reference condition.

Special-Status Plants. Impacts on plant species listed or proposed for state or federal listing as threatened or endangered were considered significant if they would result in:

- direct loss of individual plants,

- permanent loss of existing or potential habitat, or

- temporary loss of habitat that might result in increased mortality or lowered reproductive success.

Impacts on state or federal candidate species and CNPS List 1b and List 2 species were considered significant if they would result in:

- direct loss of substantial portions of local populations,

- permanent loss of existing habitat, or

- temporary loss of habitat that might result in increased mortality or lowered reproductive success.

Criteria were not developed for CNPS List 3 or List 4 species because none could potentially be affected by the project.

SUMMARY COMPARISON OF IMPACTS AND BENEFITS OF THE ALTERNATIVES

Tributary Streams

Several key variables represent the relative condition of tributary riparian vegetation under the alternatives, as described in the "Impact Assessment Methodology" section:

- frequency of channel dewatering,

- channel erosion and incision erosion potential,
- frequency of riparian recruitment flows,
- extent of shallow water table, and
- predicted acreages of riparian vegetation, estimated principally from a water table depth and lake inundation model.

Table 3C-10 provides a summary comparison of the alternatives using these variables and provides a comparison with values for the point-of-reference and prediversion conditions. Significant adverse changes from the point-of-reference condition are indicated.

As Table 3C-10 indicates, most adverse impacts in relation to the point of reference are associated with the No-Diversion Alternative, because of both insufficient water for plant growth and incision potential. Impacts would be similar to those that occurred during the diversion period. In addition, the 6,372-Ft and 6,377-Ft Alternatives would result in an adverse change: the level of riparian recruitment flows would be reduced well below a functional level.

Effects among the alternatives are demonstrated more fully by several detailed comparisons. Table 3C-11 shows the frequency of stream releases during the growing season that would not be sufficient to overcome channel losses. If these periods of dewatering are more than infrequent, habitat for riparian vegetation is lost. This consequence would occur only under the No-Restriction Alternative.

Table 3C-12 shows the potential under each alternative for loss of riparian vegetation and habitat from stream erosion. Comparative values for stream incision potential and frequency of projected high flows that may cause bank and floodplain erosion are both reported. As presently formulated, only the 6,377-Ft and 6,383.5-Ft Alternatives would not present significant erosion problems. These and the 6,390-Ft Alternative would not entail adverse change from the point of reference.

Table 3C-13 compares the frequency of seasonal overflow channel wetting capable of inducing significant recruitment of riparian vegetation in areas not now supporting it. Flows under the No-Restriction, 6,372-Ft, and 6,377-Ft Alternatives would be sufficient in less than 1-in-3 years to provide recruitment and promote establishment. These flows are needed to help the stream corridors regain some of the large acreage losses of riparian vegetation over the diversion period.

Table 3C-14 displays the predicted range of extent of riparian and wetland vegetation among the alternatives for the tributary steams. These estimates were made primarily using the groundwater depth and lake inundation model described in Appendix P. The data reveal that different levels of streamflow and lake levels among the alternatives, in the absence of dewatering, have relatively constant effect on the extent of habitats capable of supporting riparian vegetation. The provision of continuous flows capable of overcoming channel losses is essential to riparian habitat, but higher flows do relatively little to expand the habitat.

Developed from Table 3C-14, Figure 3C-11 shows the estimated acreages of woody riparian vegetation for all four tributary streams under each alternative, at the point of reference, and before diversions began. Although woody riparian acreage would tend to increase under each higher lake level because of groundwater effects of increased streamflow, riparian acreage would actually decrease as the lake rose and inundated establishing riparian vegetation near the mouths of Rush and Lee Vining Creeks. The countereffects of increased growth and increased inundation at higher elevations result in similar acreage predictions for riparian vegetation under all alternatives except the No-Restriction Alternative, under which losses would be extensive. These riparian acreages under all alternatives would be significantly less than prediversion acreages. The unavoidable shortfall results primarily from irreversible stream incision.

Lake-Fringing Wetlands

As described in the assessment methodology section, relative effects on lake-fringing wetlands are assessed based on the areal extent of three habitat categories:

- marsh + meadow + riparian scrub,
- lagoon, and
- alkali lakebed.

Table 3C-15 is a summary comparison of the alternatives to both the point-of-reference and prediversion condition using the areal extent variables. Significant adverse changes from the point-of-reference condition are indicated. A discussion of these variables for each alternative is provided in the following sections of this chapter.

As Table 3C-15 indicates, most lakebed wetland impacts are associated with the No-Restriction Alternative; existing vegetated wetlands would be drained as the lake surface fell below the nick point, and a vast area of alkali lakebed would border the lake. Significant losses of vegetated wetlands would also occur under the 6,383.5-Ft and higher lake level alternatives, as conditions returned toward the prediversion state where much smaller wetlands were present. Under the 6,410-Ft and No-Diversion Alternatives, these losses would be major. Table 3C-16 indicates where these losses would occur for each alternative.

Upper Owens River

As described in the assessment methodology section, relative effects on habitats of the Upper Owens River floodplain are assessed based on:

- channel stability,
- marsh-meadow extent and productivity, and
- willow scrub extent and sustainability.

Table 3C-17 is a summary comparison of the alternatives to both the point-of-reference and prediversion condition using these variables. Significant adverse changes from the point-of-reference condition are indicated. A discussion of these variables for each alternative is provided in the following sections of this chapter.

As indicated in Table 3C-17, channel stability would worsen only under the No-Restriction Alternative and may improve for the 6,383.5-Ft and higher alternatives as flow augmentation diminished. The extent of marsh and meadow and the threat of elimination of willow scrub below East Portal does not appreciably vary among the alternatives. Willow growth is seen to be slightly suppressed under alternatives with either large exports or no exports, but the effect is not significant.

Tables 3C-18 and 3C-19 provide the supporting comparative data for the environmental variables. As shown on Table 3C-18, the point of reference and the No-Restriction Alternative involve sustained flows exceeding 300 cfs during wet years. Under all of the target lake level alternatives, however, maximum flows have been kept below 300 cfs in the model simulations. The table also shows relative sizes of growing season streamflows under the alternatives.

Table 3C-19 presents stream stage data for the alternatives. Higher stages indicate a tendency toward more extensive meadows and marshes, but this effect is probably masked by effects of irrigation. This table also shows the willow growth increment data for the alternatives as measured for this report, indicating maximum growth for the 6,410-Ft Alternative.

Special-Status Plants

No changes in the condition of special-status plant populations in Mono Basin or Long Valley would occur under all alternatives but one. Several populations of Mono buckwheat and Utah monkeyflower (neither a state or federally listed or proposed species) might be inundated by long-term fluctuations of Mono Lake under the No-Diversion Alternative. Their loss would not be considered significant.

IMPACTS COMMON TO MOST ALTERNATIVES

Changes in Resource Condition

Lake-Fringing Wetlands

Under the alternatives having lake levels above the point-of-reference level, wetlands will be eliminated by inundation and wetland extent will decline. The zone above the managed lake level and below the assessment elevation is inundated more often than not as lake level fluctuates in response to runoff variation. Inundation frequency would be high enough that this zone would rarely support vegetation, and when vegetated, plant cover would be sparse and short-lived.

Two exceptions are important. Along the Sierran front abundant groundwater inflows rapidly leach lakebed sediment, permitting early plant establishment following recessions (Stine 1993). At the northern, eastern, and southern Mono shorelands, vegetation would likely not become established below the 6,381-foot contour because the saline-alkali groundwater requires a long time period to drain from the basin sediments. Therefore, when the zone below the assessment elevation is not inundated, it will generally consist of barren alkali lakebed.

Plant cover and plant species richness in wetlands will gradually increase above the zone of periodic inundation under each alternative.

Upper Owens River

Rapid declines in flow rate may continue to cause river banks to gradually collapse under most alternatives, leading to channel widening and the loss of river terrace habitat and aquatic undercut bank habitat. LADWP has not adopted a ramping schedule governing maximum rates of change of exported flows. The effect of this loss is significant because willow growth in river channel habitats, together with suppression of willow growth from frequently high water tables, may result in a significant loss of willow scrub habitat. Although some willow recruitment may occur, the declining trends in extent associated with past flow augmentation would continue under the export alternatives. Willows would continue to senesce and die with limited replacement. Willow scrub could eventually be eliminated or reduced to a few scattered plants because of the combined effects of flow augmentation and livestock grazing. Loss of willows reduces invertebrate productivity and stream shading important to the resident trout fishery.

- Flow changes in the Upper Owens River continue to cause bank erosion and habitat loss.

Mitigation Measures. Impacts of export rate changes could be fully mitigated by adopting a ramping schedule that mimics natural rates of flow decline. DFG recently negotiated a temporary ramping schedule with LADWP to use during IFIM studies. It called for a maximum flow reduction of 25% in an 8-hour period. However, DFG believes a 10-15% increment would more closely mimic natural conditions (Smith pers. comm.). A ramping increment of 10% was also recommended by Hill et al. (1991). A site-specific study of rates of bank drainage might help establish the most appropriate increment.

IMPACTS AND MITIGATION MEASURES FOR THE NO-RESTRICTION ALTERNATIVE

Changes in Resource Condition

Tributary Streams

Under this alternative, no water would be released into any of the streams in most years (Figure 2-2). Flows would occur in Rush and Lee Vining Creeks during June and July in wet years but would be incapable of sustaining riparian vegetation. This flow regime would be similar to that affecting most portions of the creeks in the 1950s through 1970s.

Channel-damaging flows would occur in these two streams 10-15% of future years. Substantial incision would continue when uncontrolled spills occur because the normal minimum lake level fluctuation would fall 30 feet below the lake level of prior incision. Fires, such as the one that occurred along Lee Vining Creek in the early 1950s, could occur on any of the creeks.

Quantitative effects of the No-Restriction Alternative on existing vegetation are very difficult to estimate (Table 3C-14). Many areas reestablishing vegetation since stream rewatering began would be lost again under this alternative. Additional areas would also be lost but some new habitat would be created as substantial channel incision occurred.

About one-half of woody riparian vegetation would be lost on all four creeks because streamflows and groundwater would be inadequate to sustain the vegetation. About three-quarters of current habitat on Rush Creek would be lost, although seepage from Grant Lake reservoir might minimize losses in the upper reaches. About 20 acres, or 26% of that existing, would be lost on Lee Vining Creek in losing reaches below U.S. 395. Some of the surviving woody riparian vegetation would be severely stressed by lack of water, except in areas with groundwater sources other than the stream.

On Parker and Walker Creeks, smaller amounts of existing vegetation would die because vegetation has been reduced already by over 100 years of water diversions and grazing, and because use of the channels for conveyance of irrigation waters and irrigation of adjacent lands would continue.

Most of the meadows along Rush and Lee Vining Creeks would become dry. Some would be replaced by Great Basin scrub and some would remain as dry meadows, with a species composition adapted to dry conditions. Relatively wet meadows may persist near the springs on Rush Creek. Most channel-margin wetlands and all the small, scattered pockets of emergent wetland vegetation on the creeks would be lost.

Great Basin scrub may eventually become established over 40-60% of the area where woody riparian and meadow vegetation is lost on all creeks. The remaining portion would be unvegetated, sparsely vegetated, or have dense accumulations of dead trees and shrubs.

Lake-Fringing Wetlands

Mono Lake has not been observed at levels that would characterize dynamic equilibrium for this alternative. The effects of this alternative on lake-fringing wetlands are therefore difficult to predict because of the absence of geohydrologic information.

Near-Term Changes. Once the lake surface dropped below about 6,368 feet, a nick point would be encountered. This point marks the abrupt transition from the gently sloped Scholl terrace to steeper slopes. The incision of rills and streamlets would accelerate rapidly. Incision, coupled with the drop in the base elevation of the water table, would cause groundwater to drain wetlands on the Scholl terrace (Stine 1988, 1990, 1992, 1993). Some artesian springs would cease flowing because of reduced hydrostatic pressure. Most wetlands existing at the point of reference would probably dry as a result. Some wetlands would probably persist around artesian springs that are unaffected by lake level. Although new littoral springlines would develop along the shoreline, only a narrow band of vegetated wetland would develop because of the steep shoreline gradient below 6,368 feet. The area of lake-fringing wetland would decline gradually until the lake reached 6,368 feet, and would decline rapidly thereafter.

Long-Term Changes. Shoreline circumference and shoreline slope strongly influence the area of lake-fringing wetland, assuming groundwater amounts are unchanged. Shoreline slope is roughly the same for the prediversion condition and the No-Restriction Alternative, and is relatively steep compared to the point of reference. Circumference is roughly comparable to the prediversion condition because, although under the lake surface area would be reduced, the shoreline would have numerous embayments and peninsulas that would add to the net shoreline area (Stine pers. comm.). Given the similarities in slope and circumference, the prediversion wetland acreage is a good first approximation for the extent of wetlands under No-Restriction Alternative, with two important exceptions.

First, lagoons would not develop because the steep shoreline would prevent the deposition of littoral berms. Second, most of the prediversion wetlands existed on flat deltas and were sustained, in part, by artificial irrigation. Similar flat benches do not exist at the shoreline under the No-Restriction Alternative.

Assuming that the acreage of vegetated wetlands for the No-Restriction Alternative would be similar to the prediversion acreage (clearly not more than double this acreage) (Table 3C-15), the area of vegetated wetlands would decline to 13-26% of the point-of-reference extent. (Dry meadow extent was assumed to be about the same as at the point of reference.) The reduction in vegetated wetlands and complete loss of lagoons (1 acre) are both significant effects.

Exposure of the entire Scholl terrace would increase the area of alkali lakebed. Although eventually groundwater underlying this terrace would drain, an efflorescent crust would be produced over larger areas for a long period of time (Appendix U). As groundwater drained, the land would remain as dry, unvegetated salt flats, although much of the salt deposits would be removed by wind and rain. Rabbitbrush, greasewood, and various dryland halophytes such as salt grass would colonize areas after some salt removal had occurred, but large areas of unvegetated alkali lakebed would persist for centuries. This habitat would replace existing littoral aquatic habitat supporting invertebrate production.

Drought Effects. Drought would not appreciably affect wetland acreage but could periodically reduce wetland vegetation.

Upper Owens River

Flow augmentation would result in sustained high monthly average flows in excess of 300 cfs for 6 months in normal years (Table 3C-18). Average annual discharge of 172 cfs would result in a mean annual willow growth increment that is 98% of the point-of-reference growth (Table 3C-19). Willow seedling establishment habitat would be absent from the river's edge, but the frequency of flows in excess of 300 cfs would frequently cause overbank flooding, allowing seedling establishment in the floodplain. Irrigation demand would be fully met in all years (Table 3A-9), and river stage would be slightly higher than the point of reference (Table 3C-19), thereby maintaining the extent and productivity of meadow and marsh wetlands.

Long-Term Changes. River channel stability would decline from the point of reference because of higher levels of flow augmentation, especially higher frequency and duration of flows above 300 cfs. Higher flows and abrupt flow changes would continue the process of channel widening and deepening and channel avulsions (primarily meander cutoffs) that apparently increased with flow augmentation. After the channel had reequilibrated to the augmented flow regime, it would presumably attain the widest and deepest dimensions under this alternative. These changes would lead to the loss of river terrace wetlands and undercut riverbank habitat and are considered significantly adverse.

No changes in the extent of meadow and marsh wetlands are expected. Channels abandoned by meander cutoffs would provide new habitat for meadows, marshes, and willow seedlings.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (No-Restriction Alternative)

Tributary Streams

- Creates extreme potential for stream incision.

Mitigation Measures. Upstream migration of incision of the Rush and Lee Vining Creek channels could be arrested at the County Road crossings or elsewhere by construction of engineered drop structures. These structures would create waterfalls, armored to prevent scour and undercutting by the falling waters.

- Results in a high frequency of channel dewatering and loss of shallow water tables.

Mitigation Measures. None are available.

- Causes loss of 52% of woody riparian vegetation on the tributary streams and 44% of meadow and wetland vegetation on Rush and Lee Vining Creeks; degrades remaining woody riparian and meadow vegetation condition along tributary streams.

Mitigation Measures. None are available other than partial compensation at other locations.

Lake-Fringing Wetlands

- Reduces extent of vegetated lake-fringing wetlands by 75-85%.

Mitigation Measure. Wetland losses could be partially mitigated using creation, enhancement, and restoration techniques. Wetland losses are typically compensated using replacement ratios of 1 or more acres created for each acre eliminated, but this approach would not be feasible because of the vast decrease in wetland area. Specific mitigation requirements would have to be determined in consultation with resource agencies because no directly applicable precedent exists.

Mitigation efforts should be dispersed around the lake to maintain a semblance of the natural wetland distribution. Opportunities exist at several locations. DeChambeau Ranch and the county park have water sources and irrigable lands. Wetlands also could possibly be enhanced or created at newly relicted springs. Existing wetlands could be maintained by inhibiting surface drainage. At Simon's Spring, the tufa-cemented beach terrace may inhibit drainage, providing an opportunity to maintain and create wetlands on the Scholl terrace, assuming the springs continue to discharge water after the lake has retreated.

- Converts 3,500 acres of aquatic habitat to barren alkali lakebeds.

Mitigation Measure. The impact is unavoidable, unless plant species and establishment techniques to facilitate vegetation establishment on alkali flats were discovered (Groeneveld pers. comm.).

- Completely eliminates remaining lagoons.

Mitigation Measures. Ponds could be created and maintained with diverted creek water at various locations around the lake, such as DeChambeau Ranch and the Rush and Lee Vining Creek deltas. Other opportunities may exist where surface water or pumped groundwater is available; windmills could be employed to lift groundwater in areas without access to electricity. To replace the wildlife functions provided by lagoons, the lagoons should be designed to maintain some areas of open water free of vegetation.

Upper Owens River

- Causes substantial decrease in channel stability.

Mitigation Measure. A flow ramping increment described above could be adopted and a cap of 300 cfs could be placed on total flow below the East Portal as used in the simulations. The maximum flow requirement would reduce annual exports an unknown amount. Another possible mitigation measure is bank protection, which generally involves extensive construction-related habitat impacts. Bank stabilization does not eliminate the source of the problem and thus requires long-term monitoring and maintenance commitments. It may also necessitate stabilizing additional reaches until complete channelization is attained.

IMPACTS AND MITIGATION MEASURES FOR THE 6,372-FT ALTERNATIVE

Changes in Resource Condition

Tributary Streams

Under the 6,372-Ft Alternative, minimum monthly flows would be required if runoff is sufficient, but no additional ecosystem maintenance flows would be required in June (Table 2-3). The range of flows would be the same in dry, normal, and wet years (Figure 2-2). No incidences of channel dewatering would be expected to occur (Table 3C-11), but flows capable of causing seedling recruitment in restored flood channels would be infrequent, about once every 15 years on Rush and Lee Vining Creeks, once every 7 years on Parker Creek, and never on Walker Creek.

Compared to point-of-reference flows (19 cfs and 5 cfs in Rush and Lee Vining Creeks, respectively), Rush Creek flows in average runoff years would be 30-50 cfs higher during May through July and Lee Vining Creek flows in average runoff years would be 70-90 cfs higher during May and June and about equal during July in average runoff years. Erosive flows would probably never occur in Rush, Parker, and Walker Creeks but could occur in Lee Vining Creek once every 15-20 years on the average (Table 3C-12). These events could cause 3-4 feet of additional incision along Lee Vining Creek because of the low lake level (Table 3C-12).

Compared to minimum required flows, Rush Creek flows in 40-80% runoff years would be about 15-20 cfs higher during May and June and 5-10 cfs higher during July. Lee Vining Creek flows in 40-80% runoff years would be about 50 cfs higher during May and June and 10-20 cfs higher during July and August (Chapter 3A, "Hydrology").

Springs influenced by Parker and Walker Creek flows on the west side of Rush Creek would have roughly the same flows as in 1991-1992, following rewatering of Parker and Walker Creeks. Springs on the east side of Rush Creek would remain the same as at the point of reference. The lake would advance 50-100 feet upstream on Rush Creek and 100-200 feet upstream on Lee Vining Creek. Table 3C-14 lists the estimated minimum and maximum changes in woody riparian and meadow habitat acreages on each creek for the 6,372-Ft Alternative, based principally on the water table depth and lake inundation model.

Mature riparian vegetation would improve in condition and expand in areas mapped in 1990 as improving in response to rewatering (Figure 3C-11). The lake would not rise enough to inundate riparian vegetation becoming established at the mouths of Rush and Lee Vining Creeks. New areas of establishing vegetation would appear along the channels rewatered in 1992 on Lee Vining Creek, but woody riparian expansion more than a few yards from the wetted channel edges would be unlikely because overbank flows would be rare. Meadow and wetland vegetation on Rush and Lee Vining Creeks may expand slightly in area and improve in condition in the near-term as a result of both the grazing moratorium and the increased extent of shallow groundwater.

Great Basin scrub and other upland vegetation types would continue to become established slowly along Rush and Lee Vining Creeks in most areas of decadent (mostly dead) riparian vegetation, in dry sites where vegetation was removed by the late-1960s floods, and in side channels where flow was eliminated by main channel incision and quarry gravel deposition.

Under this and all higher lake-level alternatives, significant long-term changes in the distribution of vegetation along Parker and Walker Creeks are expected to occur. Under these alternatives, irrigation of the Cain meadowlands below the Lee Vining conduit would be substantially reduced, causing gradual reduction in the extensive meadows and loss of return flows in local drainages and remnant overflow channels. Grazing of woody riparian vegetation would diminish. Flows in both stream systems would be confined to primary channels, even during spring snowmelt.

These changes are expected to result in a loss of about 15-20 acres of woody riparian vegetation from the north channel of Walker Creek and along other overflow channels and in a gain of similar area in shallow groundwater adjacent to the losing reaches of the main channels. As described in Appendix P, observed water table slopes along these streams indicate that the potential riparian zone will typically be 100-300 feet wide. Application of the water table model suggests that the anticipated losses and gains will be nearly offsetting, with slight net gains probably occurring.

Lake-Fringing Wetlands

Long-Term Changes. Under this alternative, the area of vegetated wetland would increase by 2.2% and the area of low-value dry meadow would increase by 12% (Table 3C-16). Although habitat acreage would decline at some sites, it would increase at others because the lakebed between 6,381 and 6,390 feet at the eastern and southern Mono Shorelines and the Sierran Front would continue to be leached, thereby slowly increasing the area suitable for plant establishment. Lagoon area would remain unchanged while the area of alkali lakebed would decrease by up to 34%.

Drought Effects. Existing wetlands would largely desiccate and be replaced by narrow shoreline wetlands if the lake dropped below 6,368 feet (see the No-Restriction Alternative). The probability of the lake dropping below this level, however, is considerably less than 1% under this alternative.

Upper Owens River

Average monthly flows of 275-300 cfs would be sustained 2 months during normal years and 7 months during wet years (Table 3C-18). An average annual willow growth increment would be 2% more than the point of reference (Table 3C-19). Willow seedling establishment habitat would be absent from the river's edge, but the frequency of flows in excess of 275 cfs would occasionally cause overbank flooding, allowing seedling establishment in the floodplain. Irrigation demand would be fully met except during droughts (Table 3A-9). Average river stage would be noticeably higher than at the point of reference (Table 3C-19), inducing higher floodplain water tables and expanding the extent of meadows and marshes on adjacent terraces.

Long-Term Changes. The severity of channel instability is less than the point of reference and the No-Restriction Alternative because of the 300 cfs flow constraint. Because of the frequency of sustained high flows, however, channel stability under this alternative is considered moderately low. The similar frequency of high flows and 300 cfs cap render any benefit compared to the point of reference relatively minor.

No changes in the extent of meadow and marsh wetlands are expected. Channels abandoned by meander cutoffs would provide new habitat for meadows, marshes, and willow seedlings.

Drought Effects. During drought (i.e., the normal minimum with a 2-4% recurrence interval), irrigation demand could exceed available flow during July (Table 3A-9). Should diversions continue, instream flows could cease or radically decline, and wetlands adjacent to the channel could begin to drain.

Some diversion structures are physically incapable of diverting water under low flows (Rossi and Edmonson pers. comms.). Thus, reduced capacity to irrigate rangeland during drought years would temporarily reduce the amount and quality of livestock forage and begin converting wet meadows and marshes to drier habitat types. These effects would have a minor impact on floodplain habitats because of their infrequent occurrence and reversible nature.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,372-Ft Alternative)

Tributary Streams

- Creates moderate potential for stream incision.

  Mitigation Measures. See discussion under the No-Restriction Alternative.

- Results in a low frequency of potential riparian recruitment flows in all four streams.

  Mitigation Measures. None are available.

- Results in reduced frequency of erosive flows in Rush and Lee Vining Creeks.

- Increases the extent of woody riparian vegetation by 2-33% and meadow and wetland vegetation by 1-17%.

- Results in a shift of woody riparian vegetation from overflow channels to the banks of Parker and Walker Creeks.

Lake-Fringing Wetlands

- Causes minor increase in the area of vegetated wetland.
- Decreases area of alkali lakebed by as much as 34%.

Upper Owens River

- Moderately increases channel stability.

IMPACTS AND MITIGATION MEASURES FOR THE 6,377-FT ALTERNATIVE

Changes in Resource Condition

Tributary Streams

Under the 6,377-Ft Alternative, the range of flows would be substantially greater than under the 6,372-Ft Alternative for dry, normal, and wet years on all four creeks (Figure 2-2). Ecosystem maintenance flows would be required each June, if runoff is sufficient. No incidences of channel dewatering would be expected to occur (Table 3C-11), but flows capable of causing seedling recruitment in restored flood channels would be infrequent on Rush Creek (once every 11 years), normal on Lee Vining Creek (once every other year), and nearly every year on Parker and Walker Creeks (Table 3C-13).

Compared to the 6,372-Ft Alternative, Rush Creek flows in average runoff years would be 90-100 cfs higher in June. Lee Vining Creek flows in average runoff years would be 80-90 cfs higher in June. Parker and Walker Creek flows in average runoff years would be 7-11 cfs higher in June.

Erosive flows would occur rarely on Rush Creek, occasionally on Lee Vining Creek, and frequently on Parker and Walker Creeks unless releases were modified (Table 3C-12). Stream incision, however, would be unlikely.

Springs influenced by Parker and Walker Creek flows on the west side of Rush Creek might have slightly higher flows than under the 6,372-Ft Alternative as a result of ecosystem maintenance flows in Parker and Walker Creeks depending on use of overflow channels. Springs on the east side of Rush Creek would remain the same as at the point of reference. The lake could advance up to 900 feet upstream on Rush Creek and up to 500 feet upstream on Lee Vining Creek (Table 3C-14).

The acreage of riparian vegetation in the existing stream system would be slightly greater compared to the point-of-reference scenario because of higher water tables induced by higher streamflows (Figure 3C-11; Table 3C-14). However, lake level fluctuations would eliminate up to 7 acres of establishing willow scrub near the mouth of Rush Creek and up to 2 acres near the mouth of Lee Vining Creek. This loss would probably be offset by increased establishment and growth elsewhere on the streams; even the minimum estimate suggests a net expansion of riparian acreage.

Woody riparian vegetation, meadows, and wetlands in some locations relatively distant from the main and subsidiary channels may become slightly denser, taller, more vigorous, or more continuous than under the 6,372-Ft Alternative. The shift in woody riparian vegetation along the Parker and Walker Creek corridors described for the 6,372-Ft Alternative would occur under this alternative, with slightly larger increases along Parker Creek because of higher streamflow.

Lake-Fringing Wetlands

Long-Term Changes. Wetland area (excluding dry meadows) would decline by 184 acres, a 7% reduction from the point of reference (Table 3C-15). Dry meadow would increase 12%. Wetland losses are not significant because of the small area affected and large extent of similar habitats remaining intact.

No new lagoons would form. Alkali lakebed would decline by up to 75% because of inundation by higher lake levels, with notable reductions at the northern and eastern Mono Shorelands, and frequent total submergence at the south Mono Shorelands and Sierran Front. These changes would occur because of habitat inundation and springline desiccation.

Drought Effects. None.

Upper Owens River

Average monthly flows in the 275-300 cfs range would not occur during normal years but would occur for 6 months during wet years (Table 3C-18). Average annual willow growth increment would be 4% more than the point of reference (Table 3C-19). Willow seedling establishment habitat would be absent from the river's edge, but in wet years the frequency of flows over 275 cfs would cause occasional overbank flooding and seedling establishment. Irrigation demand could be fully met except during droughts. The average river stage would be slightly higher than at the point of reference (Table 3C-19), maintaining floodplain water tables underlying meadows and marshes on adjacent terraces at similar levels.

Long-Term Impacts. The effects of this alternative on river channel stability are nearly the same as for the 6,372-Ft Alternative, although conditions would be slightly improved.

No changes in the extent of meadow and marsh wetlands are expected. Channels abandoned by meander cutoffs would provide new habitat for meadows, marshes, and willow seedlings.

Drought Effects. Drought effects on irrigation withdrawals and streamflow would be similar as under the 6,372-Ft Alternative, but the duration of the effect is longer.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,377-Ft Alternative)

Tributary Streams

- Results in a lower frequency of riparian recruitment flows in Rush Creek but higher frequencies in the other creeks.

Mitigation Measures. Excessive flows in Parker and Walker Creeks could be used to increase flows in Rush Creek by transferring water through the Lee Vining conduit.

- Causes substantial erosion of Parker and Walker Creeks.

Mitigation Measures. See measure above.

- Results in reduced frequency of erosive flows in Rush and Lee Vining Creeks.
- Results in a 1-32% increase in woody riparian vegetation and a 10-17% increase in meadow and wetland vegetation; improves the condition of woody riparian and meadow and wetland vegetation.
- Results in a shift of woody riparian vegetation from overflow channels to the banks of Parker and Walker Creeks.

Lake-Fringing Wetlands

- Causes a minor decrease in the area of vegetated wetland.
- Decreases area of alkali lakebed by as much as 75%.
- Slightly increases willow productivity along the Upper Owens River.
- Moderately increases channel stability.

IMPACTS AND MITIGATION MEASURES FOR THE 6,383.5-FT ALTERNATIVE

Changes in Resource Condition

Tributary Streams

Under the 6,383.5-Ft Alternative, the range of flows in dry and normal years would be similar to those under the 6,377-Ft Alternative, but high flows in wet years would be substantially greater on Rush and Lee Vining Creeks (Figure 2-2). Ecosystem maintenance flows would be required each June, if runoff is sufficient. No incidences of channel dewatering would be expected to occur (Table 3C-11), and the frequency of flows capable of causing seedling recruitment in restored flood channels would be nearly normal on Rush Creek (once every 3 years), normal on Lee Vining Creek, and nearly every year on Parker and Walker Creeks (Table 3C-13).

Under this alternative, flows in Rush and Lee Vining Creeks in average runoff years would be the same as or slightly higher than under the 6,377-Ft Alternative. In wet years, May-July flows in Rush and Lee Vining Creeks would be 60-90 cfs higher. Flows in Parker and Walker Creeks during normal to wet runoff years would be the same as under the 6,377-Ft Alternative.

Erosive flows would occur rarely on Rush Creek, fairly frequently on Lee Vining Creek (once every 7 years), and frequently on Parker and Walker Creeks unless releases were modified (Table 3C-12). Stream incision, however, would be very unlikely (Table 3C-12).

Springs influenced by Parker and Walker Creek flows on the west side of Rush Creek would have the same flows as under the 6,377-Ft Alternative. Springs on the east side of Rush Creek would remain the same as at the point of reference. The lake could advance as far as 1,800 feet upstream on Rush Creek and as much as 850 feet upstream on Lee Vining Creek.

The extent of riparian vegetation in the existing stream system under the 6,383.5-Ft Alternative would be slightly greater than at the point of reference because of higher water tables induced by higher streamflows. However, the higher lake level would eliminate up to 15 acres of establishing willow scrub near the mouth of Rush Creek and up to 3.5 acres near the mouth of Lee Vining Creek. This slight net loss would be partly offset by increased extent and improved condition of willow scrub and cottonwood-willow forest elsewhere on the streams (Figure 3C-11; Table 3C-14).

Vegetation on Parker and Walker Creeks would change the same as under the 6,377-Ft Alternative because normal and wet-year flows would be the same.

Lake-Fringing Wetlands

Long-Term Changes. Wetland area (excluding dry meadows) would decline by 484 acres, a 17% reduction from the point of reference, which is considered significant (Table 3C-15). Dry meadow area would decline by 11%. Reductions are predicted because of inundation and springline desiccation. A slight increase in wet meadow is predicted because some deep-water artesian springs would reactivate.

Lagoon area would increase because bay mouth bars would form on the Rush Creek delta. Lagoon formation could take 100 or more years after dynamic equilibrium began because the deeply entrenched creek channel would first have to refill. Alkali lakebed area would decline by up to 91% because of inundation.

Upper Owens River

Average monthly flows in the 275-300 cfs range would not occur during normal years and would occur for 3 months during wet years. Average annual willow growth increments would be 5% more than the point of reference (Table 3C-19). Willow seedling establishment habitat would be absent from the river's edge, but in wet years the frequency of flows above 275 cfs would cause occasional overbank flooding and scour. Irrigation demand could be fully met except during droughts. The average river stage would be slightly lower than at the point of reference (Table 3C-19), slightly lowering floodplain water tables that sustain wetlands and meadows on terraces flanking the river.

Long-Term Impacts. Channel stability would increase compared to the point of reference because of lower magnitude and duration of peak flows but would still be lower than the no-diversion condition. The incidence of meander cutoffs and bank erosion would decrease compared to the point of reference.

Drought Effects. Drought effects would be similar to those of the 6,377-Ft Alternative.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,383.5-Ft Alternative)

Tributary Streams

- Results in nearer to normal frequency of riparian recruitment flows in Rush and Lee Vining Creeks and higher than normal frequencies in Parker and Walker Creeks.

- Eliminates potential for stream incision.

- Reduces the frequency of erosive flows in Rush Creek.

- Causes substantial erosion of Parker and Walker Creeks.

Mitigation Measures. The planned releases for these small streams could be reduced.

- Results in an estimated change in the extent of woody riparian vegetation of -1 to +30% (a loss of this magnitude is not significant); causes gain of 3-18% of meadow and wetland vegetation; and improves condition of woody riparian and meadow vegetation.

- Results in a shift of woody riparian vegetation from overflow channels to the banks of Parker and Walker Creeks.

Lake-Fringing Wetland

- Reduces extent of vegetated lake-fringing wetlands by 17%.

Mitigation Measures. See mitigation measures for the No-Restriction Alternative. Compensation planning should consider that in this instance terrestrial wetlands are being replaced with the productive aquatic habitats of Mono Lake.

- Decreases area of alkali lakebed by as much as 91%.
- Slightly increases lagoon area.

Upper Owens River

- Increases river channel stability of the Upper Owens River channel.
- Slightly increases willow productivity along the Upper Owens River.

IMPACTS AND MITIGATION MEASURES FOR THE 6,390-FT ALTERNATIVE

Changes in Resource Condition

Tributary Streams

Under the 6,390-Ft Alternative, the range of flows in dry and normal years would be similar to those under the 6,377-Ft and 6383.5-Ft Alternatives, but high flows in wet years would be slightly greater than under the 6,383.5-Ft Alternative on Rush and Lee Vining Creeks (Figure 2-2). Ecosystem maintenance flows would be required each June, if runoff is sufficient. No incidences of channel dewatering could occur (Table 3C-11), and the frequency of flows causing seedling recruitment along restored flood channels would be normal on Rush and Lee Vining Creeks and nearly normal on Parker and Walker Creeks (Table 3C-13).

Flows on Rush Creek would average 10-40 cfs higher than under the 6,383.5-Ft Alternative during May through August in average runoff years and up to 170 cfs higher during June and July of wet years. Flows on Lee Vining Creek would average 10-20 cfs higher than under the 6,383.5-Ft Alternative during May, July, and August of average runoff years and during June of wet years. Normal and wet-year flows on Parker and Walker Creeks would be the same as under the 6,377-Ft and 6,383.5-Ft Alternatives.

Springs influenced by Parker and Walker Creek flows on the west side of Rush Creek would have the same flows as under the 6,377-Ft and 6,383.5-Ft Alternatives. Springs on the east side of Rush Creek would have the same flows as at the point of reference. The lake could advance as far as 2,800 feet upstream on Rush Creek and as much as 1,100 feet upstream on Lee Vining Creek.

Erosive flows would occur infrequently on Rush Creek (once every 17 years), fairly frequently on Lee Vining Creek (once every 5 years), and nearly every year on Parker and Walker Creeks unless releases were modified. Stream incision would be impossible (Table 3C-12).

The extent of riparian vegetation in the existing stream system would be somewhat higher than under the point of reference because of higher water tables induced by higher streamflows. However, the higher lake levels would eliminate up to 21 acres of establishing willow scrub near the mouth of Rush Creek and up to 8 acres of establishing and mature willow scrub near the mouth of Lee Vining Creek. This slight net loss would probably be offset by increased extent and improved condition of willow scrub and cottonwood-willow forest elsewhere on the creeks (Figure 3C-11; Table 3C-14).

Vegetation on Parker and Walker Creeks would change the same as under the 6,377-Ft and 6,383.5-Ft Alternatives because normal and wet-year flows would be the same.

Lake-Fringing Wetland

Long-Term Changes. Wetland area (excluding dry meadows) would decline by 724 acres, a 26% reduction from the point of reference, which is considered significant (Table 3C-15). Dry meadows would decline in area by about 37%. Marked loss of marsh, wet meadow, alkali meadow, dry meadow, and wetland scrub are predicted because of inundation and springline desiccation.

Lagoon area would increase because bay mouth bars form on the Rush Creek delta. Lagoon formation could take 100 or more years after dynamic equilibrium began because the deeply entrenched creek channel would first have to refill. Alkali lakebed area would decline by up to 94% because of inundation.

Upper Owens River

Average monthly flows in the 275-300 cfs range would not occur during normal years and would occur 1 month in wet years (Table 3C-18). Average annual willow growth increment would be 6% more than the point of reference (Table 3C-19). Willow seedling establishment would be precluded infrequently along the river's edge. Irrigation demand could be fully met except during drought. The average river stage would be about 0.4 feet lower than at the point of reference (Table 3C-19), similarly lowering water tables that sustain wetlands on terraces flanking the river.

Long-Term Changes. Long-term changes of this alternative would be the same as for the 6,383.5-Ft Alternative, although channel stability and willow productivity would be slightly higher.

Drought Effects. Drought effects on irrigation withdrawals and streamflow would be similar as under the 6,372-Ft Alternative, but the duration would be considerably longer (May-July) thereby affecting vegetation during much of the growing season. The effect is still considered less than significant because of its infrequent occurrence and reversible nature.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,390-Ft Alternative)

Tributary Streams

- Results in normal or higher frequency of riparian recruitment flows in all creeks.
- Eliminates potential for stream incision.
- Causes substantial erosion of Parker and Walker Creeks.

Mitigation Measures. The planned releases for these small streams could be reduced.

- Results in an estimated change in the extent of woody riparian vegetation of -2 to +30% (the possible net reduction being less than significant); causes gain of 48% in meadow and wetland vegetation; improves condition of woody riparian and meadow vegetation.

- Results in a shift of woody riparian vegetation from overflow channels to the banks of Parker and Walker Creeks.

Lake-Fringing Wetland

- Reduces extent of vegetated lake-fringing wetlands by 26%.

Mitigation Measures. Refer to the 6,383.5-Ft Alternative.

- Decreases area of alkali lakebed by as much as 94%.
- Slightly increases lagoon area.

Upper Owens River

- Increases stability of the Upper Owens River channel.
- Slightly increases willow productivity along the Upper Owens River.

IMPACTS AND MITIGATION MEASURES FOR THE 6,410-FT ALTERNATIVE

Changes in Resource Condition

Tributary Streams

Under the 6,410-Ft Alternative, the range of flows in dry years would be similar to those under the 6,377-Ft through 6,390-Ft Alternatives, but high flows in both normal and wet years would be slightly greater than under the 6,390-Ft Alternative on Rush and Lee Vining Creeks (Figure 2-2). Ecosystem maintenance flows would be required each June, if runoff is sufficient. No incidences of stream dewatering would occur (Table 3C-1), and the frequency of flows supporting seedling recruitment on restored flood channels would be normal on Rush and Lee Vining Creeks and nearly annual on Parker and Walker Creeks (Table 3C-13).

Rush Creek flows would average 10-20 cfs higher than under the 6,390-Ft Alternative during May through July in average runoff years and 20-80 cfs higher during August through November. Lee Vining Creek flows would average 10-15 cfs higher than under the 6,390-Ft Alternative during May and June of normal runoff years, but 15-60 cfs higher during July and August and 10-30 cfs higher during September through November of normal runoff years. Normal and wet-year flows on Parker and Walker Creeks would be the same as under the 6,390-Ft Alternative.

Erosive flows would occur frequently on Rush Creek (once every 10 years), slightly less than at the point of reference. The frequency of erosive flows on Lee Vining Creek, however, would increase to about once every 3 years. Parker and Walker Creeks would experience erosive flows nearly annually unless releases were modified. Stream incision would be impossible (Table 3C-12).

Springs on the west side of Rush Creek would be affected as under the 6,377-Ft through 6,390-Ft Alternatives. Springs on the east side of Rush Creek would not change. The lake could advance substantially up the existing mouths of Rush Creek (up to 4,200 feet near-term and 5,100 feet long-term) and Lee Vining Creek (up to 1,600 feet near-term and 2,000 feet long-term).

The extent of riparian vegetation in the existing stream system would be significantly higher (10%) than under the point of reference because of higher water tables induced by higher streamflows. However, lake level fluctuations would eliminate up to 27 acres of establishing and mature willow scrub near the mouth of Rush Creek and up to 9 acres near the mouth of Lee Vining Creek. This loss (Table 3C-14) would probably be offset by the increased extent of willow scrub and cottonwood-willow forest elsewhere on the creeks (Figure 3C-11).

Meadow and wetland vegetation on Parker and Walker Creeks would change the same as under the 6,377-Ft through 6,390-Ft Alternatives because normal and wet-year flows would be the same.

Lake-Fringing Wetlands

Long-Term Changes. Wetland area (excluding dry meadows) would decline by 1,777 acres, a 74% reduction from the point of reference, considered to be significant (Tables 3C-15 and 3C-16). Dry meadow would decline by 74%. Marked loss of marsh, wet meadow, alkali meadow, dry meadow, and wetland scrub occur because of inundation and springline desiccation.

Lagoon area would increase substantially as these features would reform at the DeChambeau embayment, Dune Lagoons, Paoha Island, and Lee Vining and Rush Creek deltas. Lagoon formation on the Sierran deltas would require many years. Alkali lakebed area would decline by up to 97% because of inundation.

Upper Owens River

Average monthly flows would never exceed 200 cfs during normal or dry years (Table 3C-18). Average annual willow growth increment would be 9% more than the point of reference (Table 3C-19). Willow seedling establishment habitat would be uninhibited along much of the river's edge. Irrigation demand would be fully provided for except during drought. The average river stage would be 0.5 foot lower than at the point of reference (Table 3C-19), similarly lowering floodplain water tables underlying wetlands on terraces flanking the river.

Long-Term Changes. Long-term changes of this alternative would be the same as for the 6,490-Ft Alternative, although channel stability and willow productivity would be slightly higher.

Drought Effects. Drought effects on irrigation withdrawals and streamflows would be the same as described above for the 6,490-Ft Alternative.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,410-Ft Alternative)

Tributary Streams

- Results in normal or higher frequency of riparian recruitment flows in all creeks.
- Eliminates potential for stream incision.
- Increases annual probability of erosive flows in Lee Vining Creek to one in three.

Mitigation Measures. The frequency of erosive flows could be reduced by shunting water through the Lee Vining conduit and diverting through Mono Gate No. 1 up to 150 cfs in the A-Ditch declivity and A-Ditch for spreading in Pumice Valley.

- Causes substantial erosion of Parker and Walker Creeks.

Mitigation Measures. The planned releases to these small streams could be reduced.

- Results in an estimated change in extent of woody riparian vegetation of -3 to +30% (the possible net reduction being less than significant); causes gain of 6-21% in meadow and wetland vegetation; and improves condition of woody riparian and meadow vegetation.

- Results in a shift of woody riparian vegetation from overflow channels to the banks of Parker and Walker Creeks.

Lake-Fringing Wetland

- Reduces extent of vegetated lake-fringing wetlands by 73%.

  Mitigation Measures. Refer to the 6,383.5-Ft Alternative.

- Decreases area of alkali lakebed by as much as 97%.
- Reforms more than 200 acres of lagoons.

Upper Owens River

- Substantially increases stability of the Upper Owens River channel.
- Slightly increases willow productivity along the Upper Owens River.

IMPACTS AND MITIGATION MEASURES FOR THE NO-DIVERSION ALTERNATIVE

Changes in Resource Condition

Tributary Streams

Under the No-Diversion Alternative, minimum and maximum flows in dry, normal, and wet years on all creeks would generally be higher than under the 6,410-Ft Alternative (Figure 2-2), especially during summer and fall. Diversions from Parker and Walker Creeks that added to Rush Creek flows under the 6,410-Ft Alternative would not occur under the No-Diversion Alternative; therefore, Rush Creek flows would be 10-20 cfs less during summer months in average runoff years. No ecosystem maintenance or minimum monthly flows would be required, but the natural seasonal high-flow regime would be restored, providing flows capable of allowing seedling recruitment on restored flood channels of Rush and Lee Vining Creeks nearly every other year (Table 3C-13).

Flows on Parker Creek would be 0-14 cfs higher during May and June, 9-32 cfs higher in July, 5-18 cfs higher in August, and 1-7 cfs higher during September through November of average runoff years. Flows on Walker Creek would be 5-20 cfs higher during May through July and 1-5 cfs higher during September through November of average runoff years. June and July flows in maximum runoff years would be double those under the 6,410-Ft Alternative. The apparent higher than normal frequencies of seasonal overflows (Table 3C-13) would approach normal as overflow channels connected to the main channels.

Erosive flows would occur infrequently on Rush Creek (once every 17 years) and frequently on Lee Vining Creek (once every 3-4 years) (Table 3C-12). The latter frequency is undoubtedly higher than for the undisturbed condition, reflecting the sensitive nature of the eroded and partially restored channel condition. Parker and Walker Creeks would experience erosive flows nearly annually unless releases were modified. This contrast with the prehistorical condition underscores the importance of natural distributary channels, now blocked, in reducing erosive forces during normal high-flow periods.

Springs on the west side of Rush Creek could become wetter than under the 6377-Ft to 6410-Ft Alternatives, because of increased groundwater recharge with higher flows in Parker and Walker Creeks. Springs on the east side of Rush Creek would not change. The lake could advance substantially up the existing mouths of Rush Creek (up to 5,000 feet near-term and 7,200 feet long-term) and Lee Vining Creek (up to 2,000 feet near-term and 2,200 feet long-term).

The extent of riparian vegetation in the existing stream system would be significantly higher (11%) than under the point of reference because of higher water tables induced by higher streamflow. However, lake level fluctuations would eliminate up to 30 acres of establishing and mature willow scrub near the mouth of Rush Creek and up to 12 acres near the mouth of Lee Vining Creek. This loss (Table 3C-14) would probably be offset by increased extent of willow scrub and cottonwood forest elsewhere along the creeks (Figure 3C-11).

On Parker and Walker Creeks, woody plant establishment along the main channels could be about 10% greater than under the target lake level alternatives, because of the effects of increased stream stage during the growing season. Also, meadow vegetation on the west side of Rush Creek from The Narrows to Bohler Creek might increase in acreage and quality compared to all other alternatives, if higher flows in the main channels of Parker and Walker Creeks resulted in higher flows from springs.

Lake-Fringing Wetlands

Long-Term Changes. The area of vegetated wetland would decline by over 2,400 acres, or about 87% of the point-of-reference condition (Tables 3C-15 and 3C-16). This is considered significant. Nearly all dry meadows would be inundated. A marked loss of marsh, wet meadow, alkali meadow, dry meadow, and wetland scrub is predicted, based on habitat inundation and springline desiccation.

Predictions of the extent of vegetated wetlands for this alternative are based on the prediversion condition because lake level and slope and substrate properties would be nearly the same. Total vegetated wetland acreage would be slightly less than before diversions began because the rangeland irrigation upslope of the DeChambeau embayment, Sierran escarpment, and the Horse Creek embayment no longer occurs, and because water would not be diverted from Rush and Lee Vining Creeks to flood artificial ponds and meadowy flats.

Lagoon area would increase substantially because of their reformation at the DeChambeau embayment, Dune Lagoons, Paoha Island, and Lee Vining and Rush Creek deltas. Lagoon formation on the Sierran deltas would require many years. Alkali lakebed would essentially be eliminated because of inundation, although the zone within the range of fluctuation may be alkali lakebed during lake regressions.

Upper Owens River

Average monthly flows would never exceed 200 cfs during normal or dry years (Table 3C-18). Average annual willow growth increment would be 4% less than the point of reference (Table 3C-19). Willow seedling establishment habitat would occur along the river's edge and on river terraces from occasional flooding. Irrigation demand would be fully provided for except during drought. The average river stage would be 0.5 foot lower than at the point of reference (Table 3C-19), similarly lowering floodplain water tables underlying wetlands on terraces flanking the river.

Long-Term Changes. Reestablishment of natural flow regimes would return the system to natural rates of meander cutoffs and bank erosion, and sand bar and river bank habitat would again become exposed for willow seedling establishment. Whether these changes alone could reverse the adverse trends in willow scrub extent and sustainability is unclear because of the possible countervailing effects of livestock grazing. Willow productivity would decline slightly compared to the point of reference.

Livestock operators irrigating the floodplain during flow augmentation apparently sometimes divert more water than is available under unaugmented conditions (Rawson pers. comm.). This tendency, combined with the lower overall river stage associated with the lower discharge, might result in a net decline in wetland habitat under this alternative. Or, the extent of irrigated meadow might be reduced because of the unavailability of water and likely requirements by DFG to leave adequate water in the river for fishery habitat maintenance. This declines is considered potentially significant, but the magnitude of the effect cannot be estimated.

Drought Effects. Drought effects on irrigation withdrawals and streamflows would be the same as described for the 6,390-Ft Alternative.

Special-Status Plants

Long-term fluctuations of Mono Lake under the No-Diversion Alternative could result in partial or complete flooding of special-status plant populations that may occur in the 6410-6440-foot elevation range. Up to 5 reported populations of Mono buckwheat and up to 2 reported populations of Utah monkeyflower could be affected by these fluctuations.

This impact is considered less than significant because neither species is listed or proposed for listing as threatened or endangered under the state or federal Endangered Species Acts, both species could presumably colonize new sites in response to future lake level changes (as they have probably colonized sites below the historical high lake level of

6,428 feet), and these natural responses to changes in habitat conditions would probably offset most or all of the potential loss.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (No-Diversion Alternative)

Tributary Streams

- Results in normal frequency of riparian recruitment flows in all creeks.
- Eliminates potential for stream incision.
- Increases annual probability of erosive flows in Lee Vining Creek to one in three.

Mitigation Measures. See 6,410-Ft Alternative.

- Causes substantial erosion of Parker and Walker Creeks.

Mitigation Measures. Initiating the natural flow regime could be delayed until these creeks have been more fully restored through natural processes; overflow channels could be connected to the main channels.

- Results in an estimated change in extent of woody riparian vegetation of -3 to +30% (the possible net reduction being less than significant); causes gain of 4-8% in meadow and wetland vegetation; and improves condition of woody riparian and meadow vegetation.

- Results in renewal of Cain Ranch irrigation using riparian water rights (not included in alternative simulations) and continuance of point-of-reference vegetation along Parker and Walker Creeks.

Lake-Fringing Wetlands

- Reduces extent of vegetated lake-fringing wetlands by 87%.

Mitigation Measures. Refer to the 6,383.5-Ft Alternative.

- Eliminates nearly all alkali lakebed.
- Reforms more than 200 acres of lagoons.

Upper Owens River

- Substantially increases stability of the Upper Owens River channel.
- Slightly reduces willow productivity.
- Potentially results in reduced area of floodplain wetlands under irrigation practices.

Mitigation Measure. Irrigation diversions could be limited so that adequate instream flows are ensured.

CUMULATIVE IMPACTS OF THE ALTERNATIVES

Related Impacts of Earlier Stream Diversions by LADWP

Tributary Streams

Impacts of LADWP Diversions from 1940 to 1989. Changes in resource condition between 1940 and 1989 and the causes of these changes are described for each stream in the "Environmental Setting" section. Changes specifically attributable to diversion of tributary stream flows are summarized below.

A net loss of 156 acres of woody riparian vegetation occurred on the four streams diverted by LADWP (Table 3C-14). Another 61 acres of cottonwood-willow forest and willow scrub vegetation were converted to mixed riparian scrub. The most substantial component of this change was the loss or conversion of approximately 203 acres of mature cottonwood-willow forest to unvegetated ground, decadent vegetation, or mixed riparian vegetation. Most of these changes occurred on Rush Creek below The Narrows and on Lee Vining Creek below the town (Appendix P).

Much of the mature woody riparian vegetation remaining in 1989 (288 acres on all four creeks) had a less dense and shorter canopy, lower overall vigor, and less herbaceous groundcover than in 1940. Little or no establishment of new woody riparian plants occurred on the streams during the 1950s, 1960s, and 1970s.

With the resumption of continuous flows in Rush Creek (beginning in 1982) and Lee Vining Creek (beginning in 1986), vegetation closest to the channel margins improved in condition and new cottonwoods and willows began to establish from seed (Stromberg and Patten 1989b, 1989d). In 1989, at least 63 acres of mature woody riparian vegetation were benefitting from increased water availability (49 acres on Rush Creek and 14 acres on Lee Vining Creek below U.S. 395) (Appendix P). Also in 1989, approximately 43 acres of new woody riparian vegetation were establishing (33 acres on Rush Creek and 10 acres on Lee

Vining Creek) (Appendix P). The establishing vegetation does not compensate for previous losses of woody riparian acreage or ecological value, but it is the beginning of long-term ecological recovery of the riparian system.

Losses of over 100 acres of meadow and wetland acreage within the Rush and Lee Vining Creek riparian corridors resulted most directly from changes in streamflow and stream-fed groundwater (Table 3C-14). The greatest loss of meadow and wetland habitat (over 80 acres) occurred along Rush Creek between The Narrows and the County Road. Reduced flows from springs near The Narrows that were fed by Walker Creek and depressed water tables resulting from the dewatering and incision of Rush Creek were the primary causes of this decline. Continued sheep grazing during the years of dewatering probably exacerbated the decline of these meadows.

Irrigated pastures in Pumice Valley and wetlands on the east side of the Rush Creek Bottomlands declined when irrigation via the A- and B-Ditches diminished and eventually ceased.

Impacts of LADWP Facilities Construction around 1940. Diversion facility construction in about 1940 caused losses of riparian and meadow vegetation on all four diverted streams. The largest losses occurred on Rush Creek, where approximately 1.5 miles of the creek were inundated by the enlarged Grant Lake. Approximately 50 acres of aspen forest (interspersed with patches of conifer-broadleaf forest) and approximately 40 acres of undifferentiated wet meadow and cottonwood-willow forest were eliminated on Rush Creek upstream of the dam. These areas were logged and burned in summer and fall 1940, before Grant Lake expanded (Stine 1991). Approximately 4.5 acres of dense willow scrub and scattered aspen forest were eliminated along Rush Creek and the C-Ditch at the new dam site (Stine 1991).

Pond excavation and spoils dumping removed smaller amounts of woody riparian vegetation at the diversion sites on the other three creeks (an estimated 0.5 acre on Parker Creek, 0.5 acre on Walker Creek, and 1 acre on Lee Vining Creek). An estimated 1, 1.5, and 1 acres of meadow were also eliminated by diversion facilities constriction on Parker, Walker, and Lee Vining Creeks, respectively.

Indirect Impacts on Other Tributaries. Mill Creek experienced incision similar to that on Rush Creek as a result of Lake level declines during the 1940s-1980s and uncontrolled spilling flows in 1967, 1969, and the early 1980s. Approximately 11,000 feet of the stream were incised, from the 1989 lakeshore to about 5,000 feet below U.S. 395. The severity of the incision is partly attributable to reductions in riparian vegetation acreage and vigor caused by water diversions by SCE and ranchers; however, the incision and consequent further losses of riparian habitat on lower Mill Creek would not have occurred if the lake level had not been lowered artificially by LADWP's diversions on Rush, Parker, Walker, and Lee Vining Creeks. An estimated 40 acres (±10-15%) of the riparian vegetation on lower Mill Creek was eliminated between 1940 and 1989 by the combined effects of dewatering and channel incision.

Lake-Fringing Wetlands

Mono Basin water exports and the resulting lake regression had a net beneficial effect on wetlands in the form of substantial increases in extent. The area of vegetated wetlands, excluding dry meadows, increased from about 360 to 2,800 acres, a nearly seven-fold increase over prediversion conditions and a major increase in total wetland area in Mono Basin. Lake regression did, however, nearly eliminate all lagoons, and extensive vegetated wetlands on the Lee Vining, Mill, Wilson, and Rush Creek deltas were desiccated.

Numerous large lagoons along the North Shoreline and at DeChambeau embayment disappeared after the lake dropped below 6400 feet. Other smaller lagoons on Paoha Island, at the mouths of Lee Vining and Rush Creek and at Simon Spring also disappeared.

After the lake dropped below 6,400 feet, the channels of Lee Vining and Rush Creeks began to incise. After the lake fell below the delta plain, the surface of groundwater moving lakeward deepened within the delta, eliminating the surface saturation required by vegetated wetlands. Springlines at the mouths of Mill and Wilson Creek shifted lakeward. The Rush and Lee Vining Creek channels are so deeply incised today that restoration of a higher lake level could inundate a significant acreage of newly establishing willow habitat.

Upper Owens River

Earlier stream diversions resulted in augmented flows for the Upper Owens River below the East Portal. Flow augmentation apparently caused decreased channel stability and subsequent loss of river bank and aquatic habitat through erosion, reduced extent and sustainability of willow scrub, and increased willow productivity. These changes, summarized below, are described in detail in the "Environmental Setting" section.

Channel Stability. Augmented flows correlate with a period of decreased channel stability as evidenced by the number of meander cutoffs: 54 occurred along the augmented reach compared to none along the control reach above the East Portal. Meander cutoffs and bank erosion eliminated river bank wetlands, but this loss may have been compensated by an increase in the availability of wetland habitat along the abandoned river channels. Bank erosion also eliminated overhanging river bank habitat of importance to the fishery.

Meadow and Marsh Extent. The overall extent of meadow and marsh wetlands on the floodplain of the Upper Owens River did not appear to change markedly as a result of flow augmentation. The proportion of wet meadows and marshes probably increased relative to drier meadows because of higher river stage and increased availability of water for irrigation.

Willow Scrub Extent and Sustainability. During the period of past flow augmentation the extent of willow scrub declined from 16 to 4 acres, a 75% reduction. The recruitment of new individuals into the willow stands did not kept pace with the loss of plants. The extent of habitat suitable for willow seedling establishment, and the number of established willow seedlings, differs significantly above and below the East Portal. Although livestock grazing undoubtedly influences the extent and sustainability of willow scrub, the data indicate that flow augmentation also has played a role in limiting the extent and reproduction of willows below the East Portal.

Without willow reproduction the long-term sustainability of this habitat is questionable. This impact is significant because of the local scarcity of this habitat, which represents a retreat of woody riparian habitat along the Owens River from the Long Valley meadowlands.

Willow Productivity. Willow productivity increased about 2% during the diversion period, according to application of the measured correlation in annual streamflow and growth (Stromberg and Patten 1991b). This increase is statistically significant.

Special-Status Plants

The number and condition of special-status plant populations in the Mono Basin and upper Long Valley are not believed to have changed substantially between 1940 and 1989.

Related Impacts of Other Past, Present, or Anticipated Projects or Events

Tributary Streams

Past Changes in Irrigation. Changes in irrigation along Lee Vining and Rush Creeks coincided with changes in water availability that resulted from LADWP's diversions. Pasture irrigation along Lee Vining Creek above and below the County Road ceased when streamflows declined in the early or mid-1940s. Irrigation in the Rush Creek bottomlands via Indian Ditch and diversions for artificial ponds near the mouth of Rush Creek also ended about this time. Most of the meadows and wetlands maintained by this irrigation disappeared during the 1950s and 1960s. About half of the "lower meadows" (farthest from The Narrows) in the Rush Creek bottomlands have continued to be sustained by groundwater until the present.

Changes in pasture irrigation in Pumice Valley also coincided with changes in water availability resulting from LADWP's diversions. A-Ditch flows declined by about 80% and B-Ditch flows by about 70% after 1947. The B-Ditch ceased operating entirely when floods destroyed the intake and the first 400-500 feet of the ditch in 1967. The A-Ditch continued operating until 1970 (Stine 1991). When irrigation in Pumice valley declined, flows from springs on the east side of the Rush Creek bottomlands also declined. This was the primary cause of declines in the condition of meadows, wetlands, and willow scrub thickets at the springs on the east side of the bottomlands.

Irrigation of pastures at Cain Ranch continued throughout the period of diversions. Groundwater recharge from irrigation and streamflow in the Cain Ranch area supports springs on lower Parker and Walker Creeks and at the "upper meadows" (closest to The Narrows) on the west side of the Rush Creek bottomlands. Spring flows and the condition of meadows and willow scrub declined during the diversion period; however, these changes were probably associated more with the dewatering of Parker and Walker Creeks than with any changes in irrigation at Cain Ranch.

Past Grazing Practices. Sheep began grazing in the riparian corridors and surrounding uplands of Rush, Parker, Walker, and Lee Vining Creeks as early as the 1860s (Fletcher 1982; see also Chapter 3G, "Land Use"). Sheep continued to graze in the riparian corridors throughout the years of dewatering. The effects of this grazing cannot be quantitatively separated from the effects of water diversions. The livestock exacerbated the decline in habitat quality, accelerated the loss of meadow and woody riparian acreage, and retarded the recovery of vegetation after rewatering; however, these effects probably did not substantially add to the acres of habitat lost as a result of dewatering.

LADWP implemented a grazing moratorium in the riparian zones of Rush, Parker, Walker, and Lee Vining Creeks in 1991. The result of the moratorium has been a substantial increase in the cover and diversity of herbaceous and woody riparian vegetation where the vegetation was previously suppressed by sheep and where soil moisture is available from the streams or springs.

Past Gravel Extraction. Gravel has been quarried on Rush Creek near the mouth of Parker Creek since the 1950s. By 1967, the quarries and gravel stockpiles had eliminated 3-5 acres of woody riparian vegetation. The severe flood of 1967, in which flood waters from Lee Vining, Walker, and Parker Creeks were added to the overflow from Grant Lake, moved large quantities of gravel downstream from the quarries, burying up to 1,400 feet of Rush Creek's channel and floodplain above The Narrows and 1,100 feet of channel and floodplain below The Narrows (Stine pers. comm.). Later floods in 1969 and the early 1980s may have moved more gravel downstream from the quarries.

In the early or mid-1960s, quarry gravels were pushed into about 500 linear feet of the dry Parker Creek channel starting approximately 2,200 feet below U.S. 395. Most or all of the riparian vegetation in this reach had been eliminated already by dewatering. Most of the "Parker plug" was removed and the channel was reconstructed in summer 1991.

Past Highway Construction. Construction of the current U.S. 395 during the 1930s removed an estimated 0.5 acre of woody riparian vegetation on Rush Creek, 0.2 acre on Parker Creek, 0.1 acre on Walker Creek, and 0.1 acre on Horse Creek. Construction of existing Highway 120 removed an estimated 0.2 acre of woody riparian vegetation on Lee Vining Creek and prevented water from entering an overflow channel on the east side of the creek. Approximately 2 acres of conifer-broadleaf forest that existed along the overflow channel in 1940 was no longer present 1989.

Past Construction on Lee Vining Creek by SCE. When SCE constructed a small diversion dam and powerhouse on Lee Vining Creek, an estimated 1.5-2.5 acres of woody riparian vegetation were removed from the diversion site and an estimated 2-3 acres were removed from the powerhouse site. About 1 acre of riparian and meadow vegetation has become reestablished at the diversion site since its use as a forebay ceased.

Present Interim Streamflows. Minimum flows are currently maintained in all four tributary streams pursuant to an order by the El Dorado County Superior Court (Chapter 1). Flows in Rush and Lee Vining Creeks were generally higher during 1990-1992 than point-of-reference (1989) flows. Flows were returned to the dry channels of Parker and Walker Creeks in October 1991. Interim flows will continue to be governed by the court order until SWRCB makes a final decision based in part on this EIR.

The effects of interim flows on riparian vegetation have been to:

- promote natural establishment of willows, cottonwoods, and herbaceous plants along the banks of Rush and Lee Vining Creeks,
- improve the vigor of mature woody and herbaceous plants within reach of groundwater fed by the creek,
- apparently increase flows at springs in the "upper meadows" of the Rush Creek bottomlands, just below The Narrows (Stine pers. comm.), and
- partially rewater two subsidiary channels of Lee Vining Creek.

Present Interim Stream Restoration. LADWP has implemented interim measures to restore habitat conditions that benefitted the fisheries in 1940 on Rush, Parker, Walker, and Lee Vining Creeks. These measures have been developed and implemented in response to an order from the El Dorado County Superior Court and under the direction of a Restoration Technical Committee, pending SWRCB's final decision.

One objective of the interim restoration program is to accelerate the natural recovery of riparian vegetation that benefits fish by increasing shade, nutrient input, refuge sites, bank stability, and pool formation. As of December 1992, treatments to accelerate woody riparian growth have included:

- rewatering historic main and subsidiary channel segments in reaches 3A and 3B (see Appendix P) of Lee Vining Creek in 1992,
- planting several revegetation test plots on Lee Vining Creek in April 1992,
- planting several willows salvaged during pool construction at the top of reach 2 (see Appendix P) on Rush Creek in 1991,

- constructing backwaters and gravel bars at several locations on Rush and Lee Vining Creeks in 1991 and 1992, and

- removing the old SCE dam on Lee Vining Creek above Highway 120.

Additional planting to accelerate woody vegetation recovery along watered channels may be implemented before the EIR process is concluded. Detailed baseline monitoring of riparian vegetation was conducted on Rush and Lee Vining Creeks in summer 1992.

Anticipated U.S. 395 Widening. Caltrans will widen U.S. 395 to four lanes with a median strip, from Lee Vining to the south junction of the June Lake Loop. The highway will be widened approximately 140 feet at Rush, Parker, and Walker Creeks and approximately 46 feet at Lee Vining Creek. Rush Creek will be crossed by bridges and the other creeks will have enlarged culverts. Construction at Lee Vining Creek will mainly affect woody riparian vegetation and construction at the other three creeks will mainly affect meadow vegetation. Mitigation measures have been developed through consultation with DFG and other agencies (Dayak pers. comm.).

Lake-Fringing Wetlands

Increases or decreases in wetland area in Mono Basin resulting from other past, present, or anticipated projects would be minor relative to the increases resulting from lake level decline. Minor wetland losses probably occurred in the past and may occur in the future because of highway and road construction and residential and commercial development. Future losses would generally be avoided or minimized because of increased regulatory control over projects affecting wetlands. Unavoidable future losses will likely be compensated if the project is under state or federal jurisdiction.

Upper Owens River

Livestock grazing has been partially responsible for past declines and will likely contribute to future declines in extent and sustainability of willow scrub. Livestock may also destabilize river banks and thus could have been partially responsible for the collapse of overhanging river banks. Continued livestock grazing along the Upper Owens River could cause this impact to continue into the future.

Road building, timber harvest, and other land-disturbing activities in the Upper Owens River watershed could have contributed to the decreased channel stability of the past and could reduce channel stability in the future.

Special-Status Plants

Past changes in the number and condition of special-status plant populations probably resulted from changes in grazing practices in unirrigated habitats, rather than from changes in streamflows or irrigation. No future impacts on special-status plants are anticipated from other foreseeable projects in western Mono Basin.

Significant Cumulative Adverse Impacts

No-Restriction Alternative

Tributary Streams

- Causes a cumulative loss of 67% of prediversion woody riparian vegetation and 77% of prediversion meadow and wetland vegetation.

Lake-Fringing Wetlands

- Results in 10% loss of prediversion wetland acreage, principally vegetated wetlands on Lee Vining and Rush Creeks.

- Results in complete elimination of lagoons.

- Creates 9,500 acres of alkali lakebed in place of littoral habitat.

Upper Owens River

- Results in substantial loss of river channel stability.
- Results in elimination of most willow scrub habitat.

6,372-Ft Alternative

Tributary Streams

- Results in a net loss of 7-30% of prediversion woody riparian vegetation and 52-58% of prediversion meadow and wetland vegetation.

- Allows permanent loss of vegetated wetlands on Lee Vining and Rush Creeks.

- Creates nearly 3,900 acres of alkali lakebed in place of littoral habitats.

- Results in nearly complete elimination of lagoons.

Upper Owens River

- Results in moderate loss of river channel stability.

- Results in elimination of most willow scrub habitat.

6,377-Ft Alternative

Tributary Streams

- Results in a net loss of 8-32% of prediversion woody riparian vegetation and 52-58% of prediversion meadow and wetland vegetation.

Lake-Fringing Wetlands

- Allows permanent loss of vegetated wetlands on Lee Vining and Rush Creeks.
- Creates 1,500 acres of alkali lakebed in place of littoral habitats.
- Results in nearly complete elimination of lagoons.

Upper Owens River

- Results in moderate loss of river channel stability.
- Results in elimination of most willow scrub habitat.

6,383.5-Ft Alternative

Tributary Streams

- Results in a net loss of 9-33% of prediversion woody riparian vegetation and 51-58% of prediversion meadow and wetland vegetation.

Lake-Fringing Wetlands

- Allows permanent loss of vegetated wetlands on Lee Vining and Rush Creeks.
- Creates more than 500 acres of alkali lakebed in place of littoral habitats.
- Results in nearly complete elimination of lagoons.

Upper Owens River

- Results in moderately small loss of river channel stability.
- Results in elimination of most willow scrub habitat.

6,390-Ft Alternative

Tributary Streams

- Results in a net loss of 10-34% of prediversion woody riparian vegetation and 51-57% of prediversion meadow and wetland vegetation.

Lake-Fringing Wetlands

- Allows permanent loss of most vegetated wetlands on Lee Vining and Rush Creeks.

- Creates about 375 acres of alkali lakebed in place of littoral habitats.

- Results in elimination of most lagoons.

Upper Owens River

- Results in moderately small loss of river channel stability.
- Results in elimination of most willow scrub habitat.

6,410-Ft Alternative

Tributary Streams

- Results in a net loss of 10-35% of prediversion woody riparian vegetation and 50-57% of prediversion meadow and wetland vegetation.

Lake-Fringing Wetlands. No significant cumulative adverse impacts.

Upper Owens River. No significant cumulative adverse impacts.

No-Diversion Alternative

Tributary Streams

- Results in a net loss of 10-35% of prediversion woody riparian vegetation and 50-57% of prediversion meadow and wetland vegetation.

Lake-Fringing Wetlands. No significant cumulative adverse impacts.

Upper Owens River

- Reverses past destabilization of the river channel and reductions in the extent and sustainability of willow scrub by the return to a natural flow regime and eventual reestablishment of a natural river channel morphology and flooding regime; may not reverse past reductions in willow scrub if livestock grazing continues.

Mitigation Measures for Significant Cumulative Impacts

Introduction

Cumulative losses of wetland and riparian vegetation could be mitigated through a variety of actions directed at restoring prediversion habitat types in-kind on an acreage basis. Prediversion and 1989 acreages for each vegetation type by stream and stream reach were presented previously in this chapter.

Full mitigation of cumulative losses would probably require both:

- onsite rectification and
- offsite compensation.

Near-term efforts should be directed at restoring as much of the lost riparian vegetation onsite as possible through watering of overflow channels, plantings, and construction of a combination of aquatic and riparian habitats, as described below. As described in the "Impact Assessment Methodology" section, riparian losses occurred because of stream dewatering and because of channel incision accompanied by permanent loss of shallow groundwater. Losses due solely to dewatering could in principal be rectified onsite, but additional exploration of water table depth would be needed to identify areas of lost riparian vegetation that have relatively shallow groundwater as a result of stream rewatering.

Losses due to stream incision are virtually irreversible and may be rectified only onsite through habitat construction involving grading and water delivery. These permanent losses, once they are accurately estimated, may exceed the capacity of onsite construction to compensate them. In this case, they could be mitigated only through offsite actions, including habitat construction or enhancement. Offsite mitigation should occur within Mono Basin.

Mitigation Process

A two-phase performance-based process could be used for mitigation. During the first period, 10 years for example, efforts could be directed solely at onsite mitigation. At the close of this period, total acreages of riparian vegetation would be inventoried and compared to the prediversion acreages, and net deficits would be determined. Efforts during the second phase, perhaps shorter than the first, would be directed at offsite mitigation.

During both periods, the last 3 years would be reserved for monitoring unassisted growth. Thus, where temporary watering systems were used for plant establishment in lieu of natural recruitment, scheduling should allow the withdrawal of watering at least 3 years before the close of the designated performance periods. Because temporary watering is frequently used for a 2- to 3-year establishment period, the last plantings would have to occur 5-6 years before the close of each performance period.

Clearly, monitoring of plant performance is essential to the performance approach. Monitoring parameters and intensities should be designed to identify when or if each restoration area reaches adequate sustainable cover to be considered restored. A monitoring plan is not provided in this document, but it must by law accompany the relicensing action if implementation of the selected alternative would have significant adverse impacts. The SWRCB should adopt or amend vegetation monitoring specifications adopted by the RTC, if staff review indicates that the purposes described here will be adequately served.

Special Provisions

A detailed mitigation implementation and monitoring plan should be prepared in consultation with the entities that are now parties to the RTC and with the USFS and California Department of Parks and Recreation if lands they manage are involved. The plan should be approved by the SWRCB.

Lower reaches of the tributary streams and the entire lakeshore are within the Mono Basin National Forest Scenic Area. Any mitigation activities in the Scenic Area should be compatible with the Inyo National Forest's management plan for these areas and be subject to that agency's approval.

Restoration activities should be accompanied by control of vehicle access. Plantings and habitat construction should be protected by barriers to vehicles and signing to discourage motorbike use that may impede restoration. Access by livestock should also be prevented.

All restoration activities should be preceded by cultural resource survey in restoration sites, access routes, staging areas, and materials acquisition and stockpiling areas. Discovered resources should be avoided or resource importance determined. Important resources should be excavated, based on an excavation plan approved by the SWRCB. (See Chapter 3K, "Cultural Resources".)

Measures for Tributary Streams

Rewater Overflow Channels. Seasonal flows during snowmelt could be restored to existing potential overflow channels of all four diverted tributary streams, as identified in Figures 3C-5, 3C-7, and 3C-9. These channels, identified during a ground survey in 1991, represent former overflow channels (including distributary channels of Parker and Walker Creek fans and floodplain channels of Rush and Lee Vining Creeks), abandoned primary channels, drainage swales, and perhaps former irrigation conveyances; they have the common trait of being physically capable of being charged by normal high seasonal flows in the main channels after minor earthwork.

Those channels shown in the figures have been selected from a larger set of potential overflow channels; selection was based on the relative elevation of each channel inlet and the main channel water surface measured in the field during the spring snowmelt period and during lower flows (the detailed topographic maps prepared for this EIR are not sufficiently precise for this purpose). Use of the selected channels would require removal of plug fills from their inlets (usually 25-50 feet long), construction of shallow ditches as long as about 100 feet, or both (Table 3C-6).

Other potential channels requiring significantly longer ditches, usually of considerably greater (and often impractical) depth, were eliminated because of the excessive earthwork required to connect them. The rejected candidates are in reaches where stream incision has lowered the present channels too far below the overflow channels for reconnection and gravity inflow to be feasible, such as along Rush Creek immediately below The Narrows and from just above the ford downstream.

Connection of the potential overflow channels to the main channels should include construction of diversion structures to regulate inflow and prevent the main streamflows from shifting into the overflow channels. Irrigation diversion box structures or gated culverts could be used for this purpose, as long as they are annually cleaned of debris during the first few days of the recharge period and repaired as needed after major runoff events. These diversion structures should allow only small soaking flows in the channels (a few cfs) and should be screened to prevent fish entry, unless the overflow channels were intended to be used for fish refuge during high flow periods.

Because of the generally high permeability of alluvial materials in these riparian environments as revealed by the piezometer data (see "Water Table Depth Model" in Appendix P), introduction of early summer flows into these channels would not sustain induced high water tables once the inflows ceased. Instead, these channels would provide opportunities for recruitment of riparian seedlings in areas now supporting xeric plant communities, where relatively shallow water tables are sustained by flows in the main channels. Studies conducted for the water table depth model suggest the presence of large areas that have water tables sufficiently shallow to support riparian communities once they have become established. Flows released into one of these channels in June 1991 (channel R4) had this effect, allowing establishment of a considerable number of new seedlings, promoting strong response in decadent surviving riparian vegetation, and causing elimination of sagebrush scrub species. Additional test pit observations of water table depths should be made at prospective sites before final selection of rewatering priorities.

Manage Streamflows to Optimize Conditions for Natural Vegetation Recovery. Flows under the selected alternative should be managed to resemble unregulated flow patterns as closely as feasibly possible. However, releases should be managed to minimize the risk of floodflows high enough to cause channel erosion, until riparian vegetation is sufficiently developed to protect the channels during floods. (In the next several years, flows should not exceed 350 cfs on Rush Creek, 250 cfs on Parker Creek, 23 cfs on Walker Creek, and 15 cfs on Lee Vining Creek).

Flow management would increase natural vegetation establishment on banks and bars wetted during high flows and would protect channels from flood damage until they are better protected by riparian vegetation. High seasonal flows capable of recharging overflow channels at least biannually would provide significant benefit by recruiting riparian vegetation to areas capable of supporting it. The channels may require only 2-3 cfs each to provide substantial riparian seeding and wetland habitat. A precise study will be needed to determine how to best allocate flows among the streams and how to monitor and respond to the potential for damaging floods once a particular streamflow alternative is selected.

Renovate the A-Ditch for Floodflow Spreading. The A-Ditch, damaged by the 1967 flood, could be renovated to discharge excessive floodlows to Pumice Valley. Only if used additionally for irrigation, however, would this use permanently increase flows at springs in the Rush Creek bottomlands and improve the condition of willow scrub, meadow, and wetland vegetation along the east edge; opening of an overflow channel system in the bottomlands would have similar effects.

Reduce or Eliminate Livestock Grazing in Riparian Corridors. The current grazing moratorium could be extended for the wooded riparian zones on all four diverted streams. Additional fences and gates should be constructed as needed to ensure that sheep, but not deer or small wildlife, are excluded from most of the riparian corridors. Some livestock access to streamflows can be provided. Eliminating grazing will allow an increase in the establishment and growth of woody and herbaceous riparian plants, accelerating and expanding long-term natural vegetation recovery.

Plant Woody Riparian Vegetation Onsite. Locally native cottonwoods, willows, pines, and other riparian vegetation could be planted in sites that have groundwater shallow enough to support woody riparian vegetation but lack natural establishment because of the lack of overflow conditions promoting seed germination and establishment. Some such plantings have already been conducted on Lee Vining Creek. Additional plantings would be effective on Rush Creek (primarily in the reach above U.S. 395 and in the bottomlands above the major incision), Lee Vining Creek (primarily below U.S. 395), and Parker and Walker Creeks (in meadow areas lacking willows). Plantings should be located in areas having relatively shallow water tables and fine sediment revealed by test pit or piezometer observations; the water table depth model (Appendix P) can be used as an initial guide.

Such plantings would help to accelerate naturally occurring vegetation recovery, promote revegetation where conditions do not favor natural establishment, increase species diversity and structural diversity, and mitigate impacts on wildlife, fisheries, and recreation. Additional observations are needed to determine specific planting sites that would best complement natural vegetation recovery. Provisions for watering during the seedling establishment period (2-3 years) may be required.

Plant Woody Riparian Vegetation Offsite. Riparian vegetation as described for onsite mitigation could be planted at additional sites in Mono Basin. Suitable sites may include DeChambeau Ranch, Wilson Creek, or Conway Ranch. Such plantings would help to compensate for the loss of riparian vegetation in sites that can no longer support riparian vegetation on Rush and Lee Vining Creeks because of main channel incision or floodplain burial under quarry gravels. Groundwater and soil study would be needed to determine which sites are most conducive to long-term maintenance of such vegetation without ongoing management.

Construct Freshwater Ponds at Cain Ranch. Shallow freshwater ponds could be constructed in meadows near Parker and Walker Creeks west of U.S. 395. The ponds would be supplied with water diverted from Parker and Walker Creeks and flowing through them and returning to the creeks. Willows and marsh plants would be planted in and around the ponds.

These ponds would help compensate for the loss of natural wetlands on Rush Creek from The Narrows to County Road and the loss of artificial wetlands below the road. They would also increase groundwater infiltration that may increase flows at springs on the west side of Rush Creek above and below The Narrows. An evaluation would be needed to identify suitable sites, construction designs, and water management compatible with the needs of the fishery.

Construct Freshwater Ponds on Lower Rush Creek. Shallow freshwater ponds could be excavated on the new, lower floodplain of Rush Creek below County Road where groundwater is shallow. Willow scrub would be allowed to develop around the ponds and emergent freshwater marsh would be allowed to develop within them.

These ponds would help compensate for the loss of natural wetlands on Rush Creek from The Narrows to County Road and the loss of artificial wetlands on Rush Creek below the road. Long-term lake level fluctuations would prevent this measure from being feasible for alternatives with lake levels higher than the 6,383.5-Ft Alternative. A precise siting and design study would be needed.

Measures for Lake-Fringing Wetlands

The creation of alkali lakebed at the expense of littoral habitats cannot be mitigated.

Enhance and Create Wetlands. See mitigation measure for the No-Restriction Alternative; this impact applies only to that alternative.

Create Lagoons and Ponds. In addition to the Cain Ranch and Lower Rush Creek ponds identified above, ponds could be created at DeChambeau Ranch. Other opportunities may exist where surface water or pumped groundwater is available; windmills could be employed to lift groundwater in areas without access to electricity.

One important goal of creating ponds near the lakeshore would be to restore habitat for migratory ducks and other water birds that were abundant at Mono Lake in the prediversion period (Chapter 3F, "Wildlife"). The size and configuration of the created ponds should depend on site configuration, soil permeability, and water availability. They should be designed to include substantial areas (i.e., at least 5 acres) of fresh or brackish water free of emergent vegetation, a margin of emergent vegetation for escape cover, and nesting islands surrounded by deep water (i.e., greater than 3 feet deep). In areas where brackish conditions would prevail, the discharge point of fresh water inflows could be made accessible to the birds
for bathing.

Upper Owens River

Stabilize the River Channel. Impacts of export rate changes could be fully mitigated by adopting a ramping schedule that mimics natural rates of flow decline. DFG recently negotiated a temporary ramping schedule with LADWP to use during IFIM studies. The schedule calls for a maximum flow reduction of 25% in an 8-hour period. However, DFG believes a 10-15% increment would more closely mimic natural conditions (Smith pers. comm.), and a ramping increment of 10% was also recommended by Hill et al. (1991). A site-specific study of rates of bank drainage might help establish the most appropriate increment.

Restore Willow Scrub Habitat. A restoration program could be undertaken to enhance willow scrub habitat by controlling livestock access and planting willows.

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Table 3C-1. Summary of Results of Synoptic Flow Studies

Stream	Estimated Channel Losses (cfs)
Rush Creek	11.3-13.3 cfs diversion to County Road[a] 12.4-14.5 cfs extrapolated for entire diverted reach
Parker Creek	0.9 cfs diversion to Rush Creek[b]
Walker Creek	0.7 cfs diversion to Rush Creek[b]
Lee Vining Creek	4 cfs for flows 13-23 cfs[c] 7 cfs for flows 30-50 cfs[c]

[a] Actual reach measured; losses reported are for flows of 19-100 cfs in summer periods (Source: Beak Consultants 1991).

[b] Over entire range of flows measured (Source: EBASCO Environmental and Water Engineering and Technology 1991b, 1991c).

[c] Net loss diversion to lake, including gaining reach below diversion (Source: Aquatic Systems Research 1992).

Table 3C-2. Comparison of Point of Reference and Prediversion Riparian Vegetation Acreages on the Tributary Streams (In Acres)

	Mature Woody Riparian Vegetation		Establishing Riparian Vegetation		Meadow and Wetland Vegetation	
	Point of Reference	Prediversion	Point of Reference	Prediversion	Point of Reference	Prediversion
Rush Creek	135.4	271.3	33.4	NM[a]	39.8	131.2
Parker Creek	49.2	58.4	0.0	NM	NI[b]	NI
Walker Creek	42.9	49.8	0.0	NM	NI	NI
Lee Vining Creek	60.2	112.6	10.2	NM	32.3	43.5
Total	287.7	492.1	43.6	NM	72.1	174.7

[a] NM = None measurable from historical aerial photographs.

[b] NI = Not included because meadows supported by the stream are not readily distinguishable from meadows supported by irrigation.

Table 3C-3. Lake-Fringing Wetland Types

Wetland Georegion	Wetland Site (Analysis Units)	Water Source Pathways	Geomorphology	Sediment	Supplemental Water
North Mono shorelands	Black Point, DeChambeau embayment, Bridgeport Beach, North Beach	Basin-sediment gravity seeps and springs, deep fracture artesian, intruding lake water, seeping relict lake water	Littoral berms, littoral springlines, faults, lakebed	Fine-grained lake sediment below 6,400 feet, coarse Black Point sand above 6,400 feet interbedded with lacustrine clay, well-leached to highly saline-alkali	No
North Mono lagoons	Dune lagoons, DeChambeau lagoons	Basin-sediment gravity seeps and springs, intruding lake water	Lagoons	Sand dune or gravel, alkali crust in basins	No
East Mono shoreland	Warm Spring, East Beach, Simon Spring	Basin-sediment gravity seeps and springs, deep fracture artesian, intruding lake water, seeping relict lake water	Littoral berms, littoral springlines, lagoons, faults, lakebed	Fine-grained lake sediment interbedded with lacustrine clay, well-leached to highly saline-alkali	No
South Mono shoreland	South Beach, South Tufa	Basin-sediment gravity seeps and springs, deep fracture artesian, intruding lake water, seeping relict lake water	Littoral berm, littoral springline, lagoon, faults, pumice sands	Coarse pumice sand inter-bedded with impermeable lacustine clay	South Tufa received inflow from upslope pasture irrigation
Sierran Delta	Wilson-Mill Creek Delta, Lee Vining Creek Delta, Rush Creek Delta, Lee Vining Tufa	Basin-sediment gravity seeps and springs, deltaic artesian springs, intruding lake water	Tufa cemented beach, rock, lagoons, delta plain	Coarse, well-drained sands or gravels interbedded with impermeable lacustine days	Diversion from creeks and inflows from upslope pasture irrigation
Sierran Front	Horse Creek embayment, Sierran Escarpment, County Park	Basin-sediment gravity seeps and springs, deep fracture artesian springs, fractured rock gravity springs	Faults, colluvium		Some receive groundwater inflow from upslope pasture irrigation
Mono Islands	Paoha Island	Basin-sediment gravity seeps and springs, deep fracture artesian springs, intruded lake water, seeping relict lake water	Littoral springline, faults, lakebed		No

Table 3C-5. Extent of Prediversion and Point-of-Reference Woody Riparian Vegetation along the Upper Owens River

	Control Reach	Augmented Flow Reach			
Condition	Above East Portal	Portal Reach	Middle Reach	Hot Creek Reach	Total
'ediversion	5.5	14.3	1.4	0.1	15.8
)int of Reference	4.1	3.0	1.0	0.0	4.0

tes: Marsh and meadow acreages not estimated.

Based on interpretation of 1944 and 1990 aerial photographs.

Table 3C-6a. Potential Overflow Channel Inlet Data
Rush and Lee Vining Creeks

Overflow Channel	Length[a] (ft)	Flow in Primary Channel[b] (cfs)	Required Excavation Depth[c] (ft)	Required Excavation Distance[d] (ft)	Comments
Upper Rush Creek					
R1	3,300	NA	NA	NA	Develop a release system from reservoir
R2/R2a	850	166	1.0	50	Low plug fill
		47	1.7	100	--
R2b	325	NE	NE	NE	Similar plug fill as R2a
R3	4,900	166	Negative	0	Channel inlet gated; water surface above gate bottom
		47	Negative	0	
R3a	NA	NA	NA	NA	A-ditch; use for spilling floodflows to pumice flats
R4/R4c	1,575	166	-0.4	0	Water flowing short distance into debris jam
		47	0.3	Short	--
		22	0.6	NE	--
R4a	650	NA	NA	NA	Requires 75-foot-long ditch, maximum depth not estimated
R4b	375	NA	NA	NA	At grade with R4/R4c
R5/R5a	950	166	-0.2	0	Flowing through heavy debris; channel wet for 250 feet
		22	Negative	0	Channel wet for 100-150 feet
R5b1	190	166	1.0	NE	Willow-lined channel
R5b2	175	166	2.6	25	Plug fill
		22	3.1	45	
R6	750	166	2.8	45	Plug fill
		22	@3.3	NE	
R7	600	166	0.6	50	Plus 265 feet of shallow guide trench
R8	1,200	166	1.5	35	Plug fill
Lower Rush Creek					
R9	1,825	166	<1.1	<65	Obscured by thick vegetation; may be flowing; flows year-round 400 feet downstream
R10/R10a	3,125	165	0.8	110	Inlet requires shallow ditch across meadow bank area
		47	1.1	150	
		22	1.8	NE	

Table 3C-6a. Continued

ow iel	Length[a] (ft)	Flow in Primary Channel[b] (cfs)	Required Excavation Depth[c] (ft)	Required Excavation Distance[d] (ft)	Comments
/ :	2,725	NA	NA	NA	Develop three-way diversion structure
	1,800	166	2.7	30	Plug fill, plus additional 120 feet of channel cleaning
		44	3.5	30	Plug fill, plus additional 185 feet of channel cleaning
	1,725	NA	NA	NA	Required 1 foot deep ditch from R11 for 150 feet
	2,875	NA	NA	NA	Requires less than 0.5 foot deep ditch from short distance
ng Creek					
	4,175	168	0.6	25	Former main channel
		9	1.5	NE	
	690	NA	NE	NE	Not surveyed

\ = not applicable.
Ǝ = not estimated.

tential overflow channels with various subchannels (e.g., a, b, c), the entire channel length is listed for the first nnel mentioned; lengths for ensuing subchannel represent additional lengths.

ation dates: Rush Creek = 47 cfs on June 10, 1992; 166 cfs on June 21, 1991; 165 cfs on June 22, 1991; and 22 cfs tember 21, 1991; Lee Vining Creek = 168 cfs on June 11, 1991 and 9 cfs on September 21, 1991.

on difference between water surface in main channel and top of bank or fill preventing flow into the overflow l. Negative or a negative value means water is currently flowing or is capable of flowing into the channel.

ntal distance along overflow channel bottom to point at same elevation as water surface in the main channel, or ım distance of excavation required to open the overflow channel inlet.

Table 3C-6b. Potential Overflow Channel Inlet Data - Walker and Parker Creeks

Overflow Channel	Length[a] (ft)	Comments[b]
Walker Creek		
W1	5,400	Divert sandtrap release into former overflow channel; flows to Parker Creek
W2/W2a	11,025	Remove small plug fill, opening 200-foot-long ditch connecting to overflow channel incised from irrigation conveyance
W2b	1,400	Ditch for short distance to open channel; flows would percolate to groundwater flow for 350 feet
W2c	2,500	Ditch 2.2 feet deep for 25 feet to open channel
W3	940	Open faint historic channel with 1.3-foot-deep, 15-foot-long ditch
W4	5,525	Ditch 1.0 foot deep for 10 feet to open channel
Parker Creek		
P1	11,125	Open former channel to South Parker Creek by restoring original channel (P1a); piping from the diversion pond (P1b); creating a return ditch below the diversion dam, weir, and road (P1c); or ditching across meadow 1.0 foot deep for 50-60 feet (P1d)
P1e	2,725	Limited ditching needed to divide flows between P1 and P1e; channel flows to Rush Creek
P2	2,625	Ditching evaluation required
P3	5,900	Ditching evaluation required (two possible channels for first 800 feet)
P4	7,800	Ditching evaluation required; channel flows to Walker Creek
P5	6,275	Ditch 2.2 feet deep for 25 feet through plug fill; channel flows to Walker Creek

[a] For potential overflow channels with various subchannels (e.g., a, b, c), the entire chann length is included in the length of the first subchannel mentioned (i.e., a); lengths other subchannels therefore represent additional lengths.

[b] Observations made during period of sustained high flow in both creeks (June 22 and 2 1991).

Table 3C-7. Changes in Upper Owens River Streamflow during the Diversion Period

Month	Prediversion Streamflow[a] (PD) (cfs)	Diversion Period Streamflow[b] (DP) (cfs)	Ratio DP/PD	Point-of-Reference Streamflow[c] (POR) (cfs)	Ratio POR/PD
pril	52	164	3.2	192	3.7
ay	66	209	3.2	246	3.7
une	79	236	3.0	192	2.4
uly	62	202	3.3	137	2.2
ugust	54	183	3.9	120	2.2
eptember	53	177	3.3	138	2.6
ctober	51	163	3.2	133	2.6
ovember	51	152	3.0	136	2.7
ecember	49	134	2.7	143	2.9
anuary	50	123	2.5	135	2.7
ebruary	49	121	2.5	130	2.7
arch	50	131	2.6	142	2.8
nnual average	56	166	3.0	154	2.8

Median monthly average streamflow 1940-1989 above East Portal.

Mean monthly average streamflow 1940-1989 below East Portal.

Median monthly average streamflow from point-of-reference LAAMP simulation of streamflow below East Portal.

Table 3C-8. Prediversion and Point-of-Reference Upper Owens River Channel Attributes

Study Reach	Sinuosity		Change in Sinuosity		Number of Meander Cutoffs	
	Pre-diversion	POR	Sinuosity Value	Percent[a]	Pre-diversion	POR
Alpers to East Portal (Control)	1.75	1.76	+0.01	0.5	NA	0
Portal Reach (Augmented)[b]	1.95	1.97	+0.02	1.0	NA	8
Middle Reach (Augmented)[b]	1.57	1.71	+0.14	8.9	NA	24
Hot Creek Reach (Augmented)[b]	2.09	1.81	-0.28	-13.4	NA	22

[a] Percent change from prediversion sinuosity.

[b] Flows augmented by exported Mono Basin water from 1940-1989.

Common Name (Scientific Name)	Federal/State/CNPS[a]	Distribution	Habitat
Long Valley milk-vetch (*Astragalus johannis-howelli*)	C3c/R/1b	Northern Long Valley and eastern Bodie Hills (Mono County) and Mud Spring Valley (Mineral County, Nevada) meadows; from 6,700 to 7,000 feet	Gravelly or sandy volcanically derived and hydrothermally altered soils in sagebrush scrub and on borders of alkali
Mono milk-vetch (*Astragalus monoensis*)	C2/R/1b	East slope of the Sierra Nevada, endemic to Mono County	Pumice sand flats in sagebrush scrub and Jeffrey pine-lodgepole forest from 6,900 to 8,200 feet
Tonopah milk-vetch (*Astragalus pseudiodanthus*)	C3c/None/1b	In Mono Valley (Mono County, California), northeast of Mono Lake and rare occurrences in Nevada	Stabilized dunes in sagebrush scrub, 6,400-6,600 feet
Bodie Hills draba (*Draba quadricostats*)	C2/None/1b	Region of Masonic Mountain, Mono County, California, and extending into Nevada	Metasedimentary scree and clay soils in sagebrush scrub and pinyon-juniper woodland, 7,200-8,600 feet
Mono buckwheat (*Eriogonum ampullaceum*)	C2/None/1b	Mono, Pumice, and Long Valleys and Watterson Canyon in Mono County, California	Alkaline meadows and sandy soils of sagebrush scrub, 6,400-7,000 feet
Mono Lake lupine (*Lupinus duranii*)	C2/None/1b	Scattered distribution from Lundy Lake to June Lake (Mono County, California)	Coarse barren soils of volcanic origin in yellow pine and red fir forests and pumic sand flats in sagebrush scrub, 6,500-8,500 feet
Utah monkeyflower (*Mimulus glabratus* var. *utahensis*)	None/None/2	Eastern Mono Valley (Mono County, California) and extending into Nevada	Meadows and pinyon-juniper woodland, 6,500-6,600 feet

[a] Status explanations:

Federal

C2 = Category 2 candidate for federal listing. Category 2 includes species for which USFWS has some biological information indicating that listing may be appropriate but for which further biological research and field study are usually needed to clarify the most appropriate status. Category 2 species are not necessarily less rare, threatened, or endangered than Category 1 species or listed species; the distinction relates to the amount of data available and is therefore administrative, not biological.

C3 = no longer a candidate for federal listing. Category 3 species have been dropped from the candidate list because they are extinct (C3a), taxonomically invalid or do not meet the USFWS definition of a "species" (C3b), or too widespread or not threatened at this time (C3c).

State

R = listed as rare under the California Endangered Species Act. This category is no longer used for newly listed plants, but some plants previously listed as rare retain this designation.

California Native Plant Society

1b = List 1b species: rare, threatened, or endangered in California and elsewhere.

2 = List 2 species: rare, threatened, or endangered in California but more common elsewhere.

Table 3C-10. Summary Comparison of Effects: Tributary Riparian Vegetation

Alternative or Condition	Frequency of Channel Dewatering[a]	Erosion Potential[b]		Frequency of Recruitment Flows (% of Years)		Riparian Vegetation and Wetlands (% of Prediversion Extent)[d]
		Banks	Incision	Rush and Lee Vining	Parker and Walker	
Point of reference	NA	High	Low	NA	0	61
Point-of-reference scenario	Very low[c]	NA	NA	25	100[e]	NA
No restriction	High*	High	Extreme*	23	0*	<50*✓
6,372 Ft	Very low	Low-moderate	Moderate*	7*	7*	63-82✓
6,377 Ft	Very low	Moderate[f]	Low	9,* 52	85	61-81✓
6,383.5 Ft	Very low	High[f]	Very low	41	85	60-80✓
6,390 Ft	Very low	High[f]	Very low	47	85	60-79✓
6,410 Ft	Very low	Very high*[f]	Very low	55	85	59-79✓
No diversion	Very low	Very high*[f]	Very low	47	85	60-80✓
Prediversion	Moderate	--	Very low	--	--	100

Notes:
-- = absence of data; indicates no estimation method available.
* = significant adverse project effect.
✓ = significant cumulative adverse effect.
NA = not applicable.

[a] Table 3C-11.
[b] Table 3C-12.
[c] Table 3C-13.
[d] Figure 3C-11 and Table 3C-14.

Table 3C-11. Frequency of Stream Releases during Growing Season Insufficient to Overcome Channel Losses (Percent of Years)

Alternative or Condition	Stream			
	Lee Vining	Walker[a]	Parker	Rush
oint of reference	0	100	100	0
o-Restriction Alternative	80	100	100	80
ll other alternatives	0	0	0	0

te: Growing season is May to August.

Valker Creek would be dry in lower reaches in March, April, and November in less than .0% of years for all alternatives because natural flow is insufficient. All other streams vould have sufficient flows in all years.

ırce: LAAMP simulations and synoptic flows data in Table 3C-1.

Table 3C-12. Relative Potential for Loss of Riparian Vegetation Resulting from Floodflow

	Incision (-) or Deposition (+) Potential[a]			Probability of Erosive Flows[b]					
Condition	Rush Creek (ft)	Lee Vining Creek (ft)	Relative Rating	Rush Creek[c] (%)	Lee Vining Creek (%)	Parker Creek (%)	Walker Creek (%)	Relative Rating[d]	Conclusion[e]
Point of reference	+2.3	+0.8	Low +	13 (2)	12	0	0	High	Frequent destabilization of Rush and Lee Vining Creeks
No-Restriction Alternative	-29.6	-30.9	Extreme -	12 (2)	14	0	0	High	Frequent destabilization and extreme incision of Rush and Lee Vining Creeks
6,372-Ft Alternative	-1.8	-3.3	Low-moderate -	0	6	<1	<1	Low-moderate	Moderate incision of Lee Vining Creek
6,377-Ft Alternative	+2.5	+1.0	Low-moderate +	2 (<1)	8	80	67	Moderate	Occasional destabilization of Lee Vining Creek; PW
6,383.5-Ft Alternative	+9.2	+7.7	High +	2 (<1)	15	84	67	High	Frequent destabilization of Lee Vining Creek; PW
6,390-Ft Alternative	+14.9	+13.4	High +	6 (1)	19	84	67	High	Occasional destabilization of Rush Creek; frequent destabilization of Lee Vining Creek; PW
6,410-Ft Alternative	+33.8	+32.3	Extreme +	10 (1)	30	84	67	Very high	Frequent destabilization of Rush and Lee Vining Creeks; PW
No-Diversion Alternative	+50.0	+48.5	Extreme +	6 (<1)	28	84	67	Very high	Occasional destabilization of Rush Creek; frequent destabilization of Lee Vining Creek; PW

[a] Incision and deposition potential are estimated from the difference between the normal minimum lake surface elevation for each alternative and the lake surface elevation during the most recent incising floodflows (6,374 feet for Rush Creek in 1980 and 6,375.5 feet for Lee Vining Creek in 1983).

[b] Frequency of simulated flows for each alternative exceeding estimated channel stability thresholds: Rush Creek = 350 cfs, Lee Vining Creek = 250 cfs, Parker Creek = 23 cfs, Walker Creek = 15 cfs (Trihey pers. comm.).

[c] Figures in parentheses for Rush Creek apply if the A-Ditch is operated as a relief overflow capable of diverting up to 150 cfs.

[d] Relative rating is for Rush and Lee Vining Creeks only; for the 6,377-Ft Alternative and all higher lake-level alternatives, the probability of erosive flows in Parker and Walker Creeks is extreme unless releases are modified.

[e] PW = extreme destabilization of Parker and Walker Creeks without release modification.

Table 3C-13. Frequency of Seasonal Overflow Channel Wetting (% of Years)

Alternative or Condition	Rush Creek	Lee Vining Creek	Parker Creek	Walker Creek
oint of reference	26[a]	24[a]	0[a]	0[a]
o-Restriction lternative	27[a]	20[a]	0[a]	0[a]
,372-Ft Alternative	6[a]	7[a]	15[a]	0[a]
,377-Ft Alternative	9[a]	52	90	75
,383.5-Ft Alternative	31	51	90	75
,390-Ft Alternative	42	52	95	75
,410-Ft Alternative	45	65	90	75
o-Diversion Alternative	37	55	90	75

te: Minimum flows were estimated in spring 1991 for optimum overflow channel wetting: Rush Creek = 200 cfs, Lee Vining Creek = 180 cfs, Parker Creek = 21 cfs, and Walker Creek = 14 cfs.

requencies substantially less than biannual (50%), assumed to be 30% or less.

Table 3C-14. Extent of Riparian and Wetland Vegetation for the Alternatives

Condition	Rush Creek			Lee Vining Creek			Parker Creek	Walker Creek	All Streams				
	Woody Riparian	Meadow and Wetland	Total	Woody Riparian	Meadow and Wetland	Total	Woody Riparian	Woody Riparian	Woody Riparian	Meadow and Wetland	Total	Change from Point of Reference (%)	Percentage of Pre-diversion Extent
Point of reference	173	40	213	71	32	103	49	43	336	72	408	0	61
No-Restriction	45	15	60	50	25	75	35	30	160	40	200	-49	30
Maximum estimate													
6,372-Ft	244	51	295	115	33	148	57	45	460	84	544	+33	82
6,377-Ft	237	51	288	113	33	146	58	45	453	84	537	+32	81
6,383.5-Ft	233	51	284	111	33	144	58	45	447	85	531	+30	80
6,390-Ft	232	52	284	108	33	142	58	45	443	86	529	+30	79
6,410-Ft	229	53	283	111	34	145	58	45	443	87	530	+30	79
No-Diversion	224	53	276	108	34	142	64	49	445	87	531	+30	80
Minimum estimate													
6,372-Ft	175	40	215	73	33	106	53	43	343	73	417	+2	63
6,377-Ft	168	40	208	71	33	104	55	43	337	73	410	+1	61
6,383.5-Ft	162	41	203	69	33	102	55	43	329	74	403	-1	60
6,390-Ft	159	42	201	65	33	99	55	43	323	75	398	-2	60
6,410-Ft	155	42	198	66	34	100	55	43	320	76	396	-3	59
No-Diversion	150	42	192	63	34	97	61	48	322	76	397	-3	60
Prediversion	271	131	402	112	44	156	58	50	492	175	667	NA	100

Source: Water table lake inundation model for most alternatives; No-Restriction Alternative extrapolated from mapping of establishing vegetation in 1989.

Table 3C-15. Summary Comparison of Effects: Lake-Fringing Vegetation

Alternative or Condition	Acreage of Marsh, Wet Meadow, Alkali Meadow, Riparian Scrub	Acreage of Lagoons	Acreage of Alkali Lakebed[a]
oint of reference	2,796	1	5,368
lo-Restriction	313*√	0*√	9,512*√
,372-Ft	2,859	1√	3,883√
,377-Ft	2,625	1√	1,492√
,383.5-Ft	2,325*	6√	521√
,390-Ft	2,071*	16√	377√
,410-Ft	754*	261	157
o-Diversion	358*	261	0
rediversion	356	260	0

ignificant adverse project effect.

ignificant adverse cumulative effect.

ncludes mapped alkali flats and very sparse greasewood flat on west Paoha Island.

Table 3C-16. Lake-Fringing Wetland Location, Type, and Extent

Condition or Alternative	North Mono Shorelands	East Mono Shorelands	South Mono Shorelands	Sierran Delta	Sierran Front	Mono Islands	Total
Prediversion							
Marsh, meadow, and wetland scrub	2	79	14	60	201	1	356
Ponds and lagoons	214	0	0	41	0	5	260
Alkali lakebed	0	0	0	0	0	0	0
Total							616
Point of reference							
Marsh, meadow, and wetland scrub	884	986	284	179	460	3	2,796
Dry meadow	558	739	838	158	101	3	2,397
Ponds and lagoons	1	0	0	0	0	0	1
Alkali lakebed	3,392	1,418	18	16	59	1,056	5,959
Total							11,153
No-Restriction Alternative							
Marsh, meadow, and wetland scrub	2-4	71-142	14-28	25-50	200-400	1-2	313-626
Dry meadow	558	739	272	158	101	3	1,831
Ponds and lagoons	0	0	0	0	0	0	0
Alkali lakebed	6,200	1,963	432	195	336	386	9,512
Total							11,657-11,969
6,372-Ft Alternative							
Marsh, meadow, and wetland scrub	885	1,147	228	142	456	3	2,859
Dry meadow	559	1,034	855	115	121	4	2,687
Ponds and lagoons	1	0	0	0	0	1	2
Alkali lakebed	2,472	988	13	14	59	536	4,081
Total							9,629
6,377-Ft Alternative							
Marsh, meadow, and wetland scrub	885	1,035	183	117	404	2	2,625
Dry meadow	558	1,038	805	161	110	4	2,676
Ponds and lagoons	1	0	0	0	0	1	1
Alkali lakebed	574	458	0	0	0	460	1,492
Total							6,794
6,383.5-Ft Alternative							
Marsh, meadow, and wetland scrub	536	1,146	186	112	344	1	2,235
Dry meadow	558	751	644	101	75	4	2,132
Ponds and lagoons	0	0	0	6	0	1	6
Alkali lakebed	70	56	0	0	0	395	521
Total							4,894

Condition or Alternative	North Mono Shorelands	East Mono Shorelands	South Mono Shorelands	Sierran Delta	Sierran Front	Mono Islands	Total
6,390-Ft Alternative							
Marsh, meadow, and wetland scrub	429	1,161	106	75	300	1	2,071
Dry meadow	438	493	432	91	51	4	1,507
Ponds and lagoons	0	0	0	15	0	1	16
Alkali lakebed	46	0	0	0	0	331	377
Total							3,971
6,410-Ft Alternative							
Marsh, meadow, and wetland scrub	158	250	122	73	150	1	754
Dry meadow	260	149	154	30	24	4	620
Ponds and lagoons	214	1	4	37	0	5	261
Alkali lakebed	0	0	0	0	0	151	151
Total							1,786
No-Diversion Alternative							
Marsh, meadow, and wetland scrub	3	78	14	60	202	1	358
Ponds and lagoons	215	0	0	41	0	5	261
Alkali lakebed	0	0	0	0	0	0	0
Total							619

Note: Based on breakdown of predicted habitat extent by type for each of the 18 wetlands assessment areas in Appendix Q.

Table 3C-17. Summary Comparison of Effects: Upper Owens River Riparian and Wetland Vegetation

Alternative or Condition	Channel Stability	Meadow and Marsh Extent	Threat of Elimination of Willow Scrub	Willow Productivity Relative to POR (%)
Point of reference	Low	See text	Moderately high	100
No-Restriction	Very low*✓	Same as POR	Same as POR✓	98
6,372-Ft	Moderately low✓	Same as POR	Same as POR✓	102
6,377-Ft	Moderately low✓	Same as POR	Same as POR✓	104
6,383.5-Ft	Moderate✓	Same as POR	Same as POR✓	105
6,390-Ft	Moderate✓	Same as POR	Same as POR✓	106
6,410-Ft	Moderately high	Same as POR	Less than POR	109
No-Diversion	High	Somewhat less than POR*	Less than POR	96
Prediversion	High	Somewhat less than POR	Less than POR	96

* Significant adverse project effect.

✓ Significant adverse cumulative effect.

POR = point of reference.

Table 3C-18. Upper Owens River Streamflow

ernative of Condition	Average Monthly Flow (cfs) June	July	August	Frequency of High Flows (Months per Year) >300 cfs	275-300 cfs	250-275 cfs	200-250 cfs
of reference							
rage year	192	137	120	0	0	1	0
: year	336	281	342	4	2	1	0
estriction Alternative							
rage year	192	155	144	0	1	0	1
: year	356	305	359	6	0	1	2
Ft Alternative							
rage year	299	286	173	0	2	0	0
: year	299	299	299	0	7	0	0
Ft Alternative							
rage year	106	223	141	0	0	0	0
: year	285	299	299	0	6	0	1
5-Ft Alternative							
rage year	97	97	109	0	0	0	0
: year	152	275	299	0	3	0	0
Ft Alternative							
rage year	113	94	88	0	0	0	0
: year	128	195	299	0	1	1	0
Ft Alternative							
rage year	95	77	71	0	0	0	0
year	127	107	83	0	0	0	0
iversion Alternative							
rage year	95	77	71	0	0	0	0
year	127	107	83	0	0	0	0

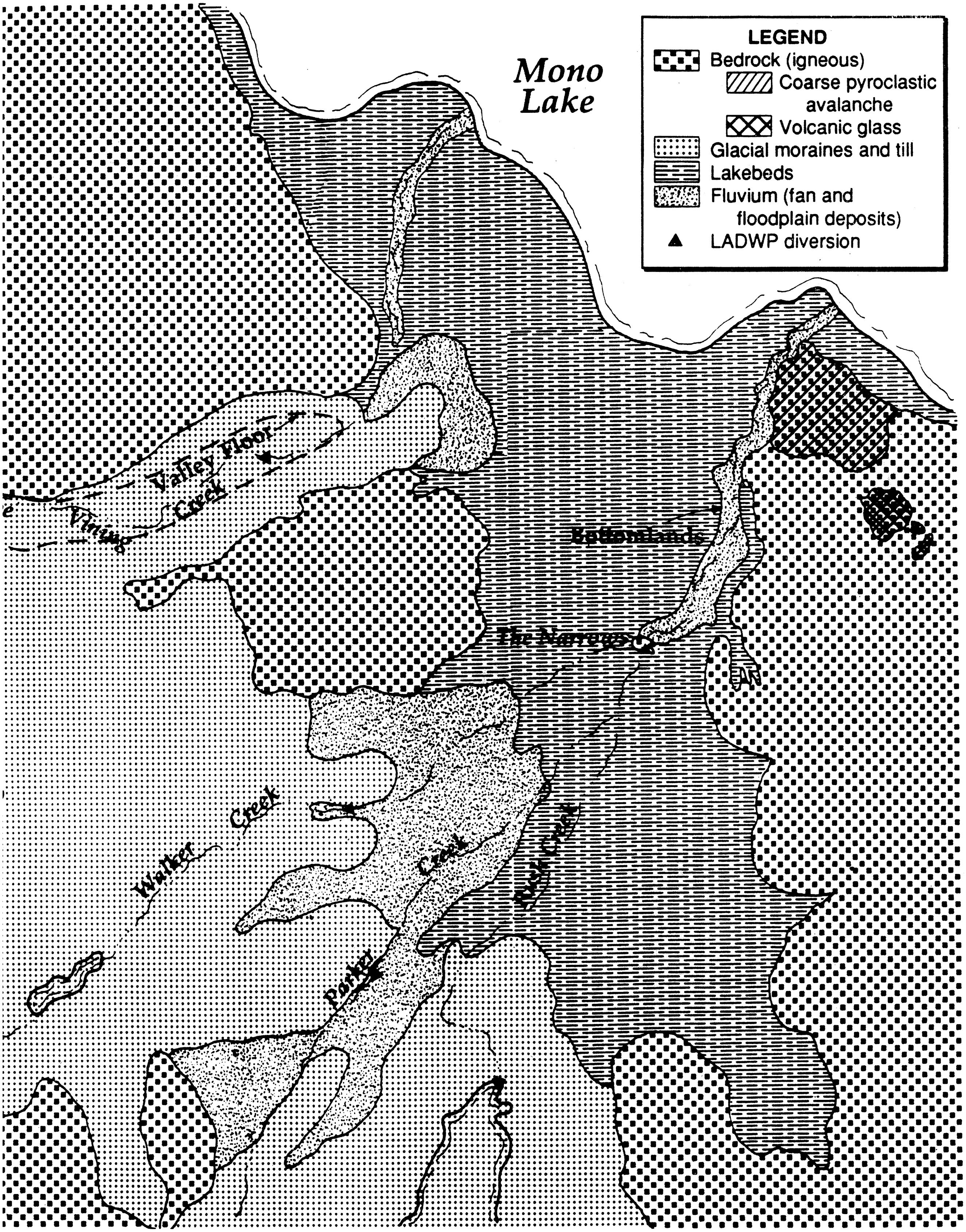
LAAMP simulations for Owens River below East Portal.

Table 3C-19. Stage and Willow Productivity of Upper Owens River

Alternative or Condition	Stage (ft)[a]			Willow Productivity[b]		
	Inaja	Below Benton Crossing	Hot Creek	Average Annual Growth Increment (mm)	Percent of Point of Reference	Percent of No-Diversion Alternative
Point of reference	1.80	1.99	1.96	2.85	100	104
No-Restriction	2.02	2.15	2.15	2.79	98	102
6,372-Ft	2.13	2.31	2.37	2.90	102	106
6,377-Ft	1.98	2.13	2.13	2.96	104	108
6,383.5-Ft	1.71	1.91	1.84	3.0	105	110
6,390-Ft	1.43	1.66	1.58	3.01	106	110
6,410-Ft	1.56	1.56	1.48	3.10	109	114
No-Diversion	1.56	1.56	1.48	2.73	96	100

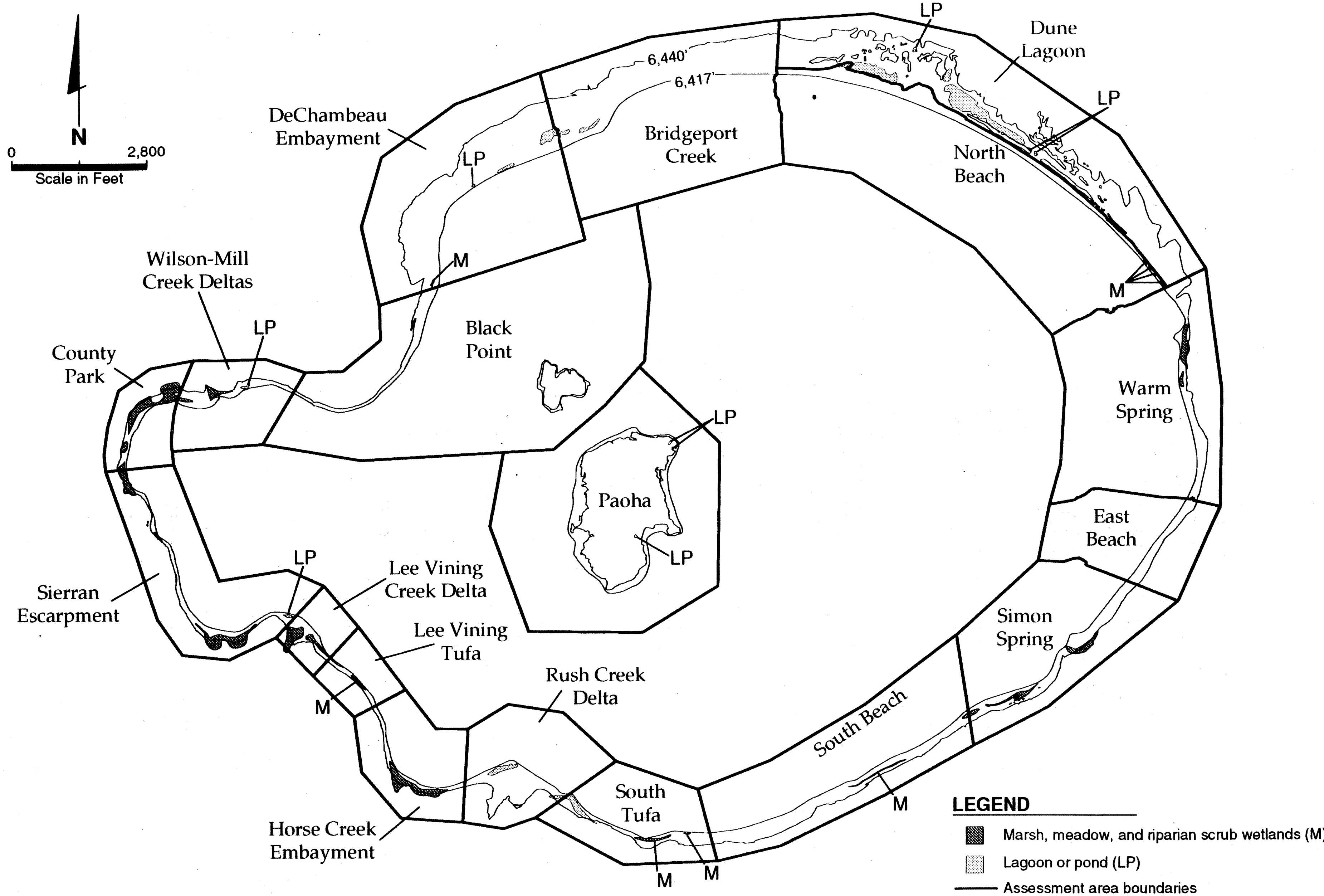
[a] Stage represented as the elevation in feet above the thalweg for average monthly flows for August during normal runoff year, from LAAMP simulations. Stage-discharge relationships are based on EBASCO Environmental et al. 1993.

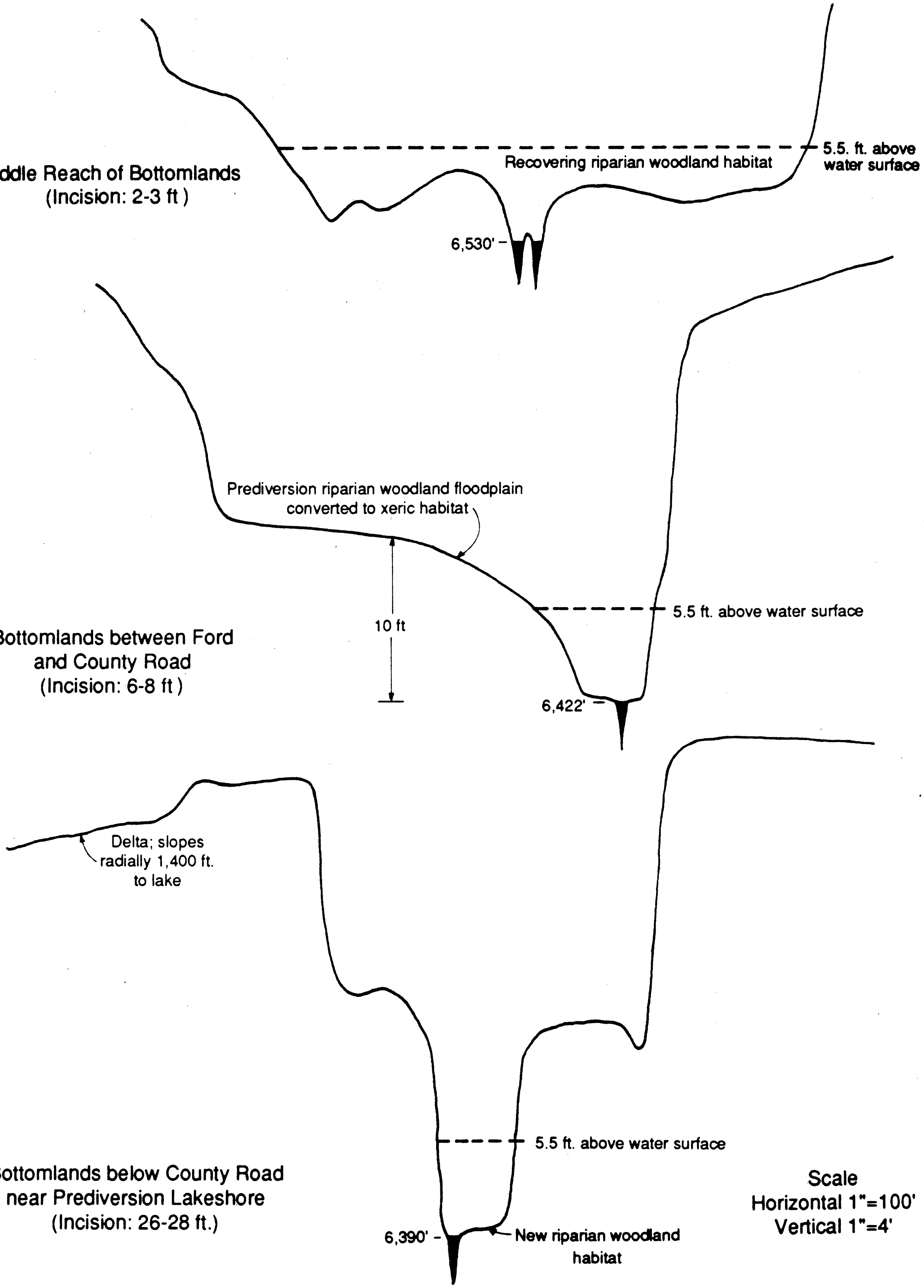
[b] Based on predicted average annual growth rate from Stromberg & Patten (1991).



ce: Bailey 1989 and Kistler 1966

ure 3C-1.
ɔmorphology of the Diverted Tributary Streams


N
0
2,800
Scale in Feet
DeChambeau Embayment
Bridgeport Creek
North Beach
Dune Lagoon
LP
LP
LP
6,440'
6,417'
M
M
Wilson-Mill Creek Deltas
LP
County Park
Black Point
LP
Paoha
LP
Warm Spring
East Beach
Simon Spring
Sierran Escarpment
LP
Lee Vining Creek Delta
Lee Vining Tufa
M
Rush Creek Delta
South Beach
South Tufa
M
M
M
Horse Creek Embayment
LEGEND
Marsh, meadow, and riparian scrub wetlands (M)
Lagoon or pond (LP)
Assessment area boundaries



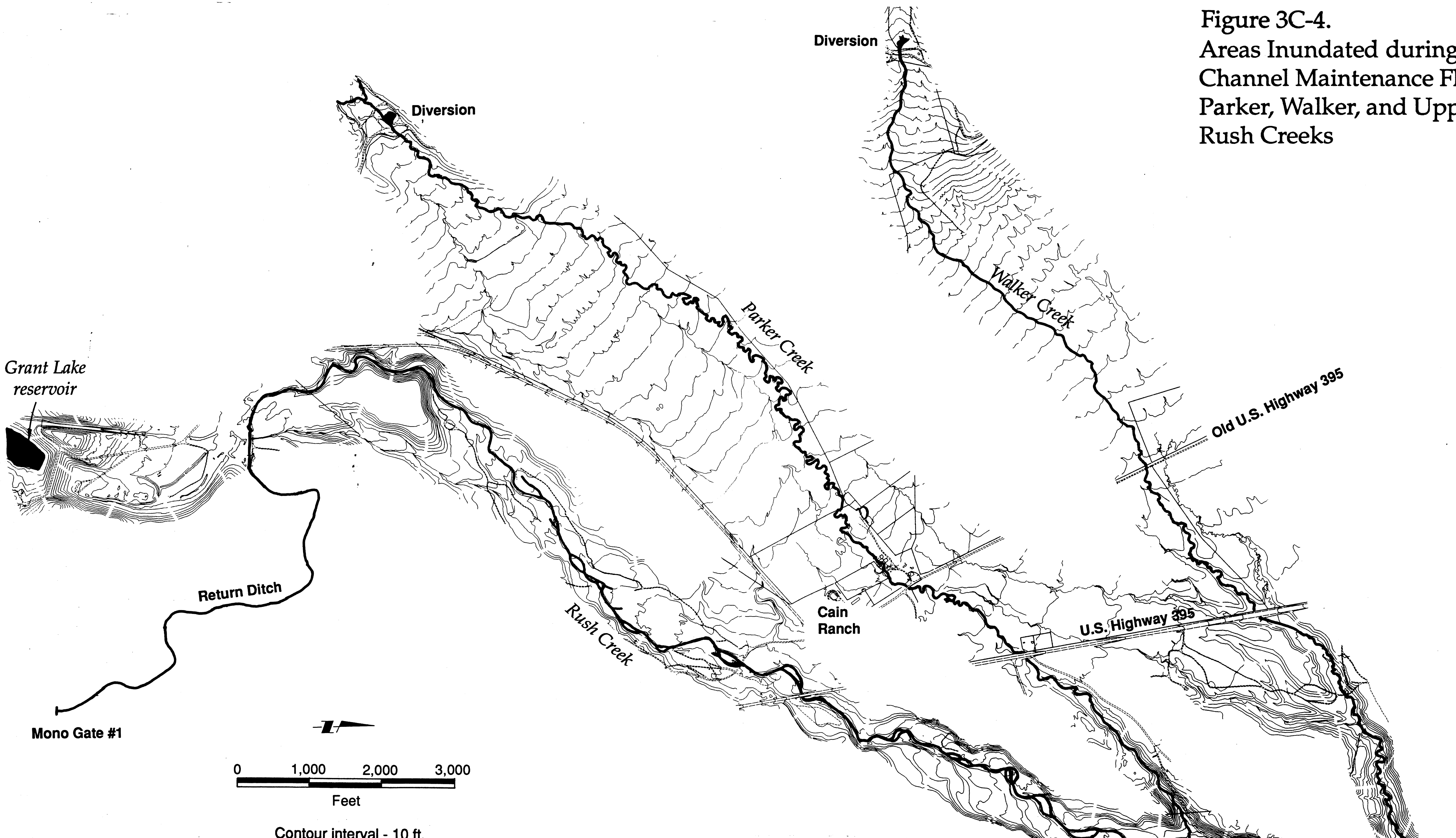
ırce: Topographic contours (2- ft. interval) prepared by Aerial Photometrics 1991.

gure 3C-3.
.cision of the Rush Creek Bottomlands

MONO BASIN EIR

Prepared by Jones & Stokes Associates

Figure 3C-4.
Areas Inundated during Channel Maintenance Flows - Parker, Walker, and Upper Rush Creeks



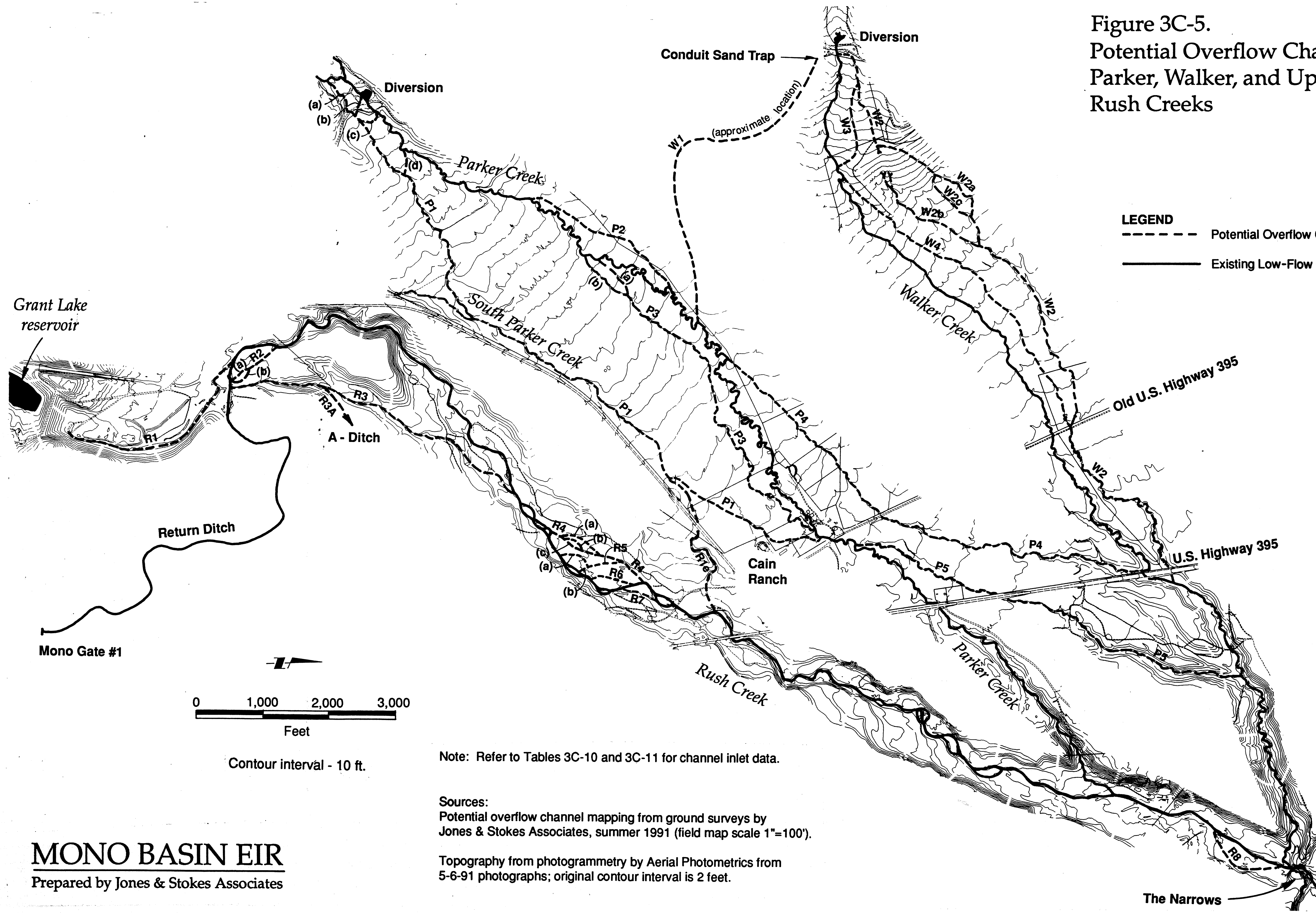
Sources:
Inundation areas from aerial photography on 6-10-91 and 6-19-91 with Mono Gate #1 release of 161 cfs; Parker Creek release of 23 cfs; Walker Creek release of 10 cfs.

Topography from photogrammetry by Aerial Photometrics from 5-6-91 photographs; original contour interval is 2 feet.

MONO BASIN EIR

Prepared by Jones & Stokes Associates

Figure 3C-5. Potential Overflow Channels - Parker, Walker, and Upper Rush Creeks

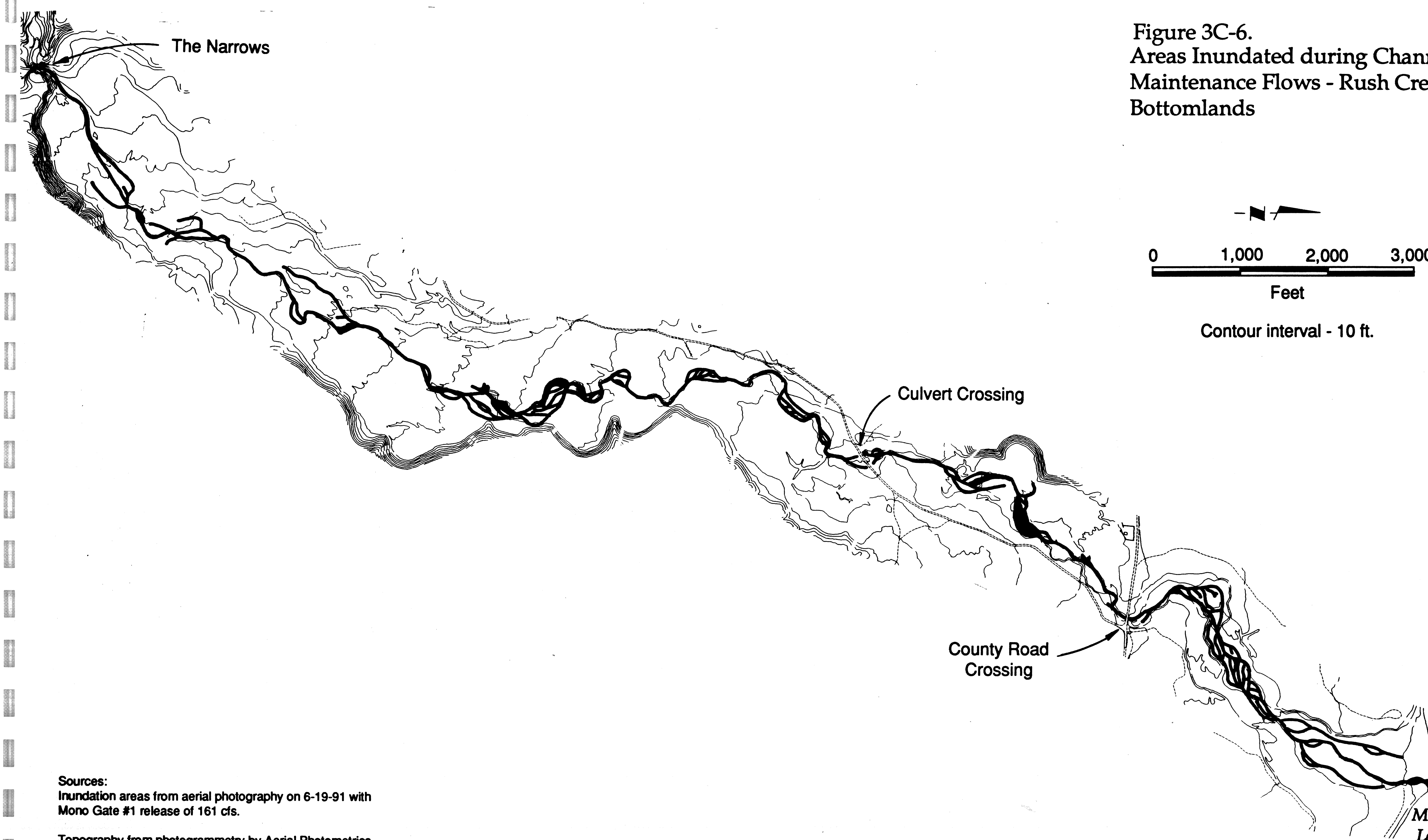


Note: Refer to Tables 3C-10 and 3C-11 for channel inlet data.

Sources:
Potential overflow channel mapping from ground surveys by Jones & Stokes Associates, summer 1991 (field map scale 1"=100').

Topography from photogrammetry by Aerial Photometrics from 5-6-91 photographs; original contour interval is 2 feet.

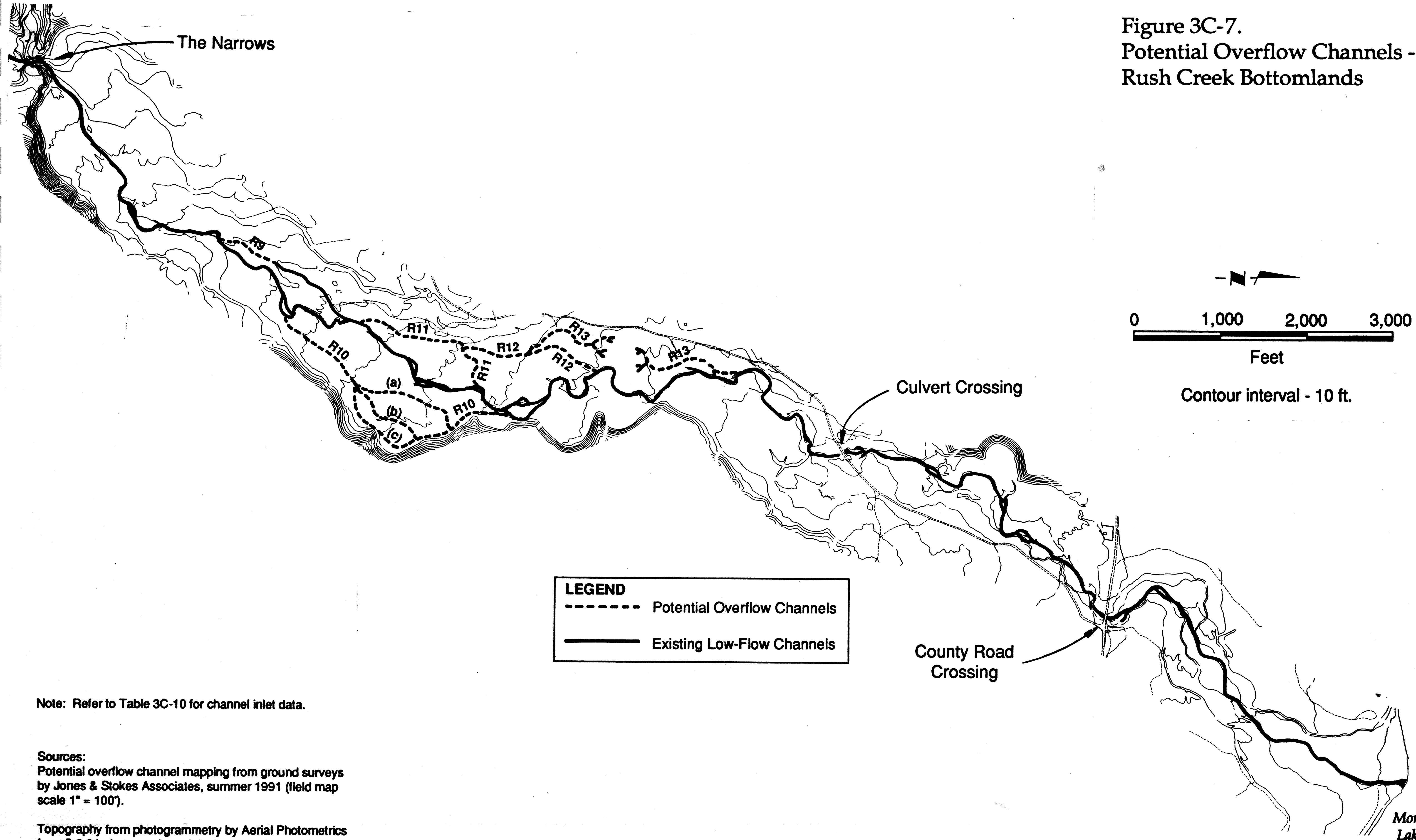
Figure 3C-6.
Areas Inundated during Channel Maintenance Flows - Rush Creek Bottomlands



Sources:
Inundation areas from aerial photography on 6-19-91 with Mono Gate #1 release of 161 cfs.

Topography from photogrammetry by Aerial Photometrics from 5-6-91 photographs; original contour interval is 2 feet.

Figure 3C-7.
Potential Overflow Channels - Rush Creek Bottomlands



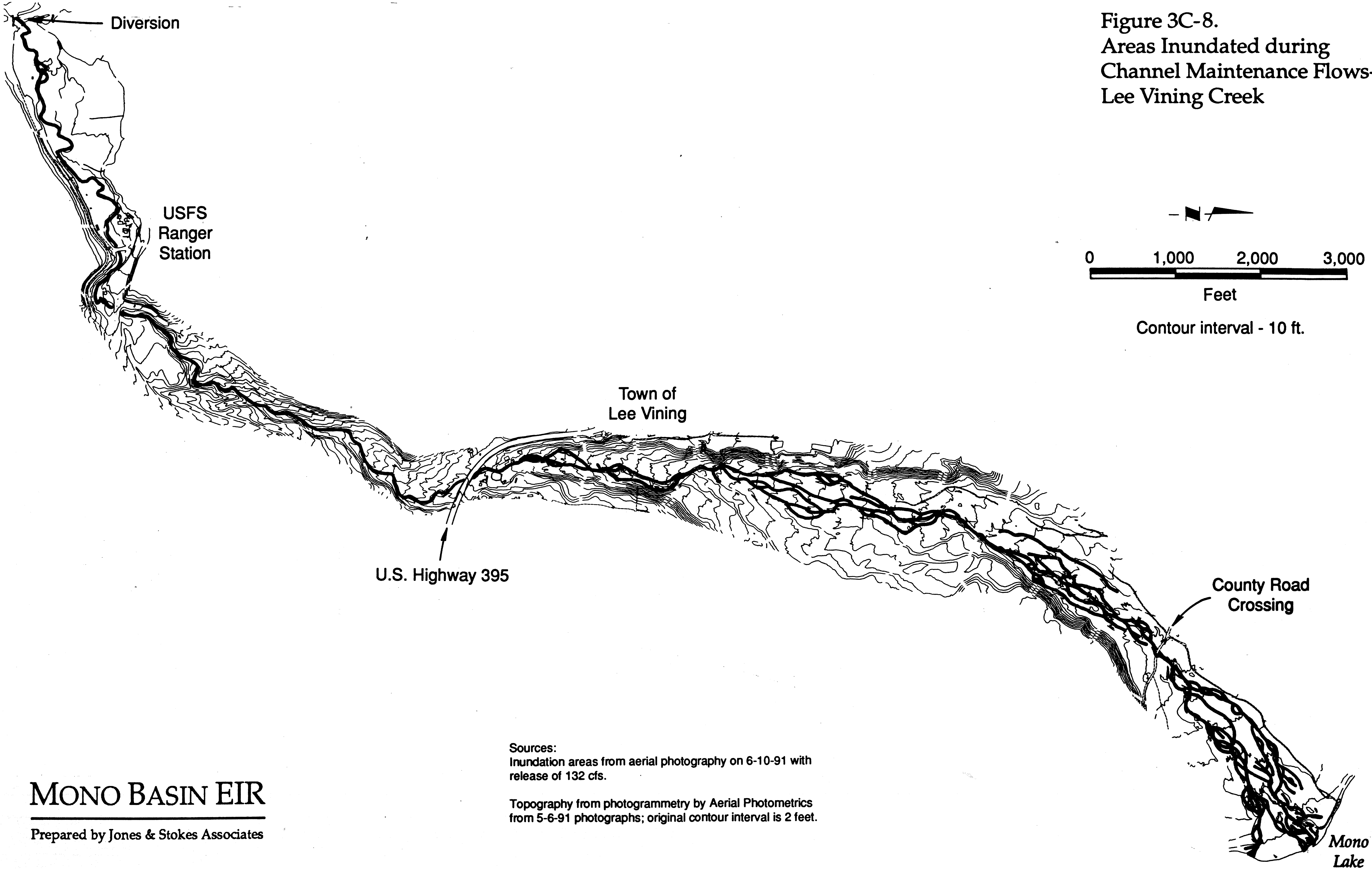
Note: Refer to Table 3C-10 for channel inlet data.

Sources:
Potential overflow channel mapping from ground surveys by Jones & Stokes Associates, summer 1991 (field map scale 1" = 100').

Topography from photogrammetry by Aerial Photometrics from 5-6-91 photographs; original contour interval is 2 feet.

MONO BASIN EIR
Prepared by Jones & Stokes Associates

Figure 3C-8.
Areas Inundated during Channel Maintenance Flows-Lee Vining Creek



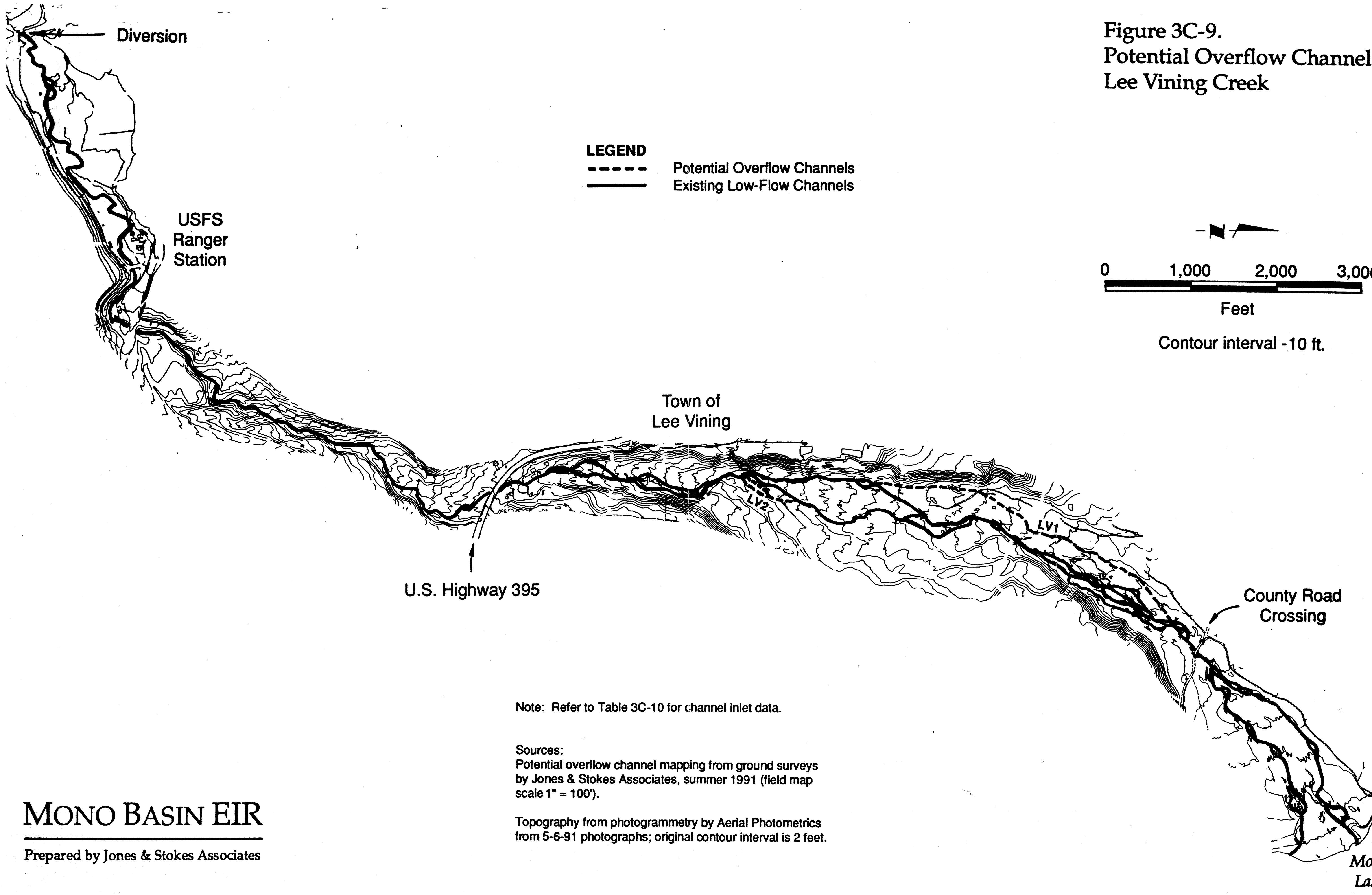
Sources:
Inundation areas from aerial photography on 6-10-91 with release of 132 cfs.

Topography from photogrammetry by Aerial Photometrics from 5-6-91 photographs; original contour interval is 2 feet.

MONO BASIN EIR

Prepared by Jones & Stokes Associates

Figure 3C-9.
Potential Overflow Channels - Lee Vining Creek



Note: Refer to Table 3C-10 for channel inlet data.

Sources:
Potential overflow channel mapping from ground surveys by Jones & Stokes Associates, summer 1991 (field map scale 1" = 100').

Topography from photogrammetry by Aerial Photometrics from 5-6-91 photographs; original contour interval is 2 feet.

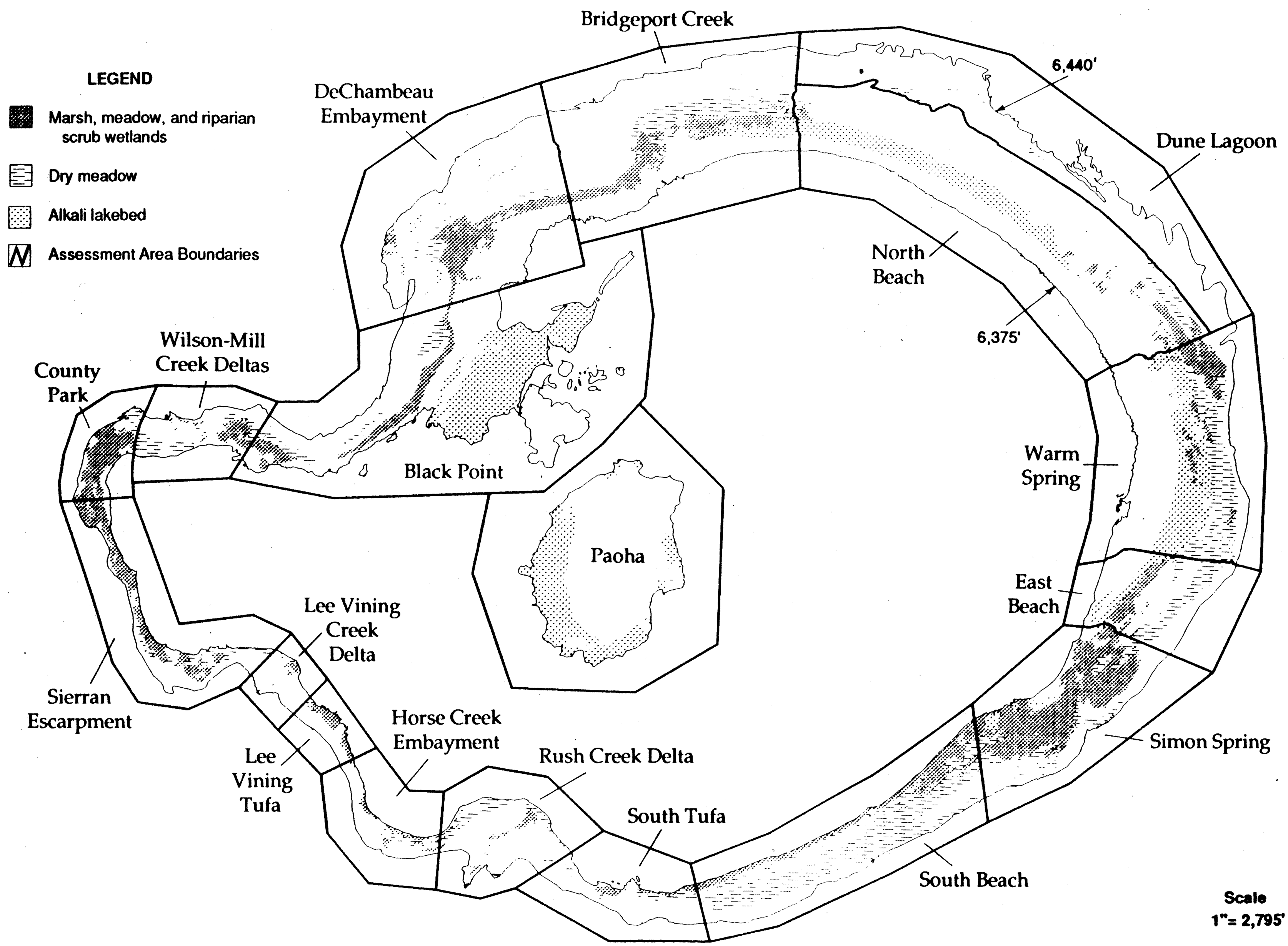
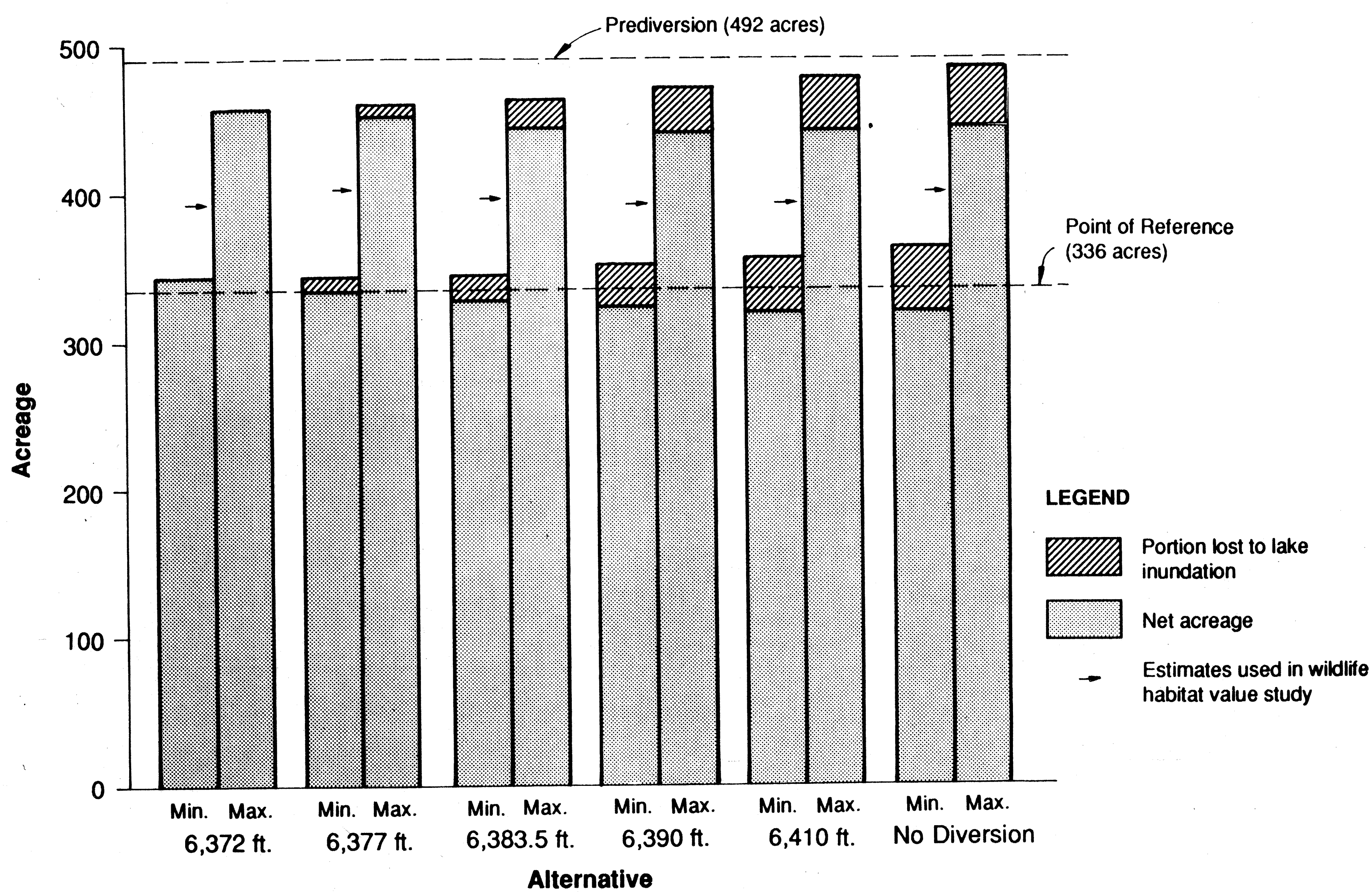


Figure 3C-10.
Lake-Fringing Wetlands under Point-of-Reference Conditions

MONO BASIN EIR

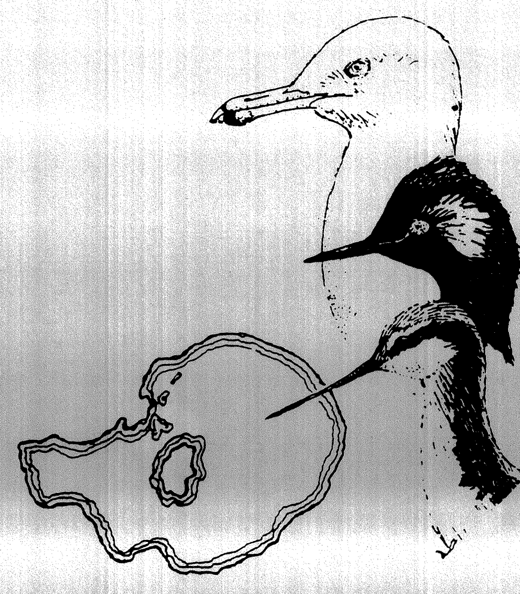
Prepared by Jones & Stokes Associates



Note: Minumum and maximum estimates from the water table model are shown; water table model cannot be used to predict acreage for the No-Restriction Alternative.

Figure 3C-11.
Extent of Woody Riparian Vegetation along the Diverted Tributary Streams for the Alternatives

Chapter 3D. Environmental Setting, Impacts, and Mitigation Measures - Fishery Resources



Chapter 3D. Environmental Setting, Impacts, and Mitigation Measures - Fishery Resources

Mono Lake is a highly alkaline, saline lake that does not provide suitable habitat for fish. This condition has persisted over a long span of geologic time. The diversion of streamflow from the Mono Lake tributaries, however, potentially affects fishery resources not only in the diverted tributary reaches but throughout most of the length of the Owens River, as well (Figure 1-5). This chapter describes potentially affected fish populations and habitats in these river systems. The SWRCB process will not address instream flows in Mill and Wilson Creeks; DFG is currently preparing instream flow studies on Mill and Wilson Creeks, but completion dates are unknown. Instream flows in the Owens River gorge, which extends from Long Valley Dam to Pleasant Valley Reservoir, also are not addressed in this EIR; the alternatives do not affect flows in the gorge, and separate actions to determine appropriate flow conditions in the gorge are ongoing.

In this chapter, the Upper Owens River includes the headwaters of the river to Long Valley Dam, which impounds Lake Crowley reservoir. The Middle Owens River extends from Pleasant Valley Dam to Tinemaha Reservoir. The Lower Owens River extends from Tinemaha Reservoir to Owens Lake.

PREDIVERSION CONDITIONS

Sources of Information

Existing information on prehistoric habitat conditions in Mono Basin and the Owens River basin is limited and based on Deinstadt et al. (1985) and Moyle (1976).

To describe historic prediversion aquatic habitats and fish populations in Mono Basin, Trihey & Associates (1991) and Jones & Stokes Associates independently identified, compiled, and reviewed potential data sources. Published and unpublished scientific information is scarce, and definitive information is unavailable to quantitatively describe historic prediversion fish habitats or populations; however, the available information that was identified is presented below. Numerous physical attributes of historic prediversion conditions and related fishery resource values were estimated for Lee Vining and Rush Creeks by use of maps, ground and aerial photographs, and written and oral historic accounts (Trihey & Associates 1991, 1992a). Primary sources of information on prediversion conditions in the Owens River basin are Moyle (1976) and Smith and Needham (1935).

Prehistoric Conditions

Mono Basin

Habitat. Prehistoric Mono Lake tributaries mostly were characterized by relatively steep gradients (from 2% to 5%); rocky substrates; and turbulent, perennial flows (Deinstadt et al. 1985). Minimum flows occurred during winter, and ice formation was extensive at higher elevations and present at lower elevations. Peak flows were associated with snowmelt during late spring and early summer and occasionally were accentuated by summer thunderstorms. Common stream habitat types in tributaries included small pools, riffles, runs, rock gardens, and cascades. Dense riparian vegetation often consisted of several species of willows, black cottonwood, Jeffrey pine, and western birch, interspersed with sagebrush in drier areas. See Chapter 3C, "Vegetation", for a detailed description of plant communities and species.

Grant Lake is the northernmost, lowest lake in the June Lake Loop chain of glacial lakes. Grant Lake, which had a maximum surface area of 150 acres, had only slight annual changes in water surface elevations and received inflow from only one tributary stream, Rush Creek.

Fish Populations. Before the mid-1850s, streams and lakes in Mono Basin, including Lee Vining and Rush Creeks, were devoid of fish. Archeological finds of fish bones lying beneath volcanic ash, however, indicate that fish were once present in Mono Basin. Geologically recent volcanic eruptions may have eliminated these fish from the basin (Hubbs pers. comm. in Moyle 1976).

Owens River Basin

Habitat. Owens River tributaries provided habitats similar to those described above for Mono Lake tributaries. Owens River habitats varied considerably, as described below.

Originating in the upper reaches of Long Valley, the Owens River drains the eastern slope of the Sierra Nevada and, to a lesser extent, the western slope of the White and Inyo Mountains. The river forms as a result of tributary inflow from Deadman and Glass Creeks and spring inflow at Big Springs. Winding its way through extensive meadow areas in Long Valley, the Owens River is joined by smaller tributaries (such as Hot, Mammoth, and Convict Creeks) before entering the Owens River gorge. Within the gorge, the river has cut into the valley, forming high canyon walls as it drops 3,000 feet in approximately 16 miles. The steeper gradient and boulder fields produced pool habitats and short cascades unlike the run habitats characteristic of the highly meandering section in Long Valley.

Downstream of the gorge, the Owens River flows through unconsolidated alluvial deposits, again becoming a meandering channel with high sinuosity. Willows and cottonwoods lining the river formed a dense riparian corridor. Recent aerial photographs show remnant meander scars and oxbow lakes, suggesting that river meanders were highly migratory under unaltered conditions.

Fish Populations. The Owens River basin contained four native fish species: Owens sucker, Owens tui chub, Owens pupfish, and Owens speckled dace. Little is known about the ecology of these endemic species prior to habitat alteration and widespread introductions of exotic species. Moyle (1976) suggests that dace was the dominant species of headwater streams. At lower elevations, dace were common in riffles, while pupfish inhabited extensive marshes of the valley floor. Suckers and tui chubs dominated the Owens River and the slower moving, lower elevation reaches of tributary streams.

Historical Conditions

Mono Tributaries

Habitat. Lee Vining and Rush Creeks were lined by dense riparian growth, primarily cottonwood and willow at lower elevations and pine and cottonwood at higher elevations (see Chapter 3C, "Vegetation"). The stream channels were quite stable and contained large deposits of high-quality spawning gravel. Overall, the channel structure and riparian vegetation provided good to excellent habitat conditions for trout in Lee Vining and Rush Creeks (Trihey & Associates 1991).

Lee Vining Creek. Lee Vining Creek streamflows were unimpaired before 1860. Early settlers soon began to divert water from the creek for use in sawmills and for irrigation. Diversions for irrigation increased through the late 1800s and early 1900s (Aquatic Systems Research 1992). In 1923, the Poole Power Plant began operating at the foot of Lee Vining Creek Falls, and water was diverted above the falls to generate hydroelectric power. Habitat changes occurred seasonally downstream of diversion sites where summer streamflows were reduced. Subsequently, several small lakes in the watershed were enlarged to increase storage capacity, and a low-head hydroelectric plant was built at the U.S. Highway 395 (U.S. 395) crossing (Aquatic Systems Research 1992). Between 1930 and 1940, water was diverted from Lee Vining Creek primarily for irrigation and hydroelectric generation. Historical sources indicate that these diversions did not dewater Lee Vining Creek, although irrigation diversions significantly reduced late summer flow in drought periods (Trihey & Associates 1992a).

Before 1940, Lee Vining Creek below the U.S. 395 crossing was characterized by a multiple channel system consisting of a single main channel and several subsidiary channels. The main and subsidiary channels contained a diversity of aquatic habitats that supported all trout lifestages. Narrow channel widths and frequent meanders provided deep water habitat and promoted the development of undercut root wads and lateral scour pools. Dense riparian vegetation occurred along most of Lee Vining Creek, providing cover and shade over most of the stream width and stabilizing streambanks. Logs, root wads, and fallen trees contributed to trout habitat quality. Because of the higher summer flows, summer water temperatures were cooler than they are today. Trout spawning gravels were abundant in Lee Vining Creek, with the largest deposits probably located near the mouth (Trihey and Associates 1992a).

Aquatic Systems Research (1992) subdivided Lee Vining Creek into six study segments based on differences in gradient, geomorphology, and riparian vegetation (Figure 3D-1). Upper Lee Vining Creek, identified as Segment 1, is the portion of the stream from Poole Powerhouse to LADWP diversion dam; lower Lee Vining Creek was delineated into five segments between the LADWP diversion dam to Mono Lake. Trihey & Associates (1991) subdivided lower Lee Vining Creek into only three segments as a basis for describing historical habitat conditions in this reach. Existing stream segment boundaries are considered to be representative of segment boundaries under historic prediversion conditions, as described by Trihey & Associates (1991).

Segment 1 (0.8 mile), corresponding to Aquatic Systems Research's Segment 2, contained abundant high-quality spawning gravels. Dense riparian vegetation consisted of Jeffrey pine, lodgepole pine, white fir, water birch, quaking aspen, black cottonwood, and several willow species. The understory along this reach included brush willows, wild rose, and various species of grasses and other herbs. Most of the cover used by trout in Segment 1 was probably associated with undercut banks, protruding tree roots, and debris jams. (Trihey & Associates 1991.)

Segment 2 (1.3 miles), corresponding to Aquatic Systems Research's Segments 3 and 4, contained good-quality spawning gravels, but these gravels were less frequent than in Segment 1. The largest deposits of spawning gravels in this segment were located immediately upstream of U.S. 395 (Vestal 1990, Court Testimony, Volumes I and II). Riparian vegetation was similar to that in Segment 1, but large rocks and debris jams were more prevalent sources of trout cover in Segment 2. (Trihey & Associates 1991.)

Segment 3 (1,8 miles), corresponding to Aquatic Systems Research's Segments 5 and 6, contained good-quality, but increasingly less frequent spawning gravels. Large deposits of spawning gravels were located primarily near the mouth of Lee Vining Creek (Vestal 1990, Court Testimony, Volumes I and II). Vegetation was less diverse (though no less dense) in Segment 3, with black cottonwood, willows, and Jeffrey pine dominating. Grasses, wild rose, sagebrush, and bitterbrush constituted major elements of the understory. Cover used by trout was similar to that in Segment 1, probably consisting of undercut banks, protruding tree roots, and debris jams. (Trihey & Associates 1991.)

Rush Creek. Between the 1860s and the late 1930s, water was diverted seasonally from Rush Creek for in-basin agricultural purposes. These diversions reduced summer streamflows in the areas immediately downstream of the diversion points, but tributary inflow and the tendency of some diverted water to return downstream through springs and seepage lessened the impacts of these diversions. (Beak Consultants 1991.) Major irrigation diversions began in the 1920s following the construction of an artificial dam that increased the storage capacity of Grant Lake (Stine 1992a).

Peak flows in Rush Creek during the snowmelt runoff period often reached a maximum of 175 cfs under the influence of Southern California Edison's (SCE's) reservoir operations, although flows of more than 300 cfs occurred in wet years. Late spring and early summer runoff from Parker and Walker Creeks typically contributed about 50 cfs of these flows (Jones & Stokes Associates 1993).

Rush Creek was divided into seven segments from Grant Lake Dam downstream to Mono Lake (Figure 3D-2). Habitat mapping surveys were conducted in 1984 (EA Engineering, Science, and Technology 1989), 1987 (Beak Consultants 1991), and 1990 (Trihey & Associates 1991) with minor differences resulting from each survey. Beak Consultants (1991) delineations primarily are used here because they provided the basis for the Rush Creek instream flow study and were most closely associated with boundaries established by Trihey & Associates (1991), which form the basis for existing aquatic and riparian habitat restoration efforts. Existing stream segment boundaries are generally representative of segment boundaries under historic prediversion conditions and are used to facilitate comparable discussions and analyses.

Segment 1 (1.4 miles), which was replaced with the return ditch when Grant Lake Dam was enlarged in 1939-1940, maintained abundant, good-quality gravels for trout spawning and insect production (Vestal 1990, Court Testimony, Volumes I and II). No other specific data are available to determine historic prediversion conditions.

Segment 2 (0.9 mile) is a relatively steep canyon characterized by a high channel gradient (3.18%), alternating cascades and pools, large substrate material (i.e., boulders), and a stand of riparian vegetation. Boulders and cobbles dominated the streambed materials, although pockets of gravels accumulated in many pools. Small clusters of Jeffrey pine grew along the stream corridor, and a continuous stand of cottonwood and willow extended along much of this reach. (Beak Consultants 1991, Trihey & Associates 1991.)

Segment 3 (3.2 miles) is the longest of the seven reaches, extending from Segment 2 downstream to a large bedrock formation known as "the narrows". The gradient is moderately flat (1.85%), and the terrain is relatively open. Aerial photographs taken in January 1930 indicate that the riparian corridor along the upper mile of Segment 3 consisted of dense willows interspersed with Jeffrey pine. Heavy bank cover of sagebrush, bitterbrush, willow, and rugosa wild rose was cited by Vestal (Vestal 1990, Court Testimony, Volumes I and II). Several cutoff meander bends and secondary channels were present and probably provided excellent habitat for young fish and, if influenced by groundwater, good overwintering habitat. In addition, the network of secondary channels probably contributed to a reduction in channel scour during periods of high runoff by shunting a portion of the flood peak out of the main channel and onto the floodplain. It appears that pool and/or low-velocity run habitats were present, and well-vegetated undercut streambanks contributed substantially to the general character of this reach. (Trihey & Associates 1991.)

The lower 2 miles of Segment 3 occupied a single channel. Clusters of pine accompanied a narrow band of cottonwoods and willow that lined the streambanks. Dense stands of cottonwood and willows extended across the floodplain above old U.S. 395. Logs and debris jams probably contributed to the diversity of instream habitat conditions, as did exposed roots along the streambank. Many large boulders were present in this reach, and gravel deposits reportedly were present immediately upstream of old U.S. 395 and near The Narrows. Habitat composition may have consisted primarily of riffles, but runs and small pools were common. (Trihey & Associates 1991.)

Segment 4 (0.05 mile), the narrows, has a relatively high gradient (2.86%) and largely is confined within vertical rock walls along both sides of the creek channel. Aquatic habitat consisted mainly of repeating cascade and plunge pool sequences over most of the reach. (Beak Consultants 1991.)

Segments 5-7 extend from the narrows to Mono Lake and are quite different from Segments 1-4 upstream. This area, called the Rush Creek bottomlands, supported a broad riparian forest throughout most of its length. The historic prediversion stream channel was quite sinuous and, in some places, the primary stream course consisted of parallel channels or meander bends with bypass channels. The quality of streambed gravels has been described as excellent for both trout spawning and aquatic insect production (Vestal 1990, Court Testimony, Volumes I and II). Exposed willow roots, a few fallen trees, and shoreline debris jams probably were the principal components of instream cover for fish. Habitat composition probably was dominated by riffles and runs; however, deep pools may have occurred at meander bends and with debris jams. (Trihey & Associates 1991.)

Segments 5 (1.8 miles) and 6 (1.6 miles) lie between the narrows and 0.4 mile above the county road and are similar (Beak Consultants 1991). The stream gradients are 1.39% and 0.49%, respectively; both segments were characterized by small substrate materials (Beak Consultants 1991). In these segments, Rush Creek flowed through a lush wet meadow bisected by numerous spring-fed channels augmented by irrigation return flow (e.g., Bohler Creek). The combined flow of these ancillary channels is estimated to have ranged from 18 to 52 cfs. The spring-fed flow resulted from the seasonal irrigation of approximately 1,500 acres on Cain Ranch and 600 acres in Pumice Valley with an annual average of 30,000 acre-feet (af) of water. These springs and the associated high water table in the meadows supported dense stands of cottonwood and willows covering more than 150 acres. The spring-fed channels must have provided ideal habitat conditions for trout. Water temperatures in these channels probably were very stable throughout the year, providing cool water temperatures during summer and ice-free habitat during winter. (Trihey & Associates 1991.)

Based on the gradient of the surrounding meadow and the sinuosity of these spring-fed channels, hydraulic conditions in Segments 5 and 6 would have favored relatively deep, slow-moving water associated with well-vegetated undercut streambanks. Vestal (1990, Court Testimony, Volumes I and II) has indicated that lush beds of watercress filled with aquatic insects grew in these channels. The abundant food and year-round growing conditions provided by these spring-fed channels supported a high-quality fishery in these reaches in the historic prediversion period. (Trihey & Associates 1991.)

The lowermost reach, Segment 7 (1.3 miles), extends from 0.4 mile upstream of county road to Mono Lake (Trihey & Associates 1991). Terrain and channel configurations were similar to those found in Segments 5 and 6, although little spring flow probably occurred in Segment 7. Dikes constructed along this reach, however, created freshwater ponds and marshy areas. Large trout were observed feeding in this area (Vestal 1990, Court Testimony, Volumes I and II), and the marsh may have been a highly productive wetland and a nursery area for young trout. Fine and coarse sands and fine gravels settled out at the mouth of Rush Creek to create a delta (Vestal 1954).

Parker and Walker Creeks. In the historic prediversion period, Parker and Walker Creeks were lined with meadows, and watercress existed at certain locations (McAfee 1990). Riparian vegetation on the lower reaches of both Parker and Walker Creeks (immediately upstream of the confluence with Rush Creek) consisted of dense willows, cottonwood, sagebrush, bitterbrush, and watercress adjacent to the springs (Vestal 1990, Court Testimony, Volumes I and II). Lower Parker and Walker Creeks contained suitable spawning gravels and may have been important spawning and rearing habitat for Rush Creek brown trout (Vestal pers. comm.).

No other published or unpublished information is available on historic prediversion habitat conditions of Parker and Walker Creeks. The smaller channel and flows in Parker and Walker Creeks, however, probably provided less habitat and supported smaller fish populations than did Lee Vining and Rush Creeks. Nonetheless, small streams like Parker and Walker Creeks can maintain significant fishery resources, especially if the creeks have reaches with perennial flows, stable channels, cover, and suitable spawning gravels, as these two creeks did. Such tributary streams also can be important in maintaining fish populations in downstream areas by providing important spawning, nursery, or juvenile-rearing habitat.

Fish Populations

Lee Vining Creek. At most eastern Sierra Nevada lakes and streams, including Lee Vining Creek, several trout species were introduced and became established in the late 1800s and early 1900s. The first trout were introduced into Lee Vining and Rush Creeks shortly after 1850, when freighters transporting goods along the eastern Sierra Nevada carried Lahontan cutthroat trout in water barrels over the Conway Summit from the East Walker River. These trout quickly colonized the streams, and an abundant cutthroat trout fishery developed by 1900. (Beak Consultants 1991.)

Plantings of hatchery-reared brown trout fingerlings and catchable rainbow trout occurred in the early 1900s in Lee Vining Creek until 1941 (Vestal 1990, Court Testimony, Volumes I and II). By 1940, brown trout was the most abundant trout species inhabiting Lee Vining Creek. Small populations of rainbow trout were present with rare occurrences of eastern brook and Lahontan cutthroat trout (McAfee 1990). Witness accounts indicated that 8- to 10-inch trout were abundant, with some trout reaching 13-15 inches (Trihey & Associates 1991). Information on the occurrence of nongame fish species in Lee Vining Creek before 1941 is not available.

Rush Creek. Trout were first introduced into Rush Creek simultaneous with introductions to Lee Vining Creek. Brown, rainbow, and eastern brook trout were stocked in Rush Creek from Fern Creek and Mount Whitney State Fish Hatcheries in the early 1900s (Beak Consultants 1991). Brown trout fingerlings were first introduced into Rush Creek approximately 15 miles upstream of Mono Lake in 1919, and plantings were continued until 1942 (Vestal 1954). Golden trout were planted in upper Rush Creek above Grant Lake in the 1920s and 1930s. In 1931 and 1932, eastern brook trout and Lahonton cutthroat trout were planted in Rush Creek and reportedly had little effect on the brown trout population, which had become well established. Threespine stickleback were incidentally introduced into the system when steelhead trout from the Ventura River were transported to Rush Creek (Vestal 1954).

By 1940, brown trout dominated the fishery, which also included a few rainbow and eastern brook trout. Only one quantitative estimate of trout populations before 1940 was made; trout population abundance in Rush Creek before 1935 was estimated to equal the abundance measured during the water spill from Grant Lake in 1970, when 50,000 adults were observed between the dam and Mono Lake. This estimate was based on personal observations of fall runs at the egg-taking station in 1938 and from hatchery records (Vestal pers. comm.). Fishing for brown trout reportedly was excellent in Rush Creek in the 1930s (Vestal 1954). On one occasion, trout even were observed to be present in Mono Lake, immediately within the freshwater inflow area below the mouth of Rush Creek (Vestal 1990, Court Testimony, Volumes I and II). Brown trout weighing 3/4 pound to 2 pounds were common and occasionally a 5- or 6-pound fish was caught (McPherson 1990 in Trihey & Associates 1991). During the Great Depression, trout from Rush Creek regularly supplemented the diets of local residents.

Parker and Walker Creeks. Existing information on the early fisheries of Parker and Walker Creeks is limited, but both of these creeks probably were planted with species similar to those planted throughout Mono Basin in the late 1800s and early 1900s, as reported by Vestal (1954). Eastern brook trout reportedly existed in Parker Creek in the 1920s, and anglers could catch a limit of 8- to 10-inch trout in 2-3 hours (McAfee 1990). Small stream size, reduced gradient, and prevalence of meadow habitat may have contributed to a larger proportion of brook trout comprising the overall fishery than in Lee Vining or Rush Creeks, but definitive information is nonexistent. Information on the occurrence of nongame fish species in Parker and Walker Creeks before 1941 was not found.

Management

Lee Vining Creek. Little information exists on historic prediversion management of Lee Vining Creek fishery resources. DFG hatchery records indicate that hatchery-reared trout were planted regularly in streams throughout the region. Reports (Vestal 1990, Court Testimony, Volumes I and II) indicate that hatchery-reared brown trout fingerlings and catchable rainbow trout were planted in Lee Vining Creek until 1941.

Rush Creek. Fish populations in Rush Creek were maintained through natural reproduction and hatchery plantings. No definitive account exists of how many fish were planted in Rush Creek and who planted them. The Rainbow Club of Bishop, an outdoor sportsmen's organization, helped stock Rush Creek beginning in the early 1920s.

An egg-collecting station was constructed in lower Rush Creek in 1925 and operated through 1953. Eggs were collected from each adult brown trout during the fall spawning migration. The destination of the fertilized eggs is uncertain; however, most eggs probably were shipped to the Mt. Whitney Hatchery (Vestal pers. comm.).

The Fern Creek Hatchery, located midway between Silver and Grant Lakes along the June Lake Loop, produced approximately 1 million fish per year (1928-1942), and some of these fish were planted into Rush Creek (Leitriz 1970).

Parker and Walker Creeks. Information on fishery management for Parker and Walker Creeks before 1940 is not available. Management practices probably consisted of planting hatchery-reared trout, which was the common practice throughout the region.

Grant Lake

Habitat. Information on preconstruction lake habitat was not found. In the late 1930s, however, LADWP increased Grant Lake's size and capacity by constructing the Grant Lake Dam and Mono Craters Tunnel. The surface area of Grant Lake was increased from 150 to 1,094 acres, and the capacity was increased to 47,525 af (Sada 1977). In addition, a second inlet stream to the lake was created with the construction of the Lee Vining conduit, which delivers water diverted from Lee Vining, Parker, and Walker Creeks.

Fish Populations. Grant Lake contained no post-Pleistocene native fishes (Hubbs and Miller 1948) until trout were introduced around 1880 (Vestal 1954). Little information has been published on the early fishery of Grant Lake, but Grant Lake probably contained species similar to those planted throughout Mono Basin in the late 1800s and early 1900s as reported by Vestal (1954). Smith and Needham (1935) determined that Lahontan cutthroat and brown trout were present in the lake. Information on the occurrence of nongame fish species in Grant Lake before 1940 was not found.

Management. Information is limited regarding Grant Lake fishery management before 1941. Management practices probably consisted of planting hatchery-reared trout to maintain trout populations and offset increasing fishing pressure.

Owens River Basin

Habitat. Habitat conditions in the Owens River before 1940 are not well documented. Conditions in 1940 probably were similar to prehistoric habitat conditions, although water diversions in the early 1900s significantly altered natural flows in the Lower Owens

River below the Los Angeles Aqueduct intake enough to alter water surface elevations of Owens Lake. Tributaries in the Owens River basin usually were productive; Smith and Needham (1935) described Hot Creek as one of the richest trout streams they had ever encountered.

Upper Owens River. Limited information on Upper Owens River habitat conditions before 1941 indicates that the channel and streamflows near the present location of East Portal provided excellent trout habitat (Chapter 3J, "Recreation Resources"). Early settlers of the Owens River basin diverted water for irrigation, and streamflows probably were reduced seasonally in certain areas. Grazing also was known to occur in the area before 1941.

Lake Crowley Reservoir. Lake Crowley reservoir did not exist in 1940; Long Valley dam was completed in 1941. No information on preimpoundment fish habitat was available.

Owens River Gorge. Beginning in 1952, the Owens River gorge below Lake Crowley reservoir was substantially dewatered because of diversion of water by LADWP for hydroelectric power generation. The issue of flows in the Owens River gorge is the subject of a lawsuit filed in 1991 by Mono County against LADWP and the SWRCB. The parties are attempting to resolve the issues raised in the suit through settlement negotiations.

Middle Owens River. Flows in the Middle Owens River were nearly unimpaired before 1941. Habitat conditions in 1940 probably approached prehistoric habitat conditions except for grazing-related impacts and water diversions.

Lower Owens River. Habitat conditions in the Lower Owens River before LADWP diversions began in 1913 probably resembled prehistoric conditions except for changes associated with grazing and local agricultural diversions. After the diversion of the Lower Owens River at the Los Angeles Aqueduct intake structure in 1913, Lower Owens River flows below the intake were eliminated except during exceptionally wet years. Habitat conditions in the Lower Owens River were altered significantly below the Los Angeles Aqueduct intake as a result of LADWP diversions.

Pleasant Valley, Tinemaha, and Haiwee Reservoirs. Haiwee and Tinemaha Reservoirs were filled in 1913 and 1929, respectively, and provided warmwater lentic (lake) habitat. Owens River habitat conditions at the Tinemaha Reservoir site before reservoir filling probably resembled prehistoric conditions except for grazing-related changes. River flow was unimpaired along the entire reach of the Owens River above the aqueduct intake until the construction of Tinemaha Reservoir. Approximately 2 miles of Owens River habitat became inundated after dam closure.

Haiwee Reservoir, constructed in 1913 south of Lake Owens, is an offsite storage facility but does store water diverted from the Owens River. Water is diverted into the Los Angeles Aqueduct from the Owens River at the aqueduct intake structure and is conveyed to Haiwee Reservoir.

Pleasant Valley Reservoir did not exist in 1940; dam construction was completed in 1955.

Los Angeles Aqueduct and Irrigation Canals. The Los Angeles Aqueduct, constructed between 1908 and 1913, is an artificial channel designed and operated to convey water diverted from the Owens River. The aqueduct not only provided warmwater fish habitat in the channel but also was responsible for habitat losses in the Lower Owens River as described above. Irrigation canals provided intermittent fish habitat.

Fish Populations. Native Owens sucker, Owens tui chub, Owens pupfish, and Owens speckled dace comprised the Owens River fish community before exotic game and nongame species were introduced, flows regulated, and habitat extensively altered. By the 1930s, however, introductions of exotic species in Owens River basin had resulted in self-sustaining populations of brown trout, largemouth bass, catfish (brown bullhead), and carp in the Owens River (Smith and Needham 1935). These introduced species coexisted and competed with the native fish fauna.

Upper Owens River. In 1940, fish populations of the Upper Owens River probably consisted of native Owens sucker, tui chub, and speckled dace (Moyle 1976) and introduced brown, rainbow, cutthroat, and brook trout (Smith and Needham 1935). Owens suckers were collected by Smith and Needham during surveys of Convict Lake, indicating that suckers also may have been present in headwater streams. Tui chub were not collected during surveys of the Upper Owens River, but definitive information on the species' presence could not be found.

Middle Owens River. The primary game species in the Middle Owens River were brown trout (wild and planted) and planted rainbow trout. Also present in 1940 were self-sustaining but limited populations of largemouth bass and brown bullhead.

Native Owens tui chub and Owens speckled dace populations in the Middle Owens River apparently had declined by 1940 but were still present in the main river where somewhat stable populations of Owens sucker still occurred. Records of Owens pupfish do not exist from this period, but small populations persisted in isolated springs within the Owens Valley. Carp were abundant in the sluggish reaches of the valley floor.

Lower Owens River. Limited information exists concerning when the first non-native species were introduced into the Lower Owens River. Introductions probably occurred before 1941 because native populations were known to be declining by this time. As introduced species and water diversions increased, native species largely were displaced by introduced species. By 1940, fish populations in the Lower Owens River above the LA Aqueduct probably were similar to those identified for the Middle Owens River. Below the LA Aqueduct, the Lower Owens River was generally dry with extremely limited, if any, fish populations.

Pleasant Valley, Tinemaha, and Haiwee Reservoirs. Game and nongame species similar to those present in the Middle and Lower Owens River likely occurred in

Tinemaha and Haiwee Reservoirs, as well. The warm and slower-moving waters of these reservoirs favored introduced warmwater species, such as largemouth bass, bluegill, carp, and mosquitofish, although some native species, Owens sucker and tui chub, probably were present.

Los Angeles Aqueduct and Irrigation Canals. Fish species inhabiting the Los Angeles Aqueduct and irrigation canals consisted of species found in the Lower Owens River above the aqueduct intake. Fish populations were maintained chiefly through natural reproduction and recruitment from upstream sources. Introduced species would have dominated species composition in these modified habitats.

Management. The principal management activity in Owens River basin before 1940 was the initial stocking of accessible lakes and streams with rainbow, golden, cutthroat, brook, and brown trout. Subsequent stocking was initiated annually to maintain trout populations in response to increasing pressure from anglers. Smith and Needham (1935) surveyed streams of Inyo and Mono National Forests and found that heavy fishing pressure was occurring throughout the region. Planting of the Upper Owens River also was conducted by resort owners eager to attract anglers to the area (Smith and Needham 1935). Fishery management in the Middle Owens River; Lower Owens River; and Pleasant Valley, Tinemaha, and Haiwee Reservoirs consisted of planting trout in response to the increasing fishing pressure.

ENVIRONMENTAL SETTING

This section describes the conditions of fishery resources at the point of reference in August 1989. Important changes in these resources between 1941 and 1989 also are described.

Sources of Information

The following is based on information derived from recent publications, agency data, and discussions with agency personnel. Available DFG fishery and instream needs investigations and Restoration Technical Committee reports provide the primary basis for this section.

Mono Basin

Overview

Habitats. Water diversions and impoundments constructed to meet downstream water demands have significantly altered the natural flows in every major stream in Mono Basin. Mono Basin streams, such as Lee Vining, Rush, Parker, and Walker Creeks, have experienced significantly reduced flows below LADWP diversions since 1941. These modified flows have reduced or eliminated available fish habitat in specific reaches of these streams. Since 1985-1986, however, court-ordered flows in Lee Vining and Rush Creeks have increased available fish habitat. Flows were restored in Parker and Walker Creeks in 1990.

Fish Populations. Moyle (1976) indicates that five game and four nongame species (all introduced) occur in Mono Basin (Table 3D-1). Recent trout population estimates conducted on Mono Basin tributaries such as Lee Vining and Rush Creeks indicate that brown trout is the dominant species, followed by rainbow trout (EA Engineering, Science, and Technology 1990b; Beak Consultants 1991). The threespine stickleback is the only nongame fish species reported to occur in Lee Vining, Rush, Parker, and Walker Creeks, although Owens sucker and a tui chub hybrid reportedly occur in Rush Creek above Grant Lake (Sada 1977). Mono Basin does not support any special-status species, except the introduced Owens sucker upstream of Grant Lake.

Management. Most of the streams and lakes in Mono Basin are heavily fished throughout the typical fishing season (May-October). In response to this fishing pressure, DFG has stocked most of the streams and lakes with rainbow, brown, eastern brook, and Lahontan cutthroat trout. Most of the trout planted are catchable size, but fingerling-, subcatchable-, and trophy-sized fish also are stocked. Trout populations are maintained by natural reproduction, intensive stocking, or both.

Lee Vining, Parker, and Walker Creeks below the conduit have been planted with fingerling brown trout since instream flows were restored; Rush Creek below Grant Lake has not been planted since flows were restored. DFG has not decided whether these streams will be managed for wild trout, hatchery trout, or a combination of wild and hatchery trout.

Fishing regulations target the intensive trout fishery; the open season is generally the last Saturday in April through October 31. A daily bag limit of five trout per day and a possession limit of ten trout are permitted. These regulations apply to all Mono Basin streams, lakes, and reservoirs. Exceptions include Rush Creek below Grant Lake and Parker and Walker Creeks below the Lee Vining conduit, where the maximum size limit is 10 inches and only artificial lures with barbless hooks may be used.

Habitat Restoration. The 1990 court order amending interim flows in Rush Creek and Lee Vining Creek included a provision requiring LADWP to consult with the affected parties and attempt to reach an agreement regarding "channel modification and any related actions that should be accomplished in Rush Creek and Lee Vining Creek to help reestablish the conditions which benefitted the fisheries which existed in them before DWP's diversions began in 1941".

A conceptual plan for restoring aquatic and riparian habitats in Rush and Lee Vining Creeks was drafted and revised on May 30, 1991 (Trihey & Associates 1991). The goal of the restoration program is to establish aquatic and riparian conditions and resource values equivalent to those which existed before 1941. A multidisciplinary planning team was assembled, and various technical and pre-restoration field studies were performed as part of the planning process. In addition, a multiple-year habitat and fish population monitoring program was developed to evaluate the success of the restoration program and guide future restoration efforts (Trihey & Associates 1991).

Lee Vining Creek

Instream Flows. The majority of upper Lee Vining Creek flows are regulated by the discharge from SCE's Poole powerhouse. SCE stores water in Saddlebag, Tioga, and Ellery Reservoirs (headwaters of Lee Vining Creek) during the spring runoff period, reducing downstream flows by as much as 25% (Aquatic Systems Research 1992). Substantial inflow from several small tributary streams contributes to upper Lee Vining Creek flows and often continues through the late spring runoff period into August. In upper Lee Vining Creek, peak flows (June) range from 40 to 350 cfs, while low flows (October-April) range from 20 to 30 cfs with an occasional minimum flow of 10 cfs (Jones & Stokes Associates 1993).

Increased diversions from lower Lee Vining Creek began in 1941 when LADWP constructed a diversion structure to export water south. Until 1947, only minor flow reductions occurred in lower Lee Vining Creek. After the 1947-1951 dry period, however, all runoff was diverted. After 1951, flows in lower Lee Vining Creek occurred only during periods of high runoff.

Court-mandated interim flows have been imposed to maintain the fishery resources that were reestablished in the mid-1980s. The minimum release flow at the point of reference into lower Lee Vining Creek below LADWP's diversion structure is a court-mandated 5 cfs. Higher flows occur only in spring in above-average water years and in all months during only the wettest years. Higher minimum-flow requirements were established in April 1991 to comply with a preliminary injunction requiring LADWP to maintain a minimum Mono Lake surface elevation of 6,377 feet.

General Habitat. The geomorphic, hydrologic, vegetative, and aquatic habitat conditions in lower Lee Vining Creek have changed dramatically since LADWP began diverting water in 1940. The greatest changes have occurred in the lowermost 1.5 miles of the creek from 1,500 feet below U.S. 395 to Mono Lake; little geomorphic and vegetative change has occurred upstream from U.S. 395 to the LADWP diversion dam (Stine 1992a).

Major water diversions by LADWP after 1947 resulted in dewatering of lower Lee Vining Creek except during periods of high runoff. The extensive riparian zone became dessicated and was destroyed by fire in the early 1950s. With the loss of riparian vegetation along lower Lee Vining Creek, floodflows in the late 1960s and early to mid-1980s caused significant streambank erosion and major changes in channel morphology and location. All channels occupied by the stream today are wider, straighter, and less physically complex than the former stream system. The length of subsidiary channels has been reduced 70%. In addition, the length of the former channel has increased 0.55 mile through the former Mono Lake delta because of receding lake levels since 1941 (Trihey & Associates 1992a).

Aquatic Systems Research (1992) identified six distinct study segments in Lee Vining Creek between the Poole Powerhouse and Mono Lake and further delineated these segments into individual habitat units as a basis for an IFIM study (Figure 3D-1). Segment boundaries below LADWP's diversion dam are generally consistent with those established for habitat restoration planning (Trihey & Associates 1991) and fish population sampling (EA Engineering, Science, and Technology 1989) but include further subdivisions of the segments identified below State Route (SR) 120. The following descriptions are adapted from Aquatic Systems Research (1992) and EA Engineering, Science, and Technology (1989).

Segment 1 (5 miles) extends from the Poole Powerhouse to LADWP's diversion dam. This low-gradient segment meanders through a meadow area and consists of pools, runs, and short riffles.

Segment 2 (0.8 mile) extends from LADWP's diversion dam to the head of a bedrock gorge immediately above SR 120. Like Segment 1, Segment 2 is a low-gradient, meandering segment consisting of pools, runs, and short riffles. It has a dense riparian community consisting mostly of pines, willows, and grasses. Habitat complexity is generally low. Suitable spawning substrate is present, but trout cover is limited. Springs and return flow from the O-Ditch occur along this segment.

Segment 3 (1.0 mile) extends from the head of a bedrock gorge to U.S. 395. This steep gradient segment is confined by a narrow canyon and consists mostly of cascades. The riparian community consists of pine, cottonwood, and wild rose. Habitat complexity is fairly high; a mixture of boulders, rubble, and cobbles provides cover for juvenile and adult trout, but provides little fry or spawning habitat.

Segment 4 (0.3 mile) extends from U.S. 395 to the end of the existing riparian tree cover. The upper boundary of Segment 4 marks the beginning of an alluvial fan that extends to Mono Lake. Downstream of U.S. 395, the creek splits into a large main channel and one to three smaller side channels. Cascades and riffles are the dominant macrohabitat types. Segment 4 has characteristics similar to those in downstream segments.

Segment 5 (1.5 miles) extends from the end of the riparian tree cover to the county road. This segment is largely devoid of riparian vegetation and consists of a broad, unstable and braided channel consisting largely of riffles. Because of the scarcity of pool habitat and instream cover, adult trout habitat and refuge habitat from high flows for all trout lifestages is limited. Segment 5 is the primary focus of habitat restoration planning.

Segment 6 (0.4 mile) extends from the county road to Mono Lake. Riffles and runs make up most of the habitat. This segment is influenced by fluctuations in Mono Lake levels.

Spawning Habitat. An instream flow study of upper Lee Vining Creek between the Poole Powerhouse and the LADWP diversion suggests that brown trout spawning habitat is limited to the lowermost segments and available only at flows exceeding 18 cubic feet per second (cfs) (Wesco 1981). Because brown trout had been reproducing successfully for many years in Lee Vining Creek, however, it was assumed that spawning habitat occurs in scattered localities throughout the stream at flows of 20-30 cfs.

Little suitable spawning gravels remain in Lee Vining Creek below the LADWP diversion dam (Aquatic Systems Research 1992, Trihey & Associates 1992). The results of population monitoring indicate that the Meadow segment (Segment 2) contains most of the spawning gravels in lower Lee Vining Creek and produced at least 75% of the young-of-the-year brown trout during 1987 and 1988 when streamflow releases were 4 cfs (EA Engineering, Science, and Technology 1989).

Fish Populations. Lee Vining Creek supports wild (self-sustaining) populations of brown trout and brook trout and stocked rainbow trout. Brown trout are the dominant fish species in both the upper and lower segments of Lee Vining Creek. Brook trout is the primary subdominant species in upper Lee Vining Creek, and rainbow trout is the primary subdominant species in lower Lee Vining Creek (Wesco 1981; EA Engineering, Science, and Technology 1989.)

Estimates of the brown trout population in upper Lee Vining Creek in the late 1970s and early 1980s ranged from 130 to 528 trout per mile (Wesco 1981). Similar populations probably exist today because flow releases and habitat conditions in upper Lee Vining Creek have been stable.

Most of the flow in lower Lee Vining Creek has been diverted by LADWP since 1947. For this reason, trout populations were extirpated in this segment from the 1950s through 1970s (Aquatic Systems Research 1992). Heavy snowfall and subsequent runoff in the early 1980s, however, resulted in uncontrolled flows past LADWP's diversion facility and helped reestablish fishery resources in lower Lee Vining Creek. Brown trout biomass in lower Lee Vining Creek has now increased and was estimated at 306, 355, and 224 pounds for 1988-1990, respectively (EA Engineering, Science, and Technology 1990b).

Nongame or special-status fish species are not known to exist in Lee Vining Creek (Wesco 1981).

Management. In the past, DFG stocked substantial numbers of catchable-sized rainbow trout in Lee Vining Creek throughout most of the fishing season (Wesco 1981).

DFG currently stocks Lee Vining Creek above the conduit with rainbow trout weekly during summer. The number of fish stocked is in excess of 50,000 catchables (Parnell pers. comm.).

Fisheries management objectives have not been established for Lee Vining Creek. Lee Vining Creek has the potential to be included under the DFG's Wild Trout Project if adequate habitat is maintained (Bontadelli pers. comm.).

Restoration. The focus of habitat restoration work in Lee Vining Creek is in Segments 5 and 6 where substantial habitat degradation has occurred. Completed habitat restoration treatments in Lee Vining Creek and the treated reach length (existing channel only) as of December 1992 (English pers. comm.) include:

- constructing five spawning beds, adding cover, and removing sediment in Segment 2 (800 feet);
- providing fish passage at the abandoned dam in Segment 2 (150 feet);
- constructing a fishway in the SR 120 culvert in Segment 3 (120 feet);
- constructing a series of jump pools in the channel at SCE's substation (225 feet);
- removing debris jam and defining and rewatering historical channels in Segment 5 (0 feet); and
- excavating or constructing pools and backwater complexes and adding object cover (i.e., woody debris and cobbles) and spawning gravels in Segments 5 and 6 (2,012 feet).

Rush Creek

Instream Flows. During the 1948-1951 dry period, offstream diversions significantly affected streamflow in lower Rush Creek. During this period, water releases from Grant Lake were eliminated and in-basin irrigation was reduced, which reduced summer base flows in the bottomlands from 24 cfs to 2 cfs in 1949 (Vestal 1954). Streamflow returned only in subsequent wet years.

Coupled with the decline in Mono Lake surface elevations from LADWP's diversions, flooding in 1967 caused major geomorphological changes in the Rush Creek bottomlands. Lower Rush Creek became steeper, straighter, and deeper (Stine 1992b).

In 1971, increases in Rush Creek and tributary diversions and termination of in-basin irrigation virtually dewatered lower Rush Creek in subsequent years, except during times of exceptionally high runoff. Riparian vegetation was degraded and fish populations were eliminated in lower Rush Creek.

Uncontrolled spills past Grant Lake dam and LADWP's diversion structure caused streamflow to return to lower Rush Creek during the wet years of the early 1980s. As a result, riparian vegetation and trout populations, in particular brown trout, became reestablished in lower Rush Creek.

Since 1982, average monthly streamflows immediately below Grant Lake have ranged from a low of 17 cfs to a high of 349 cfs. Streamflow losses occur, however, as water flows from Grant Lake reservoir toward Mono Lake, especially during dry summer months. Streamflow losses between Mono Gate #1 and Mono Lake ranged from 11 cfs to 13 cfs in summer and 4 cfs to 7 cfs in fall and winter (EA Engineering, Science, and Technology 1990c; Beak Consultants 1991).

Since 1985, and including the point of reference (1989), a court-imposed minimum flow of 19 cfs has been maintained, resulting in the reestablishment of riparian vegetation and brown trout populations. A December 1989 preliminary injunction required flows between 85 and 100 cfs to maintain a minimum Mono Lake surface elevation of 6,377 feet. In June 1990, the minimum flow requirements were amended to be 40 cfs in April-September and 28 cfs in October-March with a flushing flow requirement of 165 cfs for 3 days in below-normal runoff years and 30 days in normal to above-normal runoff years. An April 1991 preliminary injunction, which superseded the June 1990 order, requires LADWP to allow sufficient water to pass its diversion facilities to maintain Mono Lake at or above 6,377 feet.

General Habitat. Existing habitat was described and mapped from Grant Lake reservoir dam to Mono Lake in 1984 (EA Engineering, Science, and Technology 1990c) and from Grant Lake reservoir dam to the county road in 1987 (Beak Consultants 1991). While both studies basically identified the same habitat types (cascade, pool, riffle, run, and rock garden), some differences between segment boundaries occurred. As described under "Prediversion Conditions", segment delineations are primarily used in this report. Segment delineations were based on analysis of topographic maps, gradient profiles, tributary influences, riparian vegetation, surrounding topography, and direct observations.

Segment 1 (1.4 miles) consisted entirely of the low-gradient (0.25%), uniformly configured conveyance channel connecting Mono Gate #1 with the natural channel of lower Rush Creek. Detailed habitat mapping was not conducted because conveyance channel is artificial. This segment was not included in Beak Consultants' IFIM study.

In Segment 2 (0.9 mile), rock garden is the most abundant habitat type (over 50%), followed by pool (17.3%) and run (13.7%) habitats. Habitat is scarce for spawning or newly emerged trout. Segment 3 (3.2 miles) is dominated by riffle (45.3%) habitat, followed by rock garden (28.1%), run (17.1%), and pool (8.4%) habitat types. Segment 4 (0.05 mile) aquatic habitat mainly consists of repeating cascade (26.5%) and plunge pool types over the majority of the segment length. The aquatic habitat in Segment 5 (1.8 miles) is dominated by run (36.4%), riffle (greater than 20%), and pool (greater than 20%) habitat types. The small substrates provide good spawning and juvenile-rearing habitat, and the scattered pools with woody debris are used by adult trout for cover. Segment 6 (1.6 miles) aquatic habitat also is characterized by a repeating sequence of pool, riffle, and run habitats. Run habitat (49.8%) dominates the segment, followed by pool (greater than 20%) and riffle (greater than 20%) habitat types. Good spawning and juvenile-rearing habitat is present, and pools with woody debris provide cover for adult trout as in Segment 5. (EA Engineering, Science, and Technology 1990c.)

EA Engineering, Science, and Technology (1990c) conducted the only habitat mapping between the county road and Mono Lake. This 0.9-mile segment (Segment 7), has relatively low gradients and sandy substrates. Trout habitat is poor because of the high concentration of sand and numerous braided channels. Following the upstream diversions and the decline in Mono Lake water surface elevations, Rush Creek began to erode the delta region that existed prior to diversions. As a result, Rush Creek has incised 20-30 feet in the Delta segment and is now eroding laterally, creating a new floodplain (Stine 1992b).

Spawning Habitat. Spawning habitat, identified by the presence of redds (nests), was evaluated as a component of population studies conducted in 1985-1989. Fifty-five redds were found between Grant Lake dam and Mono Lake. The greatest density of observed redds (9.4 per mile) occurred in the uppermost 0.85 mile of Rush Creek below Grant Lake dam. No redds were located in the lower 2.2 miles above Mono Lake. (EA Engineering, Science, and Technology 1990c.)

Lower Parker and Walker Creeks also may be important spawning and rearing habitat for Rush Creek brown trout (Vestal 1990, Court Testimony, Volumes I and II).

Fish Populations. Brown trout is the most abundant species in Rush Creek, followed by rainbow trout. Lahontan cutthroat trout have not been observed in Rush Creek for many years (Beak Consultants 1991) and probably have been extirpated.

Creel returns from the Rush Creek Test Stream Study (see "Management" below) conducted from 1947 to 1951 indicated that 10% (6,573) of the angler catch was comprised of wild trout. Of this 10%, 87% (5,716) were brown trout, 12% (791) were rainbow trout, and 1% (66) was eastern brook trout (Vestal 1954). The catch of wild brown trout remained consistent each year of the study, and catches of wild rainbow and brook trout declined. A significant finding of the 5-year study was that wild brown trout were able to sustain a population despite heavy fishing pressure and continued competition for food and space with the large numbers of planted trout. DFG continued to plant trout in Rush Creek until 1967 (Pister pers. comm. in EA Engineering, Science, and Technology 1990c).

Trout populations in Rush Creek between Grant Lake dam and Mono Lake were eliminated when increased diversions by LADWP in 1971 eliminated downstream flows. Trout recolonized Rush Creek in the early 1980s after Grant Lake spilled, and subsequent flow releases maintained Rush Creek flows. Recent fish population surveys (1985-1989) have shown that the Rush Creek fish community now consists almost entirely of brown trout with only small populations of rainbow and brook trout. The average population abundance for brown trout from Grant Lake dam to Mono Lake was estimated to range from a low of

205 pounds per mile in 1989 to a high of 362 pounds per mile in 1988. (EA Engineering, Science, and Technology 1990c.)

Threespine stickleback was the only nongame fish species collected during electroshocking from 1985 to 1989 (EA Engineering, Science, and Technology 1990c).

Management. Annual plantings of catchable-sized rainbow trout replaced brown trout plantings in 1942 and were continued until 1947. DFG established a test section in lower Rush Creek and collected creel census and fish population data over a 9-year study period (1947-1956) to evaluate the effectiveness of fish-planting procedures (Vestal 1954). From 1947 through 1952, DFG annually planted marked, catchable-sized rainbow trout and obtained annual creel census data. From 1953 through 1956, DFG annually planted marked, catchable-sized brown trout and obtained creel census data (Kabel and Butler 1956). DFG continued to plant trout until 1967 (Pister pers. comm. in EA Engineering, Science, and Technology 1990c).

Currently, Rush Creek is not planted with hatchery-reared trout. The trout population is maintained primarily by natural reproduction in Rush Creek and its tributaries and, to a lesser extent, by immigration during uncontrolled spills at Grant Lake dam during exceptionally wet years.

Restoration. Completed habitat restoration treatments in Rush Creek and the treated reach length as of December 1992 (Dalton pers. comm.) include:

- excavating portions of the Mono Gate #1 return channel, placing 1,000 cubic yards of spawning gravels, and adding rock weirs and object cover;
- placing 200 cubic yards of spawning gravels in Segments 2 and 3;
- restoring and enlarging five existing side channels and associated backwater habitat in Segment 3 (819 feet);
- enlarging and deepening existing instream pools and adding object cover in Segment 3 (291 feet);
- stabilizing and protecting eroded banks with native sod and willows in Segment 5 (300 feet); and
- constructing a fishway at the U.S. 395 crossing.

Parker and Walker Creeks

Habitat. Parker and Walker Creeks were dry at the point of reference in 1989 and provided no fish habitat. Court-ordered flows commenced on October 9, 1990, and are currently 6 cfs from October 1 through March 31 and 9 cfs from April 1 through

September 30 in Parker Creek, and 4.5 cfs from October 1 through March 31 and 6 cfs from April 1 through September 30 in Walker Creek. The court-ordered flow will nearly always exceed natural flows from September through May for Parker Creek and August through May for Walker Creek. LADWP diversions would generally occur only during snowmelt runoff in June and July of all water year types.

Court-ordered channel maintenance flows are also required: Flushing flows of 23 cfs in Parker Creek and 15 cfs in Walker Creek are required for 3 days in below-average runoff years and 30 days in above-average runoff years.

Fish Populations. DFG sampling surveys of Parker and Walker Creeks in 1986 revealed that brown and brook trout were present in both creeks during high flows (California Department of Fish and Game 1987). Rainbow trout were not collected at any of the sampling locations. Brown trout have spawned in the lower segments of Walker Creek (Morhardt 1990). At the point of reference, however, Parker and Walker Creeks were dry and devoid of fish.

No nongame fish species were collected during DFG sampling surveys of Walker and Parker Creeks in 1986 (California Department of Fish and Game 1987).

Management. Information is not available on fishery management for Parker and Walker Creeks until after 1989. For the first time in many years, permanent flows were reestablished in Parker and Walker Creeks in fall 1990. In November 1990, DFG marked and planted 1,667 catchable-sized brown trout and five rainbow trout from Fish Springs Hatchery into Parker and Walker Creeks from the Lee Vining Conduit downstream for approximately 1 mile. The objective was to augment natural recolonization and enhance recovery of these recently rewatered streams (Parmenter pers. comm.).

Restoration

Completed channel and habitat restoration treatments in Parker and Walker Creeks as of December 1992 (English pers. comm.) include:

- defining and reconstructing the natural channel and blocking old diversion channels,
- removing accumulated woody debris and brush from the channel,
- removing sod from the natural channel to expose the natural streambed,
- constructing sediment traps by connecting offstream ponds and enlarging instream pools,
- removing 20,000 cubic yards of gravel deposited in Parker Creek,

- excavating 20 existing instream pools in Walker Creek, and
- replacing the culvert on Walker Creek at the old county road.

Grant Lake

Habitat. Grant Lake inflows are provided by Rush and Lee Vining Creeks with smaller contributions from Parker and Walker Creeks. Despite diversions and controls on these inflows, Rush Creek and the Lee Vining conduit have flow regimes similar to natural conditions and are characterized by high flows in late spring and low flows in winter. Lake surface elevations are affected by LADWP demands, and low elevations occur in fall and winter and higher elevations during late spring runoff. As a result, Grant Lake reservoir exhibits vertical fluctuations of up to 30 feet in water surface elevations.

Most lake-dwelling brown trout spawn in Rush Creek above the point of slack water but within the lake inundation zone. When spring-time lake elevations are higher than the previous fall elevations, brown trout redds become inundated by the lake and mortality of eggs and recently hatched fry occurs. Some brown trout have been observed migrating up the Lee Vining conduit during spawning season, although these fish probably do not spawn successfully (Sada 1977).

Fish Populations. Little information has been published on Grant Lake fishery resources. Besides supporting a wild (self-sustaining) population of brown trout, Grant Lake may contain smaller populations of rainbow and eastern brook trout; DFG planted surplus brook trout and regularly planted many catchable-sized rainbow trout in Rush Creek above Grant Lake in the late 1970s to supplement angler catches (Pister pers. comm. in Sada 1977). DFG sampling in Rush Creek above Grant Lake from 1985 through 1986, however, revealed only brown and rainbow trout.

Several species of nongame fish have been introduced into, and reportedly occur, in the Grant Lake watershed. These species include the Owens sucker, threespined stickleback, and a hybridized form of tui chub (*Gila bicolor* ssp. *snyderi x* ssp. *pectinifer*). (Sada 1977.) Information on the occurrences of these species in Grant Lake is not available although some or all of these species may occur in the lake.

Management. Information on current fishery management for Grant Lake is not available. DFG hatchery records (California Department of Fish and Game [n.d.]) indicate that catchable-sized and broodstock rainbow, fingerling Lahontan cutthroat, and subcatchable-sized brown trout have been planted in Grant Lake. Catchable-sized rainbow trout are currently planted in Grant Lake; fingerling Lahontan cutthroat and subcatchable-sized brown trout are planted when available.

Owens River Basin

Overview

Habitat. Interbasin water conveyance in the Owens River, diversions, and impoundments (e.g., Lake Crowley reservoir, Pleasant Valley Reservoir, Tinemaha Reservoir, and Haiwee Reservoir) have been developed to meet downstream water demands and have significantly altered the natural flows in the Owens River. Diversion of the Lower Owens River (at the Los Angeles Aqueduct [LA Aqueduct]) dewaters approximately 100 miles of river habitat, including Owens Lake. Likewise, flow in the Owens River gorge below Lake Crowley reservoir was eliminated from 1940 to 1991 because of water diversions for power production. These diversions have significantly reduced or eliminated fish habitat and populations in these river segments. Flows in the Middle and Lower Owens River are regulated by Pleasant Valley Reservoir and Tinemaha Reservoir, respectively. Lake Crowley reservoir, the largest of the impoundments, inundates approximately 12 miles of Owens River habitat but provides a highly productive reservoir environment for trout.

Past and present practices of grazing and vegetation removal along many eastern Sierra Nevada streams have degraded riparian habitats and accelerated bank erosion. These degraded conditions are particularly evident on the Upper, Middle, and Lower Owens River. Combined with the effects of flow regulation, these impacts have resulted in a reduction in fish habitat quantity and quality compared to prehistoric conditions.

Fish Populations. Moyle (1976) indicates that 14 game (all introduced) and seven nongame species (three introduced and four native) exist in the Owens River basin (Table 3D-2). During 1983 surveys of 29 streams within the basin, brown trout were the numerically dominant game species, followed by brook, golden, rainbow, and cutthroat trout (Deinstadt et al. 1985). Of the nongame species, Owens sucker occupied the greatest number of sampled sections, followed by Owens tui chub, threespine stickleback, common carp, brown bullhead, largemouth bass, and bluegill. Nongame and warmwater game fish species largely are confined to the Middle and Lower Owens River, including Lake Crowley reservoir and Tinemaha Reservoir. Owens pupfish and speckled dace are no longer dominant species in major habitats of the Owens River. Nongame fish populations, except the Owens sucker, have been declining throughout their range as a result of the complex interactions between habitat alterations (e.g., water diversions, water impoundments, modified flow patterns, grazing) and competition from introduced species.

All four of the endemic fish species in the basin are recognized as special-status species: Owens sucker, Owens tui chub, Owens pupfish, and Owens speckled dace. Except for the Owens sucker, these species have experienced major declines in their historical ranges and abundances.

The Owens sucker is recognized as a state species of special concern. In general, species with this designation have declined in abundance and still occupy much of their natural range, but management is needed to prevent them from becoming threatened

(Moyle et al. 1989). Owens sucker populations occur throughout the Owens Valley, including Lake Crowley reservoir, the Owens River gorge below Lake Crowley reservoir, and the Middle Owens River.

The Owens tui chub is listed as endangered by the state and USFWS. An endangered species designation means the species is in danger of extinction throughout all or a significant portion of its range. A major factor contributing to the Owens tui chub's endangered status is hybridization with the Lahontan tui chub, which probably was introduced into Lake Crowley reservoir and rapidly spread throughout the lower segments of the Owens River system. Pure populations of Owens tui chub are restricted to five isolated locations: the Hot Creek headsprings, the Owens River gorge downstream of Lake Crowley reservoir, springs and seeps along the west shore of Owens Lake, the Owens Valley Native Fish Sanctuary, and little Hot Creek. (McEwan 1990.) None of the pure populations are found in habitats that would be affected by the EIR alternatives.

Owens pupfish also is a federal- and state-listed endangered species. Owens pupfish once were present in the Owens River system from Fish Slough and its springs to Lone Pine. The species now occurs only in Warm Springs near Lone Pine and in the Owens Valley Native Fish Sanctuary (Moyle 1976). These habitats would not be affected by the EIR alternatives.

Owens speckled dace is designated a state species of special concern. Once common throughout the Owens River basin, Owens speckled dace now are known from a few springs and creeks in Long Valley and several small tributaries and irrigation ditches in the Owens Valley near Bishop, California. These habitats would not be affected by the EIR alternatives.

Management. Most of the streams and lakes in the Owens River basin are heavily fished throughout the typical fishing season (May through October). In response to fishing pressure, DFG stocks most of these streams and lakes with rainbow, brown, eastern brook, and Lahontan cutthroat trout. Most of the trout planted are catchable size, but fingerling-, subcatchable-, and catchable-sized, and trophy-sized fish also are stocked. Trout populations are maintained by natural reproduction, intensive stocking, or both.

Generally, fishing regulations in Mono Basin apply to the Owens River basin. Special regulations apply to certain other lakes and streams, including Lake Crowley reservoir and its tributaries and the Owens River between Pleasant Valley Dam and Five Bridges Road. (California Department of Fish and Game 1992c.)

DFG manages the 16-mile-long section of the Middle Owens River from Pleasant Valley Dam to Five Bridges Road as a component of the Wild Trout Program. Wild brown trout is the management species, and no trout are planted in this section of the Owens River. The fishing season is open all year, but the daily bag limit is two trout. Other streams in the region, including lower Rush Creek, also are managed for wild trout and are not planted with hatchery trout. Fish populations in streams managed as wild trout fisheries are maintained by a combination of natural reproduction and immigration from upstream or downstream areas.

In part of the agreement between the City of Los Angeles and the California Fish and Game Commission, the city granted the commission permanent use of the Hot Creek Hatchery site and contributed $25,000 toward construction of the hatchery in lieu of constructing fishways at Grant Lake and Long Valley Dams in 1940 (Leitritz 1970). Today, hatchery production is carried out at several DFG hatchery facilities in the Owens River basin, including Hot Creek, Fish Springs, and Mt. Whitney-Black Rock Hatcheries. Hot Creek Hatchery produces about 75% of all hatchery-planted fish in Inyo and Mono Counties.

Upper Owens River

Instream Flows. The Upper Owens River meanders through Long Valley for over 20 miles from Big Springs to its terminus at Lake Crowley reservoir (Figure 3D-3). The river is supplied by springs and snowmelt runoff, and by its major tributary, Hot Creek. Upper Owens River flows were augmented by water diversions from Mono Basin by LADWP beginning in 1941. Diversion flows from Mono Basin increased the annual average Upper Owens River flows by nearly 100 cfs, or approximately 120%, with substantial flow increases occurring in every month. Average annual flows for 1941-1989, as measured above and below East Portal, were 58 cfs and 168 cfs, respectively. Flows downstream of East Portal are subsequently modified by ungaged diversions for bypassing flow around portions of the main river or for irrigating adjacent pastures; however, the dominating characteristic of Upper Owens River flows remains the LADWP exports from Mono Basin. The resulting flows in the Upper Owens River have altered channel locations, current velocities, stream widths, streambanks, water temperatures, and sediment transport and sediment deposition. (EBASCO Environmental et al. 1993.)

These flow augmentations to the Upper Owens River were essentially the point-of-reference conditions in August 1989, with some reductions in the flows because of court-ordered instream flow requirements in Rush and Lee Vining Creeks that otherwise would have been exported into the Owens basin.

Instream flows in the Upper Owens River have been modified since August 1989 by additional court-ordered flows in Mono Basin. In 1990, the court ordered increased streamflows for Mono Basin tributaries downstream of LADWP's conduit. In 1991, LADWP was ordered by the court to maintain Mono Lake at 6,377 feet before diverting water from Mono Basin to the Upper Owens River. As a result of these orders and the absence of surplus waters because of the 1987-1992 drought, Upper Owens River flows have been at natural rates since 1991, although flows were augmented in October 1991 for the purpose of conducting an instream flow study. (EBASCO Environmental et al. 1993.)

Habitat. From East Portal to Lake Crowley reservoir (Figure 3D-3), the Upper Owens River is characterized by multiple channels and a sand and gravel bed. The river geomorphology can generally be defined as an interconnecting network of low-gradient, relatively deep and narrow, straight to sinuous channels with stable banks composed of fine-grained sediment and vegetation (Smith and Smith 1980 in EBASCO Environmental et al. 1993). Flood channels flank the sinuous main channel and have formed from historical overbank floods, which have increased in frequency and duration since Mono Basin exports began in 1941. Channel length and meander bends also have been reduced since 1944 by 3.6 miles of river channel, with most of this loss upstream of Hot Creek and attributed primarily to the Mono Basin exports. Despite geomorphic changes, adequate flushing flows exist in the Upper Owens River regardless of hydrologic condition or Mono Basin exports. (EBASCO Environmental et al. 1993.)

Woody riparian vegetation occurs sporadically along the Upper Owens River and is dominated by willows and a variety of herbaceous species. The upper portions of the Upper Owens River contain most of the riparian vegetation, and the lowermost sections contain little or no woody riparian vegetation. Historical accounts indicate that riparian vegetation was also lacking in 1925. Aquatic macrophytes also provide important cover and macro-invertebrate habitat in the Upper Owens River (EBASCO Environmental et al. 1993).

Water exports from Mono Basin into the Upper Owens River have eroded and widened the channel below the East Portal discharge. Fluctuations in Lake Crowley reservoir storage have periodically exposed or inundated the lowest portion of the Upper Owens River channel. Irrigation diversions have reduced flows along various reaches of the main channel. Livestock grazing has occurred all along the Upper Owens River and has reduced vegetative cover, compacted soils, and eroded streambanks. Streambank erosion and concomitant loss of streamside vegetation can affect fish populations by reducing undercut bank cover and availability of terrestrial insects. Livestock grazing enclosures constructed along portions of the Upper Owens River have increased herbaceous species diversity, density, and height within the enclosures, illustrating the adverse effects of grazing practices. (EBASCO Environmental et al. 1993.)

The Upper Owens River comprises three segments with differing hydrology, geomorphology, and land use practices (Figure 3D-3). Segment 1 extends from East Portal to the most downstream major water diversion and is characterized by bypass channels or diversions of varying capacity and less than 20% shaded riverine conditions. Segment 2 extends to the Hot Creek confluence and is characterized by lower mean flows, an absence of major diversions, and less than 20% shaded riverine conditions. Segment 3 extends to Lake Crowley reservoir and is characterized by decreased pool habitats, higher average flows than other reaches due to the contribution of Hot Creek, and no shaded riverine conditions. Glides and runs provide the greatest habitat types in each segment, followed by riffles, and then pools. Only four pools were defined in Segment 3 in 1990. (EBASCO Environmental et al. 1993.)

Arsenic concentrations are relatively high near Benton Crossing because of Hot Creek and a nearby active geothermal area, and impacts on fish may be occurring. Effects from elevated arsenic concentrations should be considered tentative, however, until further data are developed. (EBASCO Environmental et al. 1993.)

Fish Populations. Native fish species of the Upper Owens River include Owens tui chub and Owens sucker (Moyle 1976). The Owens tui chub was observed only in Hot Creek recently, while the Owens sucker was observed in Hot Creek and in the Upper Owens River. Three introduced species are known to occur in the Upper Owens River: brown trout, rainbow trout, and threespine stickleback. (Deinstadt et al. 1986 in EBASCO Environmental et al. 1993.) Lahontan cutthroat trout probably inhabit the Upper Owens River because they were planted there during 1987 and 1989 (Pickard pers. comm.). Fish planting practices in Lake Crowley reservoir also affect fish populations in the Upper Owens River. (EBASCO Environmental et al. 1993.)

Brown and rainbow trout density estimates were highest in Segment 1 and lowest in Segment 3 during 1990 sampling. Mean brown trout biomass estimates were 249, 53, and 22 pounds per acre in Segments 1, 2, and 3, respectively. Mean rainbow trout biomass estimates were 97, 38, and 49 pounds per acre in Segments 1, 2, and 3, respectively. Total trout biomass estimates of 346, 91, and 71 pounds per acre for Segments 1, 2, and 3, respectively, are comparable to or higher than estimates for the Upper Owens River in previous studies and for other Sierra Nevada streams. Gerstung (1973 in EBASCO Environmental et al. 1993) reported a mean biomass of 41 pounds per acre for 278 northern Sierra Nevada stream sections and a mean biomass of 37 pounds per acre for 65 south Sierra Nevada stream sections. A mean of 73 pounds per acre was estimated for 73 selected streams in the Sierra Forest Ecoregion (Platts and McHenry 1988 in EBASCO Environmental et al. 1993).

Catchable trout populations are larger in the Upper Owens River than estimated for other Sierra Nevada streams; brown and rainbow trout up to 18-20 inches in length are present in the fishery. Trout growth rates and condition generally exceed average values reported for other Sierra Nevada streams. Aquatic macroinvertebrate populations are relatively large and diverse, and food production does not appear to be a limiting factor to trout production. The Upper Owens River, therefore, contains large trout populations and maintains an excellent fishery, particularly in Segment 1. (EBASCO Environmental et al. 1993.) The excellent fishery is maintained in part by controlled access and catch-and-release regulations on private land.

Major migrating periods of brown and rainbow trout from Lake Crowley reservoir into the Upper Owens River occur primarily in October and November for fall-run brown trout and March through May for the spring-run rainbow trout (Milliron pers. comm.). Fall-run rainbow trout make up a much smaller spawning run in late summer and fall. No instream barriers exist from just below East Portal downstream, and successful upstream migration can be achieved at low lake levels with river discharges exceeding 20 cfs (EBASCO Environmental et al. 1993). Consequently, Lake Crowley reservoir trout have spawning habitat available to them throughout the Upper Owens River under a range of hydrologic conditions.

Management. DFG routinely plants catchable- and subcatchable-sized rainbow trout in the Upper Owens River (Pickard pers. comm.) During 1985-1987 and 1989-1991, an average of 221,206 rainbow trout were planted annually in the Upper Owens River near

Benton Crossing. An average of 42,501 per year were of catchable size. During this same period, an average of 4,577 catchable-sized rainbow trout were planted upstream near Big Springs. Additionally, 122,304 subcatchable-sized Lahontan cutthroat trout were planted in the Owens River near Benton Crossing. During 1987 and 1989, a total of 200,052 subcatchable-sized Lahontan cutthroat trout were planted near Big Springs. (EBASCO Environmental et al. 1993.)

Lake Crowley Reservoir and Tributaries

Habitat. Lake Crowley reservoir is highly productive compared to other eastern Sierra Nevada lakes because of its high alkalinity, moderate lake level fluctuations, and shallow depth. The initial filling of the reservoir inundated extensive meadowland and sagebrush flats, which now provide productive habitat for bottom-dwelling chironomid larvae, a principal prey species for trout.

Trout growth in Lake Crowley reservoir is excellent compared to growth in other eastern Sierra Nevada lakes. Differences in overwinter growth of subcatchable-sized trout appear to be related to the severity of winter conditions (i.e., extent of ice cover) and the reservoir operations, which determine the amount of productive shoal area (Pister 1965). The summer diet of trout mainly consists of chironomid pupae, cladocera (*Daphnia* sp.), and fish (Sacramento perch, tui chub) (Pister 1965, Loudermilk pers. comm.). Recent food habit studies also have been conducted to examine potential effects of algal control practices (e.g., copper sulfate treatment) on zooplankton populations and potential secondary effects on fish growth (Loudermilk pers. comm.).

The Upper Owens River and Hot, Convict, McGee, Hilton, Whiskey, and Crooked Creeks provide spawning habitat for lake-dwelling brown and rainbow trout. Significant spawning habitat is located in the Upper Owens River and Hot, Convict, and McGee Creeks, but high water temperatures can reduce egg and alevin survival in Hot Creek, especially after runoff (Wong pers. comm.). Juvenile trout produced naturally occur in the Upper Owens River and Convict Creek, but the extent of stream or lake rearing is unknown.

Fish Populations. Game fish populations in Lake Crowley reservoir and its tributaries are the result of past introductions and an intensive stocking program. Rainbow trout of different strains is the most abundant game species, followed by brown trout, Sacramento perch, and Lahontan cutthroat trout. The principal nongame species are Owens sucker and Owens tui chub, which provide important forage for the trout.

Spawning rainbow and brown trout occur in virtually all Lake Crowley reservoir tributaries, including the Upper Owens River and Hot, Convict, McGee, Hilton, Whiskey, and Crooked Creeks. Spring and fall spawning runs of rainbow trout in the Upper Owens River may consist of planted rainbow trout or wild trout representing a mixture of any of the strains planted in the past. Planted and wild brown trout contribute to fall spawning runs in the Upper Owens River and Lake Crowley tributaries. The contribution of natural spawning to the lake or tributary trout populations is unknown. (Wong pers. comm.)

Management. Lake Crowley reservoir supports one of the largest trout fisheries in California. Since the opening of the reservoir to angling in 1941, reservoir fishery management has focused on the annual stocking of many hatchery-reared trout to meet increasing public demand for angling. Early management practices primarily consisted of annual plants of fingerling brown and rainbow trout. Since 1951, stocking practices have shifted increasingly toward summer and fall (end of season) plants of subcatchable-sized rainbow trout, which has increased angler success considerably (Pister 1965). Since 1975, the reservoir has received annual plants of 200,000-450,000 subcatchable- and catchable-sized rainbow trout of a variety of strains and 100,000 subcatchable-sized brown trout. In addition, surplus broodstock and fingerling rainbow, brown, and Lahontan cutthroat trout are planted periodically (Pister 1965).

Catch rates in the reservoir are generally high early in the season (May) but then gradually decline throughout the remainder of the season (June-July). DFG has sought to improve late season fishery through an experimental planting program designed to evaluate the long-term survival and growth qualities of various rainbow trout strains. Current management goals emphasize maintaining a high-yield early season fishery and providing opportunities to catch trophy-sized fish. In 1985, a trophy trout season with restrictions on size, fishing gear, and bag limit was established from August 1 through October 31. Larger trout are important to sustain spawning runs and tributary fisheries.

Lake Crowley reservoir management practices have been evaluated by conducting a creel census program, primarily on weekends, throughout the angling season. In recent years, angler surveys have been conducted the opening weekend or periodically during the season. Evaluations are based on angler use and catch rates from season to season and the returns of marked subcatchable-sized trout planted in previous years. Angler surveys and trapping studies have been initiated on reservoir tributaries to evaluate existing angling regulations relative to angler use and success, and run timing and composition (Wong pers. comm.).

Middle Owens River

Instream Flows. Water diversions from Mono Basin, together with the creation and operation of Lake Crowley reservoir, have changed the Middle Owens River flow regime considerably. After the completion of the Mono Craters Tunnel and Long Valley Dam, the average annual flow increased from 245 to 366 cfs; flows were higher than preproject levels throughout the year and peak monthly flows averaging between 400 and 500 cfs extended through the summer months during 1948-1970. In 1971, export capacity increased by nearly 50%, thus increasing the average annual flow to 436 cfs during 1971-1976. Peak monthly flows exceeded 500 cfs during summer.

Minimum instream flow releases below Pleasant Valley Dam were established in 1961 at 75 cfs. LADWP notifies DFG when flows below Pleasant Valley Reservoir drop below 100 cfs (Pickard pers. comm.). In March 1966, DFG recommended that a constant, or gradually fluctuating, flow of at least 200 cfs be maintained from October 15 through

April 15 to provide suitable spawning flows and protect developing eggs and young in the gravel (Wong pers. comm.). Flows up to 500 cfs were appropriate during this period only if increases were made gradually. The 75-cfs minimum flow standard and DFG's recommendations remain unchanged at present.

Sustained high flows ranging from 400 cfs to 600 cfs from November through March 1978 were identified as potentially limiting brown trout recruitment in 1979 (Deinstadt and Wong 1980b). These flows apparently formed a complete barrier to upstream migrating adults at culverts below the Pleasant Valley spawning channel during the November-December spawning period. In addition, high water current velocities during the spawning and early rearing period may have restricted the amount of usable spawning and fry habitat in the main channel of the Owens River.

Habitat. Since 1948, increased flows in the Middle Owens River below Pleasant Valley Dam have resulted in increased mean width of the channel and loss of undercut banks. Since 1967, accelerated bank erosion rates along the Owens River below Pleasant Valley Dam have been attributed to increases in the flow regime (Ponder and Deinstadt 1978). Also contributing to increased erosion and loss of bank cover along the Middle Owens River was the removal, spraying, and burning of riparian vegetation by agricultural and grazing interests from the 1950s to 1970s (Ponder and Deinstadt 1978).

Since Pleasant Valley Dam was completed in 1954, downstream gravel movements from upper portions of the drainage have been blocked. The reduced gravel supply, combined with higher flows below the dam, has reduced the quantity and quality of suitable spawning gravels, degraded the streambed, and armored the streambed with coarser substrate. These changes have continued downstream, and observations in 1977 indicated that the process may have affected approximately half of the wild trout segment (Williams 1975). Fish migration from the Middle Owens River to spawning habitat located in the lower segments of Pine and Rock Creeks also was eliminated following dam construction. To compensate for the lost spawning habitat, an artificial spawning channel was constructed downstream of the dam (see "Management" below).

Brown trout spawn primarily in the gravel-bottom runs of the Middle Owens River within the wild trout management area. A survey of the entire Middle Owens River in November and December 1990 revealed the presence of redds from Pleasant Valley Dam to Big Pine canal, with most redds concentrated in the upper one-third of the wild trout segment.

Existing habitat in the Middle Owens River reflects the generally low river gradient and erodible nature of the Owens Valley floor, and sinuosity prevails throughout the segment. Observed changes in general channel features from Pleasant Valley Dam to Tinemaha Reservoir include a gradual decrease in stream gradient (approximately 0.4% to less than 0.1%), increased channel width, and increasing proportions of fine sediment. Actively eroding banks are common along the outside of meander bends, especially along the segment below Laws Creek ditch. Detailed information on habitat characteristics of the Middle Owens River are presented in Jones & Stokes Associates (1992).

Water Quality. Water quality problems in Pleasant Valley Reservoir have affected the Middle Owens River below Pleasant Valley Dam. In August 1974, an algae bloom and several days of cloud cover without wind reduced dissolved oxygen to less than 0.5 parts per million (ppm) in Pleasant Valley Reservoir and caused a complete fish kill in the Middle Owens River from the dam to Pleasant Valley campground. A similar event in 1977 resulted in a "near fish kill" (Ponder and Deinstadt 1978). An aerating device was subsequently installed at Pleasant Valley Dam to overcome future oxygen depletion problems in the river below Pleasant Valley Reservoir (Ponder and Deinstadt 1978).

Fish Populations. Introduced game fish in the Middle Owens River include brown trout, rainbow trout, brown bullhead, largemouth bass, and bluegill. Brown trout are the dominant game fish in the wild trout management section, a 16-mile segment immediately below Pleasant Valley Reservoir. Recent surveys and tagging studies indicate that the river 1.5 miles downstream of Pleasant Valley Dam, including the river channels within the existing campground, contains the highest brown trout densities within the wild trout segment (Worthley pers. comm.). Below the wild trout segment, catchable-sized rainbow trout are seasonally abundant in areas where DFG continues to plant these fish.

DFG brown trout surveys in fall 1977 and 1979 detected reduced trout abundance and biomass in 1979, which was attributed primarily to poor recruitment of subyearling trout (Deinstadt and Wong 1980a, 1980b).

Nongame species in the Middle Owens River include carp, threespine stickleback, Owens sucker, and Owens tui chub. Recent surveys indicate that Owens pupfish are present only in a few isolated springs, while speckled dace occur in small tributaries and irrigation ditches in the Owens Valley near Bishop, California. Tui chubs are present in the main river, but their numbers have declined (Moyle 1976). In contrast, Owens suckers have maintained relatively large populations in the Middle Owens River.

Management

Wild Trout Management Area. Before 1968, the Middle Owens River supported a predominantly put-and-take fishery maintained by annual plants of hatchery-reared rainbow trout from several state hatcheries. Following an evaluation of the trout fishery in 1967 and 1968, DFG discontinued stocking of hatchery-reared rainbow trout and began managing the 16-mile segment between Pleasant Valley Dam and Five Bridges Road bridge as a wild brown trout fishery (Segment 2, Figure 3D-4). In 1972, the segment was included under the newly created wild trout management program. The primary purpose of the program is to preserve high-quality trout fisheries sustained by naturally produced wild trout strains. The wild trout reach has become California's top brown trout stream in terms of angler use and number of trout harvested (Deinstadt and Wong 1980a).

DFG's general management recommendations for the wild trout area, as outlined in the Lower Owens River Management Plan (Ponder and Deinstadt 1978), include:

- maintaining angling opportunities and harvest levels attractive to wild trout anglers;
- providing optimal flow, water quality, and physical habitat conditions;
- providing for recreational use of wild trout while minimizing uses not compatible with wild trout angling; and
- preserving or restoring the natural character of the streamside environment.

Additional recommendations include coordinating with LADWP to continue policies and operations beneficial to the fishery, continuing efforts to correct conditions recognized as detrimental to the trout population and fishery, and attempting to define more clearly the changes that could improve brown trout production (Ponder and Deinstadt 1978).

DFG initiated monitoring of the Owens River brown trout fishery in 1967. Creel surveys within the wild trout management area revealed a decline in angler use and catch between 1967 and 1976 (Deinstadt and Wong 1980a). During this period, catch rate (catch per angler hour) and age structure of creeled brown trout fluctuated but without apparent trends (Ponder and Deinstadt 1978). Creel surveys in 1981, 1985, and 1988 indicated that use increased slightly from the previous levels. The proportion of fly anglers and fish released also has increased (Deinstadt 1988).

Angling in the Middle Owens River is open year round. Before 1980, regulations within the wild trout area included a 10-trout limit during the general season and a five-trout limit in winter with no gear restrictions. In 1980, the limit was reduced to two fish year round with no gear restriction. The river section from Five Bridges Road bridge to the U.S. Highway 6 bridge is being considered for inclusion in the wild trout management area (Deinstadt pers. comm.).

Pleasant Valley Spawning Channel. The Pleasant Valley Spawning Channel, located approximately 0.5 mile downstream from Pleasant Valley Reservoir, was constructed by LADWP in 1962 with guidance from DFG. The purpose of the artificial spawning channel is to compensate for inundated trout spawning areas above Pleasant Valley Dam and provide a supplementary spawning area for resident trout below the dam. The spawning channel essentially is a diversion loop of the main stream with structures that regulate channel flows and prevent upstream migrating brown trout from bypassing the channel.

Periodic monitoring of brown trout spawning and channel maintenance has been performed by LADWP with DFG guidance. An estimated 200 to 500 spawning brown trout entered the spawning channel annually between 1967 and 1972. DFG recognized the Pleasant Valley spawning channel as an increasingly important spawning area for upstream migrants because of reduced suitable spawning areas in the main channel of the river.

Based on a 1961 agreement between LADWP and DFG, a minimum flow release of 75 cfs from Pleasant Valley Dam was established for proper operation of the spawning channel.

Lower Owens River

Habitat. Before 1986, the Lower Owens River channel was dry because of LA Aqueduct operations. Since June 1986, a continuous flow in the Lower Owens River has been reestablished through cooperative efforts of Inyo County and the City of Los Angeles to implement the existing habitat management plan, which was drafted in 1988. A formal agreement between Inyo County and the City of Los Angeles has not yet been reached. (Tillemans pers. comm.)

Fish Populations. The Lower Owens River below Tinemaha Reservoir supports limited populations of warmwater game fish, including largemouth bass, smallmouth bass, bluegill, channel catfish, brown bullhead, and possibly redear sunfish. Coldwater game fish include brown trout and planted rainbow trout; nongame fish include carp and mosquitofish (Milliron pers. comm.).

Management. The current focus of fisheries management in the Lower Owens River is to enhance existing warmwater fisheries through implementation of the Lower Owens River Habitat Management Plan. A key element of the proposed plan is to provide a continuous, but seasonally variable, flow in the normally dry portion of the Owens River between Blackrock Springs and Owens Lake (Tillemans pers. comm.). The objectives of the plan are to improve existing fisheries and waterfowl habitats and create additional recreational opportunities in the southern Owens Valley.

The coldwater fishery in the Lower Owens River is maintained largely by plantings of catchable-sized rainbow trout downstream of Tinemaha Reservoir (Lipp pers. comm.).

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

Habitat. Pleasant Valley Reservoir receives inflows from the Owens River, which flows out of LADWP's powerhouse approximately 0.75 mile upstream of Pleasant Valley Reservoir. Inflows are mostly controlled and can vary daily from releases for power production, while uncontrolled tributary inflows from Rock and Pine Creeks during spring also can cause brief seasonal variations in flow. Reservoir surface elevations are relatively stable because Pleasant Valley Reservoir is relatively small and is not operated as a water-storage facility; rather, it is operated as a reregulating reservoir to control releases from LADWP's powerhouse. The Owens River below LADWP's powerhouse and tributary streams, such as Rock and Pine Creeks, provide spawning habitat for Pleasant Valley Reservoir brown and rainbow trout.

The initial filling of Tinemaha Reservoir inundated several miles of riparian and sagebrush habitats. Tinemaha Reservoir is relatively shallow, provides short-term regulation of Owens River flows, and experiences daily fluctuations. Recent earthquake safety concerns have further limited the usable storage of the reservoir. Tinemaha Reservoir receives inflow from the Middle Owens River and Tinemaha Creek.

Haiwee Reservoir consists of two connected reservoirs: North and South Haiwee. Haiwee Reservoir receives inflow from the LA Aqueduct and is operated in similar fashion as Tinemaha Reservoir and therefore experiences daily water surface fluctuations. Recent earthquake concerns have limited the usable storage of Haiwee Reservoir. LADWP has treated Haiwee Reservoir with copper sulfate since the 1950s to control taste and odor problems (White pers. comm.).

Fish Populations. Based on unpublished DFG file memoranda, Pleasant Valley Reservoir contains brown trout, rainbow trout, largemouth bass, catfish (bullhead), Sacramento perch, tui chub, Owens sucker, and carp.

Tinemaha Reservoir supports a limited fishery comprised primarily of largemouth bass, bluegill, and bullhead (Milliron pers. comm.).

North Haiwee Reservoir supports known populations of smallmouth bass, largemouth bass, rainbow trout, bluegill, and carp. Brown trout, channel catfish, bullhead, tui chub, and mosquitofish also may occur. Fish species in South Haiwee Reservoir probably are similar to those found in North Haiwee Reservoir (Pickard pers. comm.).

Management. The fishery in Pleasant Valley Reservoir is maintained largely by plants of catchable-sized rainbow trout. During the 1950s, DFG planted brown trout in Rock Creek to maintain the tributary fishery. Brown trout are nearly self-sustaining and form a small percentage of the total catch in Pleasant Valley Reservoir.

Los Angeles Aqueduct and Irrigation Canals

Habitat. The portion of the LA Aqueduct from the intake structure near Aberdeen to the Alabama spillgate near Lone Pine consists of an unlined, incised ditch. Below the Alabama spillgate, the aqueduct is a lined canal. Riparian vegetation along the unlined portion of the aqueduct is limited because of the steep banks. Consequently, instream and overhead cover is limited to areas with instream vegetation and to areas where willows have become established along the margins of the aqueduct.

Fish Populations. The unlined portion of the LA Aqueduct supports limited populations of warmwater and coldwater species, including largemouth bass, smallmouth bass, carp, channel catfish, bullhead, bluegill, brown trout, and rainbow trout (Lipp and Tillemans pers. comms.). Fish populations are maintained through natural reproduction and recruitment from upstream sources. Rainbow and brown trout populations probably are maintained by natural reproduction in the creeks that drain the east side of the Sierra Nevada (Tillemans pers. comm.). The aqueduct captures many of these creeks as it winds along the western edge of the Owens Valley.

Management. Currently, no fish are planted in the unlined portion of the LA Aqueduct. Fish populations are maintained through natural reproduction and recruitment from upstream and downstream sources. Fishing is limited; however, several places along the aqueduct are popular with anglers and locally are used intensively.

IMPACT ASSESSMENT METHODOLOGY

The LAAMP model output provides the primary quantitative basis from which to develop response variables, analytical frameworks, and assessment models to assess fisheries impacts of each Mono Basin EIR alternative. Each alternative manifests its effects on the aquatic ecosystem by changing instream flows, as simulated by the LAAMP model. Consequently, response variables that vary with streamflow were identified, and relationships between these response variables and streamflow were developed when possible to most effectively evaluate impacts to fishery resources.

Optimal design of an environmental impact assessment methodology and integration approach for the Mono Basin EIR involves developing consistent response variables, analytical frameworks, assessment models, and ranges of impact thresholds. Unfortunately, the databases available for each of the streams and reservoirs vary widely, despite attempts to develop relatively consistent databases since initial instream flow studies began on Rush Creek in 1987. Most importantly, models used to determine the effects of streamflow changes on fish response variables are unavailable, provide only limited use, or may be affected by a combination of the 1987-1992 drought, ongoing habitat restoration efforts, and channel disequilibrium from relatively recent stream rewatering. For these reasons, the fisheries impact assessment for the Mono Basin EIR primarily consists of qualitative interpretations of the complex relationships between available quantitative fisheries data and LAAMP model output. Only the habitat-based models and specific hydrologic variables known to affect fisheries resources were developed sufficiently for quantitative impact assessments methodologies to be conducted.

Several examples are cited to indicate the problems associated with developing standard methodologies for fisheries impact assessments for the Mono Basin EIR. Parker and Walker Creeks underwent channel modifications (woody debris removal), flow modifications (rewatering), and fish plantings in fall 1990; consequently, the stream channels and fish populations have not developed a dynamic equilibrium, and data and models relating fisheries habitat or populations to flow are nonexistent. Extensive fisheries studies have been conducted on Rush and Lee Vining Creeks, but recent and proposed habitat restoration efforts may limit the usefulness of these assessment models and results, particularly during future management efforts. In addition, the results of the instream flow investigations on Lee Vining Creek and the Upper Owens River were still subject to revision during the EIR analysis phase. Data on fisheries resources and instream flows in the Upper and Middle Owens River have only recently become available, and multiyear data collection efforts on these rivers are limited.

Impact Prediction Methodology

Physical Habitat

Tennant Method. Quantitative relationships between physical habitat and discharge do not exist for Parker and Walker Creeks, and the Tennant Method was used to evaluate habitat conditions, since it requires limited data and has been applied to a broad range of streams throughout the United States (Wesche and Rechard 1980). The Tennant Method is based on a simple relationship between general aquatic habitat conditions and the magnitude of the base flow expressed as a percentage of average annual discharge for a given stream. According to this method, 10% of the average annual flow provides only short-term survival conditions for most aquatic life forms, 30% of the average flow provides good aquatic habitat conditions, and 60% of the average flow provides excellent to outstanding habitat conditions (Tennant 1975). Tennant provides two sets of criteria, adjusted for seasonal differences in flow ratings, and these criteria were applied to Parker and Walker Creeks based on average annual historical discharge in these two creeks (Table 3D-3).

Using LAAMP results for each alternative (Jones & Stokes Associates 1993), habitat conditions were rated for dry (20%), normal (50%), and wet (80%) hydrologic conditions for each month based on the Tennant criteria in Table 3D-3. Tennant qualitative habitat descriptions were then assigned numeric values ranging from 0 for flows associated with severely degraded conditions to 5 for optimum conditions. All monthly values were averaged to generate a single value representing the average habitat conditions for dry, normal, and wet hydrologic conditions under each alternative.

Instream Flow Incremental Methodology. The Instream Flow Incremental Methodology (IFIM) uses an index of habitat (weighted usable area [WUA]) to quantify habitat available to selected aquatic species and life stages under various flow regimes (Bovee 1982). IFIM habitat-discharge relationships for Rush Creek (Beak Consultants 1991), Lee Vining Creek (Aquatic Systems Research 1992), the Upper Owens River (EBASCO Environmental et al. 1993), and the Middle Owens River (Jones & Stokes Associates 1992) were used to predict physical habitat under simulated hydrology (Jones & Stokes Associates 1993) for each alternative. Impact analyses based on the habitat-discharge relationships focused on specific stream segments and brown trout lifestages generally limiting fish populations.

Rush Creek. Impact predictions were limited to Segments 3, 5, and 6 of lower Rush Creek because these segments contain most of the brown trout spawning, fry, juvenile, and adult habitat in lower Rush Creek (Beak Consultants 1991). Segment 1 was excluded because it is a deep, uniform artificial channel with little habitat diversity. Segment 2 was excluded because it is a relatively short, steep gradient reach contributing only a small portion (less than 10%) to the total available habitat and exhibiting only minor habitat change over a broad flow range. Segment 4 was excluded because it is a very short reach contributing little (less than 2%) to total fish habitat.

Lee Vining Creek. Impact predictions were limited to Segments 2, 5, and 6 of lower Lee Vining Creek. Segment 1 was excluded because it is located upstream of the LADWP diversion and was not included in DFG's IFIM study (Aquatic Systems Research 1992). Segment 3 was excluded because of unrealistic hydraulic simulations resulting from turbulence, air entrainment, and transect placement restrictions (Aquatic Systems Research 1992). Segment 4 was also excluded because of its small contribution (less than 10%) to total habitat values.

Segment 2 is the primary source of brown trout production and recruitment in lower Lee Vining Creek because of the scarcity of adult and spawning habitat in Segments 5 and 6 (Aquatic Systems Research 1992; EA Engineering, Science, and Technology 1989). In comparison, fry habitat in these lower segments is abundant and does not currently limit brown trout populations in this portion of the creek. Consequently, habitat evaluations for Lee Vining Creek focused on Segment 2, and Segments 5 and 6 were considered only with respect to impacts on juvenile, adult, and spawning habitat. Habitat restoration efforts were implemented after the IFIM study was conducted but have not significantly altered the habitat-discharge relationships (Aquatic Systems Research 1992).

Upper Owens River. Impact predictions for brown trout and rainbow trout were developed for all three segments identified for the Upper Owens River.

Middle Owens River. Impact analyses for the Middle Owens River were limited to Segments 1, 2, and 3, which account for most of the wild brown trout production in the Middle Owens River. Habitat evaluations for aquatic invertebrates were also limited to these segments because of their importance as food for brown trout. Largemouth bass habitat was evaluated only in Segment 4, where historical habitat conditions have been most suitable for largemouth bass production. Native fish species in the Middle Owens River were not evaluated because few, if any, data exist on their habitat preferences and sampling their populations would be extremely difficult.

Impact Prediction Methods. Impact assessments for brown and rainbow trout spawning and fry stages were limited to the principal spawning and fry rearing periods in each stream. The seasonal occurrence of each trout life stage was determined from the most relevant literature and modified according to any observed temperature-related differences in the timing of various life stages in each stream (Table 3D-4). Although fall-spawning rainbow trout occur in the Upper Owens River, it was assumed that the dominant rainbow trout life history pattern is characterized by spring spawning. Brown trout juveniles and adults are present throughout the year, but WUA was determined only for April-October because underlying habitat suitability criteria were developed from observations during this period and may not be applicable to winter conditions. The April-October period is also more important for brown trout growth than are winter months, and competition for food and space is probably greatest during spring and summer.

Under some alternatives, simulated flows in lower Rush Creek and Lee Vining Creek exceeded the flow range used for habitat simulation in the IFIM studies. Consequently, WUA predictions for brown trout life stages could not be quantified in these cases.

Habitat-discharge relationships for each life stage and stream indicate that WUA was generally constant at the highest modeled flows; therefore, monthly flows outside the range of the IFIM for a specific life stage were given a WUA value equal to that associated with the maximum simulated flows in each IFIM study (100 cfs for both Rush and Lee Vining Creeks). This rule was applied in all cases to maintain consistency and facilitate comparisons among alternatives. The uncertainty of the effects of higher flows on physical habitat was considered when interpreting results, especially when flows greatly exceeded the modeled range.

Habitat time series for each alternative were constructed by integrating habitat-discharge relationships with the monthly flow simulations generated by the LAAMP model for the 1940-1989 hydrologic period (Jones & Stokes Associates 1993). Monthly WUA values for each life stage were first computed for each selected segment. Because flows vary longitudinally, WUA predictions for each segment, and sometimes within subsegments, were based on their respective flows after adjustments were made for any known streamflow gains and losses. Accordingly, the resulting WUA values were weighted by the respective length of each segment or subsegment, then summed to yield the corrected prediction of total WUA.

Monthly WUA values for each segment and life stage were averaged and summed to obtain a single WUA value representing the average amount of habitat available in a given year. These values were graphed as a time series of annual WUA values for each alternative to examine annual differences in available habitat over time. Annual changes in WUA were presented graphically for each alternative and summarized for each life stage as the overall average WUA over the 1940-1989 hydrologic period. WUA predictions for the Upper Owens River were restricted to monthly 20%, 50%, and 80% flows developed from the 1940-1989 hydrologic period.

Water Temperature, Water Quality, and Icing

Fisheries impacts associated with water temperature, water quality, and icing were integrated with available physical habitat and other data to assess alternatives. These factors are affected by flow and generally act to limit the extent and distribution of suitable habitat along a given stream length.

Water Temperature. Water temperature impacts associated with each alternative were assessed using water temperature modeling results on Rush Creek (Beak Consultants 1991), Lee Vining Creek (Aquatic Systems Research 1992), the Upper Owens River (EBASCO Environmental et al. 1993), and the Middle Owens River (Jones & Stokes Associates 1992), with water temperature suitability criteria for brown trout reported by Raleigh et al. (1986) (Table 3D-5). Water temperature modeling for Rush Creek, Lee Vining Creek, and the Upper Owens River evaluated the effect of streamflow on daily water temperatures during summer when fish would most likely experience stress associated with high stream temperatures. Graphs representing summer water temperatures as a function of flow for various locations in Rush Creek, Lee Vining Creek, and the Upper Owens River were used to determine the relative effect of each alternative on the frequency of optimum, suboptimum, and lethal water temperatures for brown trout, fry, juveniles, and adults.

The Middle Owens River water temperature model was developed specifically to assess fisheries impacts related to each of the proposed alternatives. Accordingly, LAAMP hydrologic simulations served as input to the water temperature model. Water temperature simulations were conducted for representative dry (20%), normal (50%), and wet (80%) hydrologic conditions for April, June, August, and October. These months were selected because they encompass the period when water temperatures are most likely to affect brown trout production. Mean, maximum, and minimum daily water temperature predictions were generated monthly, assuming constant daily flow regimes within each month and daily meteorologic conditions that were the same as those measured in 1991. Three stations were selected to characterize longitudinal changes in water temperature: Owens River at Five Bridges Road, Owens River at Big Pine Canal, and Owens River near Big Pine (Figure 3D-4).

Water Quality. Existing water quality conditions in the streams potentially affected by flow alterations are expected to remain within acceptable limits over the range of alternatives. Arsenic levels were identified as a concern in the Upper Owens River (EBASCO Environmental et al. 1993) and potential impacts were addressed qualitatively. No further analyses were necessary.

Icing. Information on winter ice formation and potential fisheries impacts is based largely on field observations and is primarily qualitative. Observations and measurements of winter ice formation in Lee Vining Creek and the potential risks to trout were discussed in relation to flow, weather, and stream gradient (Aquatic Systems Research 1992). This information was used to assess potential impacts on brown trout populations in relation to the magnitude of winter flows in Lee Vining, Parker, and Walker Creeks under each alternative. Ice formation does not appear to adversely affect trout populations in Rush Creek or the Owens River.

Channel Morphology and Spawning Gravel Characteristics

Channel maintenance and flushing flow requirements are important considerations for evaluating alternative flow regimes because such flows are often critical for long-term maintenance of stream habitat quality and diversity. Potential fishery benefits and impacts of peak spring flows on channel stability, sediment transport, and spawning gravel distribution and quality were assessed using geomorphic study results developed for Rush, Lee Vining, Parker, and Walker Creeks, and the Upper and Middle Owens River. These studies provide insight on the approximate magnitude of flows necessary to maintain channel structure and mobilize streambed substrate, including gravels within the suitable size range for brown trout spawning.

Fish Population Characteristics

The potential response of brown trout populations to flow and habitat changes associated with each alternative was assessed based on available evidence of direct and indirect effects of flow on trout abundance, distribution, survival, growth, and reproduction. Information sources included recent brown trout population monitoring in Rush Creek (EA Engineering, Science, and Technology 1990c, 1991; Beak Consultants 1991) and Lee Vining Creek (EA Engineering, Science, and Technology 1989, 1990a, 1990b; Aquatic Systems Research 1992), 1990 population sampling in the Upper Owens River (EBASCO Environmental et al. 1993), and past population sampling (Deinstadt and Wong 1980a) and direct observations (Jones & Stokes Associates 1992) in the Middle Owens River. Potential changes in population interactions including competition, predation, stocking, and harvest were also considered.

Reservoir Productivity and Fluctuations

Alternative operations represent the primary source of potential impacts on reservoir fishery resources. Consequently, reservoir hydrologic modeling is critical for impact assessment. The basic approach was to develop criteria based on scientific literature regarding habitat requirements of key species and on discussions with biologists familiar with conditions of Grant Lake reservoir and Lake Crowley reservoir. Habitat requirements or conditions were then interfaced with hydrologic modeling results to determine project impacts relative to the point of reference and between alternatives. These analyses focused on changes to or impacts on the reservoir fishery relative to the point of reference and on relative differences between alternatives. Impacts on reservoir fisheries were determined through separate analyses of fish productivity (relative to reservoir levels) and spawning success (dependent on rising reservoir water surface elevations). Fisheries impacts in Pleasant Valley, Tinemaha, and Haiwee Reservoirs were treated qualitatively based on expected changes in reservoir surface area and the timing and magnitude of reservoir fluctuations.

Reservoir Productivity. Operational changes associated with each alternative could change the pattern and amplitude of Grant Lake reservoir and Lake Crowley reservoir levels. Greater reservoir areas and less fluctuations generally increase fish populations and productivity. Potential impacts from each alternative were assessed by comparing average reservoir surface areas with point-of-reference conditions.

Average monthly reservoir surface areas were computed based on end-of-month (EOM) reservoir water surface elevations simulated by the LAAMP model for the 1940-1989 hydrologic period. A total average reservoir surface area was then calculated for each alternative by averaging all monthly values occurring within the April-October growing season. For Lake Crowley reservoir, a total average reservoir surface area was also computed for the November-March period to evaluate over-winter conditions, which have been shown to affect fish productivity in Lake Crowley reservoir (Pister 1965); in general, higher reservoir levels and reduced fluctuations increased productive shoal area and fish growth.

Reservoir Fluctuations. Alternative operations could change the pattern and amplitude of Grant Lake reservoir fluctuations and adversely affect brown trout spawning success. Sada (1977) provides evidence that brown trout redds constructed in Rush Creek upstream of the reservoir can be adversely affected by rising winter and spring reservoir levels. These potential impacts were assessed by comparing simulated winter and spring (October-June) reservoir water surface elevations for each alternative with simulated reservoir elevations for the point of reference. A time series of EOM water surface elevations simulated by the LAAMP model for the 1940-1989 hydrologic period was initially developed. Monthly changes in water surface elevation were determined by computing the difference in EOM water surface elevations for each month during the October-June period. For each alternative, results were then ranked within each month to determine water surface elevations exceeded 20%, 50%, and 80% of the time.

The effects of Lake Crowley reservoir fluctuations on spawning success were not analyzed because Lake Crowley reservoir fish primarily spawn in the Owens River and other tributaries upstream of the reservoir inundation zone.

Criteria for Determining Significance

Physical Habitat

Tennant Method. Changes in aquatic habitat conditions in Parker and Walker Creeks under each alternative were considered significant if the difference in the average Tennant score between alternatives for dry, normal, and wet hydrologic conditions equaled or exceeded 1. For example, a change in the average Tennant score from 3 (i.e., good habitat conditions) under one alternative to 2 (i.e., fair habitat conditions) under another alternative was considered a significant adverse impact.

Instream Flow Incremental Methodology. Changes in WUA for each alternative were considered significant if the affected habitat would potentially limit populations based on an understanding of all relevant data, and if the average WUA over the 1940-1989 hydrologic period would increase or decrease by more than 10% relative to the average WUA under point-of-reference conditions. A 10% change in habitat conditions was considered significant because it corresponds to the minimum change in fish populations that could reasonably be detected over time given the precision of existing measurement techniques.

Water Temperature, Water Quality, and Icing

Water temperature modeling for Rush Creek, Lee Vining Creek, the Upper Owens River, and the Middle Owens River indicate that water temperatures associated with each of the alternatives fall within the tolerance range for brown trout under most weather conditions; alternatives differ mainly with respect to the frequency of optimum and suboptimum water temperatures. Raleigh et al. (1986) present optimal temperature ranges and tolerance limits for brown trout life stages, but criteria for evaluating sublethal effects based on the frequency, magnitude, and duration of exposure to suboptimal water temperatures are not defined. Therefore, specific threshold criteria for determining significant impacts could not be defined, and temperature impacts associated with each alternative were assessed based on the magnitude, frequency, and duration of suboptimal water temperatures and whether such exposure would reasonably cause significant, long-term changes in fish abundance or biomass.

Water quality conditions in the affected stream are expected to remain at acceptable levels under all alternatives. Because significance criteria could not be defined, potential risks of winter ice formation to brown trout in Lee Vining Creek were compared, for each alternative, with those associated with point-of-reference conditions. For other streams, information on ice-related impacts was unavailable or ice formation was not considered to be a limiting factor.

Channel Morphology and Spawning Gravel Characteristics

Sediment transport studies and analyses on Rush Creek, Lee Vining Creek, and the Middle Owens River provided information on flows necessary to mobilize streambed or bank materials. To the extent possible, these threshold flows were used to determine the adequacy of peak spring or summer flows in maintaining favorable spawning gravel and channel conditions in the affected streams. Significant adverse impacts on spawning gravels, aquatic invertebrate habitat, and channel structure were predicted when the frequency of such flows was reduced relative to point-of-reference conditions. More frequent high flows would have variable effects, depending on existing channel conditions and sediment budgets in each of the streams; benefits might be expected in relatively stable reaches while less stable reaches might experience excessive bank erosion and loss of cover, even at natural, unimpaired flows. These potential impacts were also considered in evaluating the frequency and magnitude of high spring and summer flows associated with each alternative. No information was available to evaluate effects related to the duration of channel maintenance and flushing flows.

Fish Population Characteristics

Changes in trout populations resulting from alternative flow regimes were expressed qualitatively based on evidence derived from population monitoring studies, observed habitat relationships, and trout population data from eastern Sierra Nevada streams. The principal evaluation criteria were general abundance and standing crop of adult trout; the effects of flow and habitat changes on survival, growth, and reproductive success were considered in terms of their probable effects on adult trout abundance and standing crop. Where possible, impact analyses focused on specific habitats or life stages that potentially limit adult populations. Existing data were inadequate for developing accurate population-habitat models to provide quantitative estimates of fish populations and therefore apply quantitative significance criteria.

Potential effects of food abundance on trout growth and survival were also considered. A general habitat-discharge relationship developed for aquatic invertebrates was used to assess potential consequences of habitat changes on food abundance or availability in the Middle Owens River, and any change greater than 25% was used as the significance criterion because of the more general nature of the invertebrate habitat suitability criteria used in the IFIM compared to the fish habitat suitability criteria.

The determination of impacts related to fish population interactions, such as competition, predation, stocking, and harvest, was largely speculative and based on indirect evidence from population monitoring studies and general literature on the behavior and ecological requirements of the species present.

Reservoir Productivity and Fluctuations

Reservoir Productivity. Adverse impacts on lake productivity could occur if alternative operations reduce reservoir surface area relative to point-of-reference conditions. Reductions in reservoir surface area were considered to have a significant effect on fish productivity if total reservoir surface area was reduced by 10% or more. A 10% reduction in reservoir surface area would likely have a measurable, adverse effect on reservoir fish production over time.

Reservoir Fluctuations. Adverse impacts on brown trout spawning could occur when alternative operations increase reservoir water surface elevations during winter and spring (October-June) relative to the point of reference. Under normal and dry water years, impacts were considered to be significant if rising reservoir levels increased the amount of inundation of potential spawning habitat by 517 linear feet or more relative to the point of reference (517 feet is 10% of the total potential spawning habitat available to brown trout under point-of-reference conditions). In wet water years, significant impacts would occur if 133 feet (10%) of potential spawning habitat were inundated; significance thresholds for wet water years are lower because total potential spawning habitat available to brown trout at the onset of the spawning season would be reduced as a result of higher initial reservoir levels.

SUMMARY COMPARISON OF BENEFITS AND IMPACTS OF THE ALTERNATIVES

Summary comparisons of benefits and impacts of the alternatives are presented in Tables 3D-6, 3D-7, and 3D-8.

Summary Consideration of Pre-1941 Fishery Standards Set by Court Order

In addition to meeting its responsibilities under CEQA, SWRCB must also meet specific criteria established in court orders addressing fisheries resources in Mono Lake tributaries. The court has directed SWRCB to exercise its ministerial duty to amend LADWP's water right licenses for appropriation of the Mono Lake tributaries to include conditions in accordance with California Fish and Game Code Sections 5937 and 5946. Most importantly, the court further specified that licenses require LADWP to "release sufficient water into the streams from its dams to reestablish and maintain the fisheries that existed in them prior to its diversion of water". This standard has an overriding influence on the evaluation and selection of alternative lake levels, as described at the end of this chapter.

Several factors limit reestablishing pre-1941 fishery conditions in the Mono Lake tributary streams. Pre-1941 fishery conditions cannot be accurately described and, consequently, it would be difficult to ascertain whether the objective of reestablishing the pre-1941 conditions was ever met. It was recognized early in the habitat restoration program ordered by the court that existing conditions may preclude restoration of some specific pre-1941 physical conditions. The Restoration Technical Committee therefore agreed to and adopted the goal of developing and implementing programs to establish aquatic and riparian conditions and resource values equivalent to those existing in the streams prior to 1941 as an acceptable substitute for the overall goal of reestablishing the conditions which benefited the fisheries that existed in the creeks prior to 1941. Establishing even equivalent conditions that benefited the pre-1941 fishery is impossible in the short term and possible in the long term only if aggressive and substantial habitat restoration programs, in concert with major instream flow releases, are undertaken.

Compared to the 1989 point of reference, all alternatives would have substantial fishery benefits in the Mono Lake tributaries. Compared to the pre-1941 conditions, however, significant cumulative impacts were identified for all alternatives. Similarly, none of the alternatives can restore and maintain pre-1941 fishery conditions for at least 50 or more years. Major geomorphic alterations are simply too great to allow restoration of the complex habitat functions present in lower Rush and Lee Vining Creeks in the pre-1941 period. Successful restoration efforts now will require greater short-term control of high flows while channel and habitat conditions are stabilized and restored.

DFG Stream Evaluation Reports provide fishery protection flows and other measures to optimize fishery conditions in Mono Lake tributaries. It is unclear whether these reports represent DFG's formal recommendations for each stream or are consultants' recommendations only. Nonetheless, the Stream Evaluation Reports represent the best available information provided by DFG for establishing conditions that approach, to the greatest degree possible, the pre-1941 habitat conditions desired by the court.

Based on aqueduct model simulations using preliminary Stream Evaluation Report instream flow recommendations, the implications of possible fisheries instream flow requirements were evaluated. The recommended flows would cause the surface elevation of Mono Lake to rise to an average elevation of 6,381 feet, using a maximum Rush Creek flow of 60 cfs, or to 6,385 feet using a maximum Rush Creek flow of 100 cfs. Uncontrolled spills would not likely occur in the Mono Basin tributaries under the conditions specified. Minimum instream flow recommendations for Rush Creek would be met in most years, but available flows in Lee Vining, Parker, and Walker Creeks would often be insufficient to meet the specified minimum instream flows in dry and normal runoff years.

These simulated lake level ranges, when compared to the lake level regimes described for each alternative, indicate the degree to which each alternative is capable of meeting the pending DFG instream flow recommendations for protection of fishery resources. The 6,383.5-Ft Alternative is the nearest alternative that satisfies preliminary DFG recommendations developed to optimize fisheries conditions. The average lake level (6,385) based on the 6,383.5-Ft Alternative would meet DFG's pending instream flow requirements.

Effects in Mono Basin

The No-Restriction Alternative results in significant adverse and unmitigable effects in Rush, Lee Vining, Parker, and Walker Creeks.

Rush Creek brown trout habitat would increase substantially with increasing lake levels from point-of-reference conditions. Beginning with the 6,377-Ft Alternative, however, peak average monthly flows in Rush Creek would significantly exceed DFG's recommended maximum flow of 100 cfs and contribute to streambank erosion and channel meandering in Segments 5 and 6 and to spawning gravel losses in Segments 2 and 3. These impacts are considered significant, and mitigation measures are identified to reduce these impacts to less-than-significant levels.

Lee Vining Creek brown trout habitat would increase substantially with increasing lake levels from point-of-reference conditions. Beginning with the 6,377-Ft Alternative, however, peak average monthly flows would adversely affect habitat restoration efforts, gradually reduce available spawning gravels, and increase mortality rates of brown trout susceptible to downstream displacement at high flows. These impacts are considered significant, and mitigation measures are identified to reduce these impacts to less-than-significant levels.

Parker and Walker Creek fishery resources benefit substantially with increasing lake levels from point-of-reference (dewatered) conditions. Average monthly flows associated with the No-Diversion Alternative, however, would cause adverse impacts on unstable channel reaches, but the net result compared to point-of-reference conditions would remain a substantial benefit to fishery resources.

Grant Lake reservoir fishery resources would experience less-than-significant adverse effects from the No-Restriction Alternative. Slight benefits to trout spawning success would occur at all lake levels above point-of-reference conditions. At the 6,383.5-Ft, 6,390-Ft, and 6,410-Ft Alternatives, however, reservoir surface area is reduced significantly, which would reduce fish productivity significantly. The slight benefits to spawning success and DFG's stocking of Grant Lake reservoir offset the reduced surface area, and the net effect on Grant Lake reservoir fishery resources would be a less-than-significant adverse impact. Substantial benefits to fisheries of Grant Lake reservoir would occur with the No-Diversion Alternative.

Effects in Owens River Basin

Upper Owens River fishery resources would experience slight benefits under the No-Restriction Alternative. Net less-than-significant impacts would occur at the 6,372-Ft Alternative; the 21% reduction in brown trout spawning habitat is minimized because spawning habitat is not limiting brown trout production in the Upper Owens River. Substantial decreases in instream flows, however, would cause significant adverse impacts to both brown and rainbow trout adult habitat at Mono Lake levels of 6,377 feet and higher, with impacts exacerbated as lake levels increase and Upper Owens River instream flows decline. In addition, water temperature increases and water quality degradation below the Hot Creek confluence become significant adverse factors at Mono Lake levels of 6,383.5 feet and higher, again with impacts exacerbated as lake levels increase and Upper Owens River instream flows decline. Mitigation measures are proposed to reduce these impacts to less-than-significant levels.

Lake Crowley reservoir fishery resources would experience slight improvements under the No-Restriction Alternative and less-than-significant impacts under all other alternatives. The alternatives have only slight effects on Lake Crowley reservoir surface area and water surface elevations.

Middle Owens River fishery resources would experience less-than-significant adverse effects with the No-Restriction Alternative and slight benefits under all other alternatives. Fry habitat is the primary limiting factor for brown trout production in the Middle Owens River, and fry habitat is stable over the range of alternatives. Brown trout spawning habitat and aquatic invertebrate habitat increase substantially for the 6,372-Ft Alternative and higher lake-level alternatives, but these factors are not considered to limit brown trout production in the Middle Owens River.

Pleasant Valley, Tinemaha, and Haiwee Reservoirs; the LA Aqueduct; and irrigation canal fishery resources would not experience any significant changes under any of the alternatives.

Cumulative Impacts

Significant cumulative impacts associated with all alternatives are:

- long-term and short-term LADWP operations on geomorphology and fish populations in Rush, Lee Vining, Parker, and Walker Creeks;
- effects of LADWP diversion facilities on gravel recruitment in Rush, Lee Vining, Parker, and Walker Creeks;
- effects of road crossing and LADWP diversion facilities on migrating trout populations in Rush, Lee Vining, Parker, and Walker Creeks; and
- effects of water diversions, impoundments, modified flow patterns, grazing, and competition from introduced species on Owens tui chub and Owens speckled dace in the Middle Owens River.

A significant cumulative impact associated with lake level alternatives from the 6,377-Ft Alternative to the No-Diversion Alternative is:

- reduced LADWP exports on fish populations in the Upper Owens River.

A significant cumulative benefit associated with the No-Restriction Alternative is:

- continued high LADWP exports on fish populations in the Upper Owens River.

All significant cumulative impacts can be reasonably mitigated with the exception of long-term LADWP operational effects in Rush, Lee Vining, Parker, and Walker Creeks, and the effects of multiple and interrelated factors on Owens tui chub and Owens speckled dace in the Middle Owens River.

IMPACTS AND MITIGATION MEASURES FOR THE NO-RESTRICTION ALTERNATIVE

Changes in Resource Condition

Rush Creek

Under the No-Restriction Alternative, aquatic habitat and fisheries resources would be eliminated or severely degraded relative to point-of-reference conditions. Diversions would dewater lower Rush Creek in all but the wettest years (highest 10% of flows) or during periods of high spring and summer runoff when Grant Lake releases exceed the diversion capacity or the reservoir spills (see Chapter 3A, "Hydrology"). Springs and irrigation return flow would maintain a small baseflow in Segment 5, but this flow would be insufficient to maintain fishery resources. The absence or severe reduction in aquatic habitat in most years under this alternative (Figures 3D-5 through 3D-8) is reflected in the 67-79% reductions in average WUA for brown trout spawning, fry, juvenile, and adult life stages relative to point-of-reference values (Tables 3D-9 through 3D-12).

Lee Vining Creek

Under the No-Restriction Alternative, aquatic habitat and fisheries resources would be eliminated or severely degraded relative to point-of-reference conditions. Diversions would dewater lower Lee Vining Creek in all but the wettest years (highest 10% flows) or during periods of high spring and summer runoff when flows exceed the diversion capacity (see Chapter 3A, "Hydrology"). The absence or severe reduction in aquatic habitat in most years (Figures 3D-9 through 3D-12) under this alternative is reflected in the 55-72% reductions in average WUA for brown trout spawning, fry, juvenile, and adult life stages relative to point-of-reference values (Tables 3D-13 through 3D-16).

Parker and Walker Creeks

The No-Restriction Alternative would not affect aquatic habitat conditions and fisheries resources in Parker and Walker Creeks relative to point-of-reference conditions. Parker and Walker Creeks were dry under 1989 point-of-reference conditions and would remain so under the No-Restriction Alternative (see Chapter 3A, "Hydrology").

Habitat impact analyses based on the Tennant Method indicate severe aquatic habitat conditions (Table 3D-17 and Appendix O, Table O-1); diversions of all Parker and Walker Creek flows to the Lee Vining conduit would severely degrade and eliminate aquatic habitat and resources downstream to their confluences with Rush Creek. Seasonal occurrences of irrigation releases or spills from the conduit dam would continue, but the intermittent nature of these flows would prevent the maintenance of aquatic habitat to sustain fisheries resources.

Grant Lake Reservoir

Reservoir Fluctuation. Under the No-Restriction Alternative, LAAMP-simulated reservoir levels indicate that brown trout redd inundation from increasing reservoir elevations during the spawning and egg incubation period (October-June) would not occur in dry water years; there would be no adverse effects on spawning success.

Under normal water year conditions, the No-Restriction Alternative would adversely affect brown trout spawning success in June because reservoir elevations would increase by 1 foot relative to point-of-reference conditions (Table 3D-18). Although this 1-foot increase in reservoir elevation would inundate approximately 167 feet of potential Rush Creek spawning habitat, impacts would be less than significant because the amount of potential spawning habitat that would be inundated represents only 3.2% of the total Rush Creek spawning habitat available to Grant Lake brown trout.

In wet water years, reservoir fluctuations during the spawning and egg incubation period would occur with greater frequency and magnitude relative to point-of-reference conditions. Brown trout spawning success would be adversely affected in all months that these fluctuations occurred, except for June, when fluctuations in reservoir elevations would be less than those occurring under point-of-reference conditions. These fluctuations would increase reservoir elevations relative to point-of-reference conditions by 1-6 feet and would cause an additional 167-916 feet of potential spawning habitat to be inundated.

Reservoir Productivity. Grant Lake reservoir operations under the No-Restriction Alternative would increase average monthly water surface elevations for the April-October period by 2 feet and cause average reservoir surface area to increase by approximately 15 acres relative to point-of-reference conditions (Table 3D-19). The No-Restriction Alternative would have slight beneficial effects on reservoir fish populations from increased reservoir surface area because reservoir surface area would increase only 1.7% relative to point-of-reference conditions.

Upper Owens River

Physical Habitat

Brown Trout. The No-Restriction Alternative would increase physical habitat available to adult brown trout by 6-7% in dry and normal water year types, and reduce the amount of habitat by 2% in wet years compared to point-of-reference levels (Table 3D-20). Brown trout spawning habitat would increase 14% in dry years, decrease by 6% in normal years, and decrease by 9% in wet years (Table 3D-20). Consequently, the No-Restriction

Alternative would have slight beneficial effects or less-than-significant adverse impacts on physical habitat.

Rainbow Trout. Changes in adult rainbow trout habitat would be less than 10% in dry, normal, and wet years (Table 3D-20). Spawning habitat would be nearly the same in dry years but would decrease by 9% in normal and wet years relative to point-of-reference levels (Table 3D-20). All impacts would be less than significant.

Water Temperature. Water temperature simulations indicate that average daily water temperatures along most of the Upper Owens River between East Portal and Lake Crowley reservoir can be kept below 68°F by maintaining summer flows below East Portal above 75-100 cfs, depending on the initial water temperature (EBASCO Environmental et al. 1993). At lower summer flows, exposure to suboptimum water temperatures would increase, particularly below Hot Creek where water temperatures are elevated by Hot Creek inflows. Flows above 75-100 cfs in the Owens River below East Portal would reduce critically high summer temperatures in this section of the river primarily in July and August (EBASCO Environmental et al. 1993).

The 68°F temperature level exceeds the maximum optimum temperature of 66°F identified for brown trout juveniles and adults by Raleigh et al. (1986), which served as a basis for evaluating temperature impacts in this EIR, and exceeds the maximum optimum temperature of 64°F reported for rainbow trout juveniles and adults (Raleigh et al. 1984). Consequently, temperature impacts based on these criteria would be somewhat greater than that based on the 68°F analysis. Nevertheless, recommended minimum summer flows of 75-100 cfs would maintain suitable water temperatures in the Upper Owens River downstream to Hot Creek and reduce the frequency and magnitude of stressful summer water temperatures below Hot Creek.

Under point-of-reference conditions, monthly Owens River flows below East Portal during June through September would nearly always exceed 75 cfs except in the driest years (lowest 10% flows during the 1940-1989 hydrologic period) (Jones & Stokes Associates 1993). Consequently, suitable summer water temperatures would occur most of the time, and trout would likely be subject to only short-term, localized stress in the reach below Hot Creek. Because the frequency of flows less than 75 cfs would be similar under the No-Restriction Alternative, no measurable temperature-related impacts on fish populations would occur.

Water Quality. Elevated concentrations of arsenic and other trace metals have been identified as a potential water quality problem in the Upper Owens River. Of the trace metals measured in 1991, only arsenic was detected at levels that could adversely affect aquatic life, although the degree of toxicity is unknown (EBASCO Environmental et al. 1993). Potentially harmful levels were measured in the segment below the confluence of Hot Creek, a major source of arsenic in the Upper Owens River basin.

Water diverted from Mono Basin improves water quality downstream of the Hot Creek confluence by diluting high concentrations of arsenic and other trace metals. Mineral concentrations are generally highest during periods of low flow or no Mono Basin diversions (EBASCO Environmental et al. 1993). Potential water quality benefits, therefore, would be expected as Mono Basin exports increase. Increased exports may also benefit aquatic production in the Upper Owens River by providing an additional source of nitrogen, which is known to limit algae growth in eastern Sierra Nevada streams (EBASCO Environmental et al. 1993). Mono Basin exports may adversely affect water quality by reducing hardness levels, thereby increasing the toxicity potential for trace metals like arsenic (EBASCO Environmental et al. 1993). The significance of these factors to aquatic production in the Upper Owens River is unknown.

Under point-of-reference conditions, concentrations of arsenic and other trace metals downstream of the Hot Creek confluence would be reduced substantially under relatively high Mono Basin exports. Water quality under the No-Restriction Alternative would be very similar to point-of-reference conditions.

Channel Morphology and Spawning Gravel Characteristics. Channel morphology of the Upper Owens River has changed in response to historical flow augmentation by Mono Basin exports, but the channel appears to have adjusted to the higher flow regime and there are no significant problems related to channel stability or flushing flows (EBASCO Environmental et al. 1993). Hydraulic and sediment transport studies on the Upper Owens River indicate that flows between 20 and 200 cfs (measured below East Portal) provide favorable conditions for maintaining gravel recruitment and spawning gravel quality while preventing the frequent occurrence of overbank flows that probably cause meander bend flooding, erosion, and cutoff, and associated losses of trout habitat (EBASCO Environmental et al. 1993).

Under the No-Restriction Alternative, minimum monthly flows would be within the optimum range of 20-200 cfs, but potential erosion-inducing flows exceeding 200 cfs would occur as much as 70% of the time in April during the 1940-1989 hydrologic period (see Chapter 3A, "Hydrology"). Because the flow regime would be similar to point-of-reference conditions, no significant impacts on channel and streambed conditions would occur under this alternative.

Fish Population Characteristics. Trout populations sampled in 1990 had been experiencing flows of about 40 cfs (combined Big Springs flow and East Portal tunnel accretion) over a 12-month period before sampling was conducted. Food availability, water temperature, water quality, and fishing pressure were not likely limiting trout populations in Segments 1 (Inaja site) and 2 (Hot Creek site) under these conditions, and trout biomass was likely a function of available habitat as indicated by positive correlations between adult trout biomass and weighted usable area. Spawning habitat in the Upper Owens River was sufficient to support existing spawning populations and was not considered limiting to trout production. (EBASCO Environmental et al. 1993.)

Past population surveys revealed that young-of-the-year trout abundance in the Upper Owens River is variable, indicating that recruitment may be influenced by habitat conditions (e.g., instream flows and water temperatures) during the spawning, incubation, and fry rearing periods. The Upper Owens River IFIM did not address trout fry (<2-inch trout) habitat requirements in the Upper Owens River (EBASCO Environmental et al. 1993). However, potential limitations on available fry habitat imposed by higher flows may be similar to those described below for the Middle Owens River. Generally, reductions in fry habitat would be expected under the higher flow regimes associated with lower lake level alternatives. The importance of numerous secondary channels along the Upper Owens River in providing fry habitat at higher flows is unknown, but may be significant.

Brown and rainbow trout populations under the No-Restriction Alternative would experience a flow and temperature regime similar to that occurring under point-of-reference conditions. Because little change in physical habitat, water temperature, water quality, and food abundance would be expected, trout populations would not differ significantly under the No-Restriction Alternative.

Lake Crowley Reservoir

Lake Crowley reservoir operations under the No-Restriction Alternative would increase average monthly water surface elevations during the April-October period and cause average reservoir surface area to increase by approximately 33 acres (0.75%) relative to point-of-reference conditions (Table 3D-21). Similarly, average surface area for the November-March period would increase by approximately 52 acres (1.2%) compared to point-of-reference conditions (Table 3D-21). Greater reservoir surface areas would have slight beneficial effects on fish productivity in Lake Crowley reservoir. Compared to point-of-reference conditions, the No-Restriction Alternative would provide slightly better conditions for fish productivity because average monthly reservoir levels would be relatively stable and reservoir surface area would be slightly greater.

Middle Owens River

Physical Habitat

Brown Trout. Under the No-Restriction Alternative, physical habitat available to spawning, fry, juvenile, and adult brown trout would be nearly equal to point-of-reference levels (Figures 3D-13 through 3D-16); changes in average WUA for each life stage would be less than 3% (Tables 3D-22 through 3D-25). WUA values at individual spawning transects would also show little change (Table 3D-26).

Aquatic Invertebrates. Under the No-Restriction Alternative, aquatic invertebrate habitat would be reduced by 18% relative to point-of-reference levels (Figure 3D-17, Table 3D-27). Because of the generalized nature of the aquatic invertebrate habitat suitability criteria used in the Middle Owens River IFIM, this reduction is not considered to be significant.

Largemouth Bass. Higher spring and summer flows under the No-Restriction Alternative would significantly reduce largemouth bass spawning habitat relative to point-of-reference levels (Figures 3D-18 through 3D-21); average WUA would be reduced by 17% under this alternative (Tables 3D-28 through 3D-31). Little change in fry, juvenile, and adult habitat availability would occur.

Water Temperature. Middle Owens River flows would be at their lowest levels under the No-Diversion Alternative compared to other alternatives, which allow various levels of Mono Basin exports. Consequently, potential fisheries impacts related to high water temperatures would be greatest under the No-Diversion Alternative during the spring and summer months. Water temperature simulations for the No-Diversion Alternative indicated that maximum daily water temperatures would remain well below the upper tolerance limit for brown trout at Five Bridges Road during the spring and summer, peaking at 72°F for several days in August under the 20% flow (Figure 3D-22). Therefore, potential impacts over the range of alternatives would be minor as measured by the frequency (i.e., number of days) that mean daily water temperatures would exceed the optimum temperature range. Relative impacts for all other alternatives were determined from the water temperature simulations for the No-Diversion Alternative and the point-of-reference scenario (Tables 3D-32 and 3D-33).

Under point-of-reference conditions, mean daily water temperatures at Five Bridges Road would exceed the optimum range for brown trout for 2 days in April (based on fry criteria), 24 days in June (based on fry criteria), and 11 days in August (based on juvenile and adult criteria) (Tables 3D-32 and 3D-33). Under the No-Restriction Alternative, flows in the Middle Owens River would be slightly higher than those occurring under point-of-reference conditions, and optimum water temperatures would occur slightly more frequently. Based on the changes in the frequency of optimum and suboptimum temperatures with respect to flow (Tables 3D-32 and 3D-33), the difference in frequency would be minimal (1-2 days per month). In October, the frequency of water temperatures within the optimum range for brown trout spawning and incubation would be virtually unchanged (Table 3D-30). No measurable or significant impacts on brown trout reproduction, growth, or survival would occur.

Water temperatures would frequently fall below the reported optimum ranges for largemouth bass spawning, incubation, and growth during the spring and summer months. Over the range of alternatives represented by the No-Diversion Alternative and the point of reference, mean daily water temperatures near Big Pine Canal, even under the warmest weather conditions (August), would remain below the optimum range (Figure 3D-23). The frequency and magnitude of water temperatures under the No-Restriction Alternative would be similar to those under point-of-reference conditions.

Channel Morphology and Spawning Gravel Characteristics. Specific channel maintenance and flushing flows have not been identified for the Middle Owens River, but flows exceeding 600-800 cfs may cause excessive bank erosion. Sediment transport studies in Segments 1 and 2 of the Middle Owens River indicate that the primary source of coarse and fine sediment is the streambed and banks. The streambanks are likely the major sediment source at high flows (Hickson and Hecht 1992). Sediment transport rates increase sharply at flows above 600-800 cfs (Hickson and Hecht 1992). Flows of this magnitude may cause disproportionate bank erosion rates, potentially widening channels and degrading trout habitat quality through changes in channel form and loss of undercut banks and woody cover.

Under the No-Restriction Alternative, peak annual Pleasant Valley Reservoir releases in July would be similar in frequency and magnitude to point-of-reference conditions; mean monthly outflows above 600 cfs would occur in approximately 40% of the years under historical hydrologic conditions (see Chapter 3A, "Hydrology"). Consequently, channel and streambed conditions under the No-Restriction Alternative would be similar to those occurring under the point-of-reference conditions.

Fish Population Characteristics

Brown Trout. Under the No-Restriction Alternative, aquatic invertebrate habitat reductions may indirectly affect brown trout growth by potentially reducing food abundance. Potential effects include reduced growth of brown trout, especially for fry and juvenile brown trout, which rely to a greater extent on invertebrate prey than adult brown trout. This impact on the fish population is less than significant.

Largemouth Bass. The significant reduction in largemouth bass spawning habitat in Segment 4 could adversely affect reproductive success and recruitment if spawning habitat within the Middle Owens River channel is a limiting factor. Largemouth bass production, however, may be limited by water temperatures that are frequently lower than the reported optimal range for reproduction and growth throughout much of the Middle Owens River. Largemouth bass production may also largely depend on conditions outside the active channel, such as the extent and availability of backwater habitat (e.g., river oxbows) or littoral habitat in Tinemaha Reservoir. Given the uncertainty of largemouth bass population ecology and limiting factors in the Middle Owens River, the impact on largemouth bass populations is considered to be less than significant.

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

Pleasant Valley Reservoir operations under the No-Restriction Alternative would not affect reservoir volumes; reservoir volumes would remain relatively constant during each month. Impacts on fishery resources would not be expected to occur because the timing and magnitude of reservoir fluctuations and surface areas would not change relative to point-of-reference conditions.

Daily operation of Tinemaha and Haiwee Reservoirs would not be affected under the No-Restriction Alternative, and the timing and magnitude of reservoir fluctuations and reservoir surface area would not change relative to point-of-reference conditions. Fishery resources within these reservoirs would not be significantly affected.

Los Angeles Aqueduct and Irrigation Canals

Under the No-Restriction Alternative, exports to Los Angeles would increase slightly relative to point-of-reference conditions and would increase flows in the LA Aqueduct. Minor effects on fishery resources would likely occur because habitat conditions within the canal are less than optimal for most fish life stages and because LA Aqueduct flows would change slightly during the April-September period, when the effects on rearing fish would be the greatest (Los Angeles export targets are set at aqueduct capacity during the April-September period regardless of alternative).

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (No-Restriction Alternative)

Rush Creek

- Eliminates or severely degrades fish habitat and resources.

Mitigation Measures. Providing permanent and adequate flows necessary to maintain aquatic resources is infeasible under this alternative; the impact cannot be mitigated.

Lee Vining Creek

- Eliminates or severely degrades fish habitat and resources.

Mitigation Measures. Providing permanent and adequate flows necessary to maintain aquatic resources is infeasible under this alternative; the impact cannot be mitigated.

Parker and Walker Creeks

- Continues to severely degrade fish habitat conditions. Point-of-reference dewatered conditions would prevail.

Mitigation Measures. None are required because no additional impacts would occur over point-of-reference conditions.

Upper Owens River

- Maintains brown and rainbow trout adult and spawning habitat.
- Maintains water temperature, water quality, channel, and streambed conditions.
- Maintains fish populations.

Grant Lake Reservoir

- Reduces brown trout spawning success by increasing lake level fluctuations (generally 0-9%).

- Slightly increases fish productivity (2% increase in reservoir surface area).

Lake Crowley Reservoir

- Slightly increases fish productivity (less than 2% increase in reservoir surface area).

Middle Owens River

- Maintains brown trout physical habitat similar to point-of-reference conditions.

- Reduces aquatic invertebrate habitat but at a less-than-significant level (-18%).

- Significantly reduces largemouth bass spawning habitat (-17%), but not to a level limiting bass population.

Mitigation Measures. Mitigation measures are not required because largemouth bass production is likely limited by low water temperatures throughout much of the Middle Owens River and spawning may be partially or primarily dependent on habitats outside the main channel.

- Causes no measurable temperature-related changes in fish populations.

- Maintains channel and streambed conditions similar to point-of-reference conditions.

- Potentially reduces brown trout growth, but not significantly, because of decreased aquatic invertebrate habitat and production.

- Adversely affects largemouth bass production by reducing spawning habitat, but population limited by low water temperatures and conditions outside main channel, so effect is less than significant.

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

- Causes no significant changes in fish productivity.

Los Angeles Aqueduct and Irrigation Canals

- Causes no significant changes in fish habitat.

IMPACTS AND MITIGATION MEASURES FOR THE 6,372-FT ALTERNATIVE

Changes in Resource Condition

Rush Creek

Physical Habitat. Higher flows in lower Rush Creek under the 6,372-Ft Alternative would significantly increase the amount of physical habitat for brown trout spawning, juvenile, and adult life stages and significantly reduce the amount of fry habitat relative to point-of-reference levels (Figures 3D-5 through 3D-8). Average WUA for brown trout spawning, juvenile, and adult life stages would be increased by 69%, 22%, and 16%, respectively, while fry WUA would be reduced by 20% (Tables 3D-9 through 3D-12).

Water Temperature. Compared to point-of-reference conditions, higher summer flows under the 6,372-Ft Alternative would maintain lower summer water temperatures and prevent water temperatures from exceeding the upper tolerance limit for brown trout. Potential benefits include reduced exposure to near-lethal water temperatures, although measurable increases in survival and growth are not likely.

Channel Morphology and Spawning Gravel Characteristics. Sediment transport modeling (Beak Consultants 1991) indicates that flows exceeding 60 cfs in lower Rush Creek would potentially cause uncompensated losses of spawning gravel in Segments 2 and 3, and flows exceeding 100 cfs would likely induce streambank erosion and channel meandering in Segments 5 and 6 where the Rush Creek channel is unstable and subject to continued habitat degradation associated with high flow events; 100 cfs was recommended as an upper flow limit under normal and wet hydrologic conditions and in association with gravel augmentation measures (Gibbons pers. comm.). It should be noted, however, that this recommendation did not consider inflows from Parker and Walker Creeks.

Under existing channel conditions, a flow of 100 cfs is a minimum threshold for mobilizing spawning-size substrate in Segments 5 and 6, although periodic events of higher magnitude appear to be needed to loosen cemented gravels or expose uncompacted gravels suitable for spawning. Spawning gravel surveys conducted in April 1987 indicated that most gravel accumulations in lower Rush Creek were cemented and unsuitable for spawning and that brown trout redds were limited to small pockets of uncompacted gravels (EA Engineering, Science, and Technology 1990c). The cemented condition of the gravels was identified as a possible mechanism reducing juvenile brown trout recruitment in five of six year classes monitored from 1985 through 1990. Flows as high as 250 cfs may also benefit channel building processes in Segment 5 (Trihey pers. comm.).

Under point-of-reference conditions, average monthly flows in July would exceed 100 cfs in roughly 30% of the years under historical hydrologic conditions; average monthly flows of 250 cfs or greater would occur in wet years only (highest 20% flows) (see Chapter 3A, "Hydrology"). July flows under the 6,372-Ft Alternative would exceed 100 cfs only in the wettest years (highest 10% flows), and flows of 250 cfs or greater would occur less frequently. This is considered a short-term benefit because it would reduce erosion impacts and facilitate habitat restoration efforts in Segments 5 and 6. Over the long term, however, the reduced frequency of channel maintenance and flushing flows would degrade spawning gravel quality and overall habitat conditions.

Fish Population Characteristics. Under the 6,372-Ft Alternative, juvenile brown trout abundance in lower Rush Creek would potentially increase in response to additional spawning and rearing habitat, relative to point-of-reference conditions. Fry habitat reductions would not affect brown trout production because available fry habitat appears sufficient to accommodate potential increases in recruitment resulting from additional spawning habitat. However, the gradual reduction in spawning gravel quality associated with infrequent flushing flows may reduce the benefits of increased spawning habitat by reducing overall spawning success. In addition, adult brown trout abundance may continue to be limited by the extent of pool habitat with woody cover, despite flow-related increases in available habitat; significant positive relationships were found between catchable trout (greater than 8 inches long) abundance and the amount of pool habitat with woody cover in lower Rush Creek from 1985 to 1990 (EA Engineering, Science, and Technology 1991).

A dramatic decrease in brown trout growth rates during a period of increased brown trout abundance suggested that competition for food may limit brown trout production in lower Rush Creek (EA Engineering, Science, and Technology 1991). Under the 6,372-Ft Alternative, increased physical habitat may reduce competition during years of high population densities.

Lee Vining Creek

Physical Habitat. Higher flows under the 6,372-Ft Alternative would significantly increase physical habitat for brown trout spawning, juvenile, and adult life stages relative to point-of-reference conditions (Figures 3D-9 through 3D-12). Average WUA (Segments 3, 5, and 6 combined) for spawning, juvenile, and adult life stages would increase by 209%, 61%, and 91%, respectively (Tables 3D-13 through 3D-16). Higher winter flows would provide additional winter habitat relative to the point-of-reference flow of 5 cfs.

Mean monthly flows during October and November would be near optimum for brown trout spawning in Segment 2, and flows from October through June would maintain suitable incubation conditions. The 13% reduction in fry habitat associated with higher spring and summer flows is not considered significant because fry habitat would remain abundant relative to the amount of available spawning habitat.

Water Temperature and Icing. Under the 6,372-Ft Alternative, summer water temperatures in lower Lee Vining Creek would remain within the optimum range for brown trout, and no measurable benefits or adverse impacts would occur relative to point-of-reference conditions; the 5-cfs point-of-reference flow maintains optimum water temperatures throughout most of the affected reach even under extreme summer weather conditions (Aquatic Systems Research 1992).

Stable winter flows of about 19 cfs under the 6,372-Ft Alternative fall within the flow range (15-20 cfs) recommended to avoid potential risks to aquatic fauna associated with anchor ice formation and ice dislodging (Aquatic Systems Research 1992). No information is available to determine differences in trout mortality that may occur at winter flows of 19 cfs compared with 5 cfs.

Channel Morphology and Spawning Gravel Characteristics. Bed material transport was observed in lower Lee Vining Creek following sluicing activities at the LADWP diversion dam that caused a sudden flow increase from about 58 to 112 cfs in May 1990, although such flows were not of sufficient magnitude or duration to effectively transport large quantities of entrained sand (Aquatic Systems Research 1992). Partial gravel mobility was also observed following experimental flow releases attaining an instantaneous maximum of 179 cfs and a daily mean of 164 cfs during a 19-day period in June 1991 (Aquatic Systems Research 1992). Aquatic Systems Research (1992) recommended a channel maintenance flow of 160 cfs for 30 days in wet years (highest 20% flows) and 160 cfs for 3 days in normal and dry years.

Average monthly flows in lower Lee Vining Creek under point-of-reference conditions would equal or exceed 160 cfs in June or July in 30% of the years, but such flows would occur only in extremely wet years (highest 10% flows) under the 6,372-Ft Alternative (see Chapter 3A, "Hydrology"). This is considered a short-term benefit under existing channel conditions because high flows would potentially disrupt or reverse the progress of habitat restoration efforts in Segments 5 and 6 and cause adverse impacts on the brown trout population. Over the long term, however, the reduced frequency of channel maintenance and flushing flows would degrade spawning gravel quality and overall habitat conditions.

Fish Population Characteristics. Increases in spawning, juvenile, and adult brown trout habitat under the 6,372-Ft Alternative would be expected to increase brown trout populations above levels that would occur under point-of-reference conditions. Specific benefits associated with increased spawning habitat availability in Segment 2, however, would likely be limited over time by infrequent channel maintenance and flushing flows.

Parker and Walker Creeks

Under the 6,372-Ft Alternative, Parker and Walker Creeks would be rewatered, and flows necessary to maintain aquatic habitat and resources would be restored. Permanent and continuous flows would be maintained throughout the year, and average monthly flows would be nearly identical during all water-year types (see Chapter 3A, "Hydrology"). Habitat impact analyses based on the Tennant Method indicate overall good aquatic habitat conditions (Table 3D-17) with poor habitat conditions occurring in April and September of all water-year types (Appendix O, Table O-1). Water temperatures in Parker and Walker Creeks would primarily fall within the optimum temperature range for brown trout of 54-56°F (Raleigh et al. 1986), based on 1991 data (EBASCO Environmental and Water Engineering and Technology 1991b, 1991c).

Restoring permanent flows to Parker and Walker Creeks under this alternative would promote the natural recolonization of these creeks by wild brown trout and the long-term maintenance of the fishery through natural production or hatchery stocking. The 6,372-Ft Alternative would provide flow regimes in Parker and Walker Creeks similar to flow regimes occurring since rewatering of these streams in October 1990. Brown trout have been successfully planted in the two creeks since rewatering, but the specific fish population levels that will be maintained under the current conditions or under the 6,372-Ft Alternative are unknown.

Recommended flushing flows for Parker and Walker Creeks are 25.2 and 15 cfs, respectively, using the Tennant Method, 23 and 15 cfs using court-ordered flows, and 25-40 and 15-30 cfs using DFG recommendations (EBASCO Environmental and Water Engineering and Technology 1991b, 1991c). None of these flushing flows would be achieved under this alternative in any water years. Without appropriate flushing flows, the improved habitat conditions predicted for Parker and Walker Creeks under the 6,372-Ft Alternative would be reduced over time, primarily by increased sediment deposition and gravel cementation. Despite reduced habitat quality over time, aquatic habitat conditions would nonetheless benefit significantly under the 6,372-Ft Alternative when compared to point-of-reference conditions.

Grant Lake Reservoir

Reservoir Fluctuations. The 6,372-Ft Alternative would not adversely affect brown trout spawning success relative to point-of-reference conditions under any water year. Under wet water years, spawning success would improve relative to point-of-reference conditions because the magnitude of fluctuations in reservoir elevation during the spawning and egg incubation period would be reduced (Table 3D-18). Under normal and dry water years, the 6,372-Ft Alternative would not increase Grant Lake reservoir elevations in any of the months during the spawning and egg incubation period relative to point-of-reference conditions (Table 3D-18) and would have no impact on brown trout spawning success.

Reservoir Productivity. Grant Lake reservoir operations under the conditions of the 6,372-Ft Alternative would decrease average monthly water surface elevations for the April-October period by 4 feet and decrease average monthly reservoir surface area by approximately 55 acres relative to point-of-reference conditions (Table 3D-19). Impacts would be less than significant because reservoir surface area would decrease by only 6.2% relative to point-of-reference conditions. The 6,372-Ft Alternative would provide slightly worse conditions for fish productivity than the No-Restriction Alternative.

Upper Owens River

Physical Habitat

Brown Trout. Under the 6,372-Ft Alternative, brown trout adult habitat would be reduced 14% in dry years, but exhibit negligible change in normal and wet years relative to point-of-reference levels (Table 3D-20). Brown trout spawning habitat would be reduced by 5% in normal years, 14% in dry years, and 44% in wet years (Table 3D-20). Impacts on adult brown trout habitat during dry years and spawning habitat in dry and wet years are considered significant adverse impacts.

Rainbow Trout. Adult rainbow trout habitat would be reduced by 13% in dry years but would exhibit negligible change in normal and wet years relative to point-of-reference levels (Table 3D-20). Rainbow trout spawning habitat would increase 5% in dry years, 12% in normal years, and 15% in wet years (Table 3D-20). The overall effect of the 6,372-Ft Alternative on adult rainbow trout habitat in dry years would be significant.

Water Temperature. Under the 6,372-Ft Alternative, flows less than 75 cfs during June through September would be limited to dry years only but would include flows as low as 32 cfs in July (see Chapter 3A, "Hydrology"). Additional temperature impacts would occur at this flow, particularly in Segment 3 below Hot Creek, but significant fisheries impacts relative to point-of-reference conditions are not expected because of the relatively rare occurrence and short duration of low flows.

Water Quality. Water quality conditions under the 6,372-Ft Alternative would be degraded relative to point-of-reference conditions, but would likely not significantly affect fishery resources, although definitive information is lacking. Mono Basin exports would be reduced relative to point-of-reference conditions but would continue to augment natural flows and reduce elevated concentrations of arsenic and other trace metals in many years, particularly below Hot Creek (Segment 3). Water quality impacts would probably be limited to dry years and therefore would not cause significant long-term fisheries impacts relative to point-of-reference conditions.

Channel Morphology and Spawning Gravel Characteristics. Channel and streambed conditions under the 6,372-Ft Alternative would be similar to those occurring under the No-Restriction Alternative.

Fish Population Characteristics. Under the 6,372-Ft Alternative, brown and rainbow trout adult populations would not change significantly relative to point-of-reference levels. Significant reductions in adult trout habitat in dry years and associated high water temperatures may periodically reduce adult trout abundance, but significant long-term effects on the populations are unlikely. Significant changes in the amount of available brown and rainbow trout spawning habitat under this alternative would probably have no significant effects on trout populations because spawning habitat does not appear to be limiting trout production in the Upper Owens River. Higher fall flows in wet years, however, would reduce brown trout spawning habitat by 44%, which may be sufficient to significantly reduce brown trout production in these years. Impacts of this magnitude, however, would be limited to wet years and would not likely cause significant long-term reductions in trout populations.

Lake Crowley Reservoir

Changes in lake productivity associated with the 6,372-Ft Alternative would be nearly identical to those associated with the No-Restriction Alternative, except that reservoir surface area during the November-March period would be slightly lower than reservoir surface area under the No-Restriction Alternative (Table 3D-21). Fish productivity would benefit slightly under the 6,372-Ft Alternative relative to point-of-reference conditions.

Middle Owens River

Physical Habitat

Brown Trout. Under the 6,372-Ft Alternative, the amount of physical habitat available to spawning, fry, juvenile, and adult brown trout would not change significantly from point-of-reference levels (Figures 3D-13 through 3D-16). Increases in average WUA ranged from 1% for fry habitat to 8% for spawning habitat (Tables 3D-22 through 3D-25). Changes in WUA at individual spawning transects ranged from a 10% decrease to a 4% increase (Table 3D-26).

Aquatic Invertebrates. Aquatic invertebrate habitat available under the 6,372-Ft Alternative would be substantially increased (36%) over point-of-reference conditions (Figure 3D-17, Table 3D-27).

Largemouth Bass. Reduced spring and summer flows under the 6,372-Ft Alternative would significantly increase (34%) largemouth bass spawning habitat over point-of-reference conditions (Figure 3D-17, Table 3D-28). Little change in fry, juvenile, and adult habitat availability would occur.

Water Temperature. Water temperatures under the 6,372-Ft Alternative would be similar in frequency and magnitude to those occurring under point-of-reference conditions.

Channel Morphology and Spawning Gravel Characteristics. Channel and streambed conditions under the 6,372-Ft Alternative would be similar to those occurring under point-of-reference conditions.

Fish Population Characteristics

Brown Trout. Increased aquatic invertebrate habitat under the 6,372-Ft Alternative may indirectly affect the brown trout population by potentially increasing food abundance. Potential effects include increased growth of brown trout, with fry and juvenile brown trout receiving the greatest potential benefit. Food, however, is not considered a major limiting factor over the range of alternatives.

Largemouth Bass. A substantial increase in largemouth bass spawning habitat in Segment 4 would potentially improve reproductive success and recruitment if spawning habitat in the main channel is in limited supply. As discussed earlier, largemouth bass production in the Middle Owens River is probably limited by low water temperatures throughout much of its length, and populations may largely depend on conditions outside the main river channel.

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

Impacts on fishery resources under the 6,372-Ft Alternative would be the same as those described above under the No-Restriction Alternative.

Los Angeles Aqueduct and Irrigation Canals

Under the 6,372-Ft Alternative, exports to Los Angeles would be slightly reduced relative to point-of-reference conditions, resulting in slightly reduced flows in the LA Aqueduct. Less-than-significant effects on fishery resources would be expected because little change in LA Aqueduct flows is expected during the April-September period, when impacts on rearing fish would be the greatest (Los Angeles export targets would be set at aqueduct capacity during the April-September period).

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,372-Ft Alternative)

Rush Creek

- Creates additional brown trout spawning (69%), juvenile (22%), and adult (16%) physical habitat.

- Reduces exposure to near-lethal water temperatures.

- Reduces impacts on bank stability and habitat restoration, but degrades aquatic habitat and spawning gravel quality over time.

Mitigation Measures. Mitigation measures include periodic scarification of existing streambed gravels or adding spawning gravel of appropriate size and quantity. A fisheries biologist should be consulted to identify treatment areas, methods, and schedules for gravel scarification or placement. Surveys of brown trout redd distribution and spawning gravel quality should be continued to assess spawning conditions. With increases in bank stability in the future, the frequency of channel maintenance and flushing flows should be increased to maintain overall aquatic habitat conditions. The need for scarification or adding spawning gravel to the stream should be reevaluated at that time. These mitigation measures should be coordinated and integrated with current or proposed habitat restoration efforts.

- Increases brown trout abundance and biomass (although populations are still limited by lack of suitable cover) and reduces spawning gravel quality over time.

Lee Vining Creek

- Substantially increases brown trout spawning (209%), juvenile (61%), and adult (91%) physical habitat.

- Causes no changes in water temperature and ice-related risks relative to point-of-reference conditions.

- Reduces impacts on habitat restoration efforts, but degrades aquatic habitat and spawning gravel quality over time.

Mitigation Measures. Mitigation measures would be identical to those specified for Rush Creek under this alternative.

- Increases brown trout abundance and biomass (although populations are still limited by lack of suitable cover) and reduces spawning gravel quality over time.

Parker and Walker Creeks

- Creates good fish habitat that would be gradually degraded without flushing flows.

Mitigation Measures. Providing adequate flushing flows is infeasible under this alternative. Adding gravel to the stream periodically would be unsuccessful mitigation because flows would remain inadequate to distribute gravels throughout Parker and Walker

Creeks. Aquatic invertebrate habitat and overall fisheries habitat would continue to decline over time.

Grant Lake Reservoir

- Improves brown trout spawning success by decreasing lake level fluctuations.
- Reduces fish productivity (7% decrease in reservoir surface area).

Upper Owens River

- Significantly reduces brown trout adult habitat in dry years (-14%) and spawning habitat in dry (-14%) and wet (-44%) years.

Mitigation Measures. Mitigation measures are not required because habitat changes are not expected to cause significant long-term reductions in trout populations.

- Significantly reduces rainbow trout adult habitat in dry years (-13%), and increases spawning habitat in normal (12%) and wet (15%) years.

Mitigation Measures. Mitigation measures are not required because habitat changes are not expected to cause significant long-term reductions in trout populations.

- Adversely affects water temperature conditions in dry years, but impacts on fisheries production considered to be less than significant.

- Degrades water quality conditions in dry years, but impacts on fisheries production considered less than significant.

- Maintains channel and streambed conditions.

- Periodically reduces fish populations but impacts considered less than significant.

Lake Crowley Reservoir

- Slightly reduces fish productivity (less than 1%).

Middle Owens River

- Causes no significant change in brown trout spawning, fry, juvenile, and adult habitat from point-of-reference levels.

- Increases aquatic invertebrate habitat (36%).

- Increases largemouth bass spawning habitat (34%) but spawning habitat is not a limiting factor.

- Causes no measurable temperature-related effects on fish populations.

- Causes channel and streambed conditions similar to those under point-of-reference conditions.

- Potentially improves brown trout growth by increasing aquatic invertebrate production.

- Maintains largemouth bass population.

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

- Causes no significant changes in fish productivity.

Los Angeles Aqueduct and Irrigation Canals

- Reduces fisheries habitat by less-than-significant levels.

IMPACTS AND MITIGATION MEASURES FOR THE 6,377-FT ALTERNATIVE

Changes in Resource Conditions

Rush Creek

Physical Habitat. Average monthly flows in lower Rush Creek under the 6,377-Ft Alternative would be nearly identical in magnitude and frequency to flows under the 6,372-Ft Alternative except for higher June flows (see Chapter 3A, "Hydrology"). Based on WUA predictions, physical habitat would increase for spawning (73%), juvenile (23%), and adult (17%) brown trout relative to point-of-reference levels and would be nearly equal to that occurring under the 6,372-Ft Alternative (Tables 3D-9 through 3D-12, Figures 3D-5 through 3D-8). Fry habitat would increase relative to the 6,372-Ft Alternative (10%) but still would be less than that available under point-of-reference conditions (-12%).

Water Temperature. Water temperatures under the 6,377-Ft Alternative would be nearly identical in magnitude and frequency to temperatures under the 6,372-Ft Alternative except for cooler temperatures associated with higher June flows. Like the 6,372-Ft

Alternative, the 6,377-Ft Alternative would provide higher summer flows and more favorable water temperatures relative to point-of-reference conditions.

Channel Morphology and Spawning Gravel Characteristics. Under the 6,377-Ft Alternative, peak average monthly flows would exceed 100 cfs in about 80% of the years compared with the 30% frequency under point-of-reference conditions (see Chapter 3A, "Hydrology"). Consequently, the frequency of events causing streambank erosion and channel meandering in Segment 6 and spawning gravel losses in Segments 2 and 3 would be substantially increased relative to point-of-reference conditions. In addition, progress toward achieving habitat restoration objectives in Segment 6 would be reduced under this flow regime. Flows equal to or exceeding 250 cfs would occur with the same frequency as under the 6,372-Ft Alternative.

Fish Population Characteristics. Brown trout populations would likely be similar to those occurring under the 6,372-Ft Alternative (see page 3D-58). Adverse impacts on brown trout fry and juveniles from flows exceeding 100 cfs have not been documented, although high flows averaging 261 cfs from March to August 1986 and 100-110 cfs from September 1989 to August 1990 did not affect survival or growth of trout up to 2 years old relative to survival and growth of these age classes during nearly constant 19-cfs releases (EA Engineering, Science, and Technology 1991).

Lee Vining Creek

Physical Habitat. Average monthly flows in lower Lee Vining Creek under the 6,377-Ft Alternative would be nearly identical in magnitude and frequency to flows under the 6,372-Ft Alternative except for higher June flows. Habitat availability under the 6,377-Ft Alternative would be significantly greater than point-of-reference levels for spawning (218%), juvenile (62%), and adult (93%) brown trout lifestages and would be similar to that under the 6,372-Ft Alternative (Tables 3D-13 through 3D-16, Figures 3D-9 through 3D-12).

Water Temperature and Icing. Water temperatures under the 6,377-Ft Alternative would be nearly identical in magnitude and frequency to temperatures under the 6,372-Ft Alternative except for slightly cooler temperatures associated with higher June flows. Relative to point-of-reference conditions, no measurable changes in growth would be expected based solely on water temperature effects. Potential risks related to winter ice formation would not change relative to point-of-reference conditions.

Channel Morphology and Spawning Gravel Characteristics. Under the 6,377-Ft Alternative, the frequency of channel maintenance and flushing flows would be significantly increased relative to the 6,372-Ft Alternative and point-of-reference conditions. Average June flows equal to or exceeding 160 cfs would occur in 60% of the years compared with less than 10% of the years under the 6,372-Ft Alternative and 30% of the years under point-of-reference conditions (see Chapter 3A, "Hydrology"). Aquatic habitat and spawning gravel quality would be improved in many years relative to these alternatives, but frequent high flows would adversely affect habitat restoration efforts and gradually reduce available spawning gravels from Segment 2 because gravels from upstream sources would be trapped by the LADWP diversion dam. Significant impacts on spawning and habitat restoration would occur.

Fish Population Characteristics. Brown trout are susceptible to downstream displacement and higher mortality rates during periods of high flow because of limited refuge habitat in lower Lee Vining Creek (EA Engineering, Science, and Technology 1990b; Aquatic Systems Research 1992). Significant numbers of dead or stressed trout with signs of physical injury were observed following a series of rapid flow fluctuations (from near 0 cfs to 112 cfs) associated with sluicing operations at the LADWP diversion dam in May 1990 (Aquatic Systems Research 1992). Additional downstream displacement of trout may have occurred during releases of 115-203 cfs in June 1991, although no direct losses were observed. All brown trout life stages within the lower reaches below Highway 120 (Segments 3-6) are vulnerable to being washed downstream or into Mono Lake during high spring flows because of a lack of adequate refuge habitat (Aquatic Systems Research 1992).

Under the 6,377-Ft Alternative, frequent spring flows exceeding 100 cfs would significantly increase the incidence of downstream displacement of brown trout fry, juveniles, and adults relative to point-of-reference conditions. In many years, significant numbers of trout may be displaced downstream from the major trout production area (Segment 2) to lower reaches (Segments 3-6) where production is currently limited by a scarcity of suitable adult habitat and spawning gravel. The loss of trout from Segment 2 to downstream reaches or Mono Lake would adversely affect the brown trout population in many years despite increases in available habitat under this alternative.

Parker and Walker Creeks

Average monthly flows in Parker and Walker Creeks under the 6,377-Ft Alternative would be identical in magnitude and frequency to flows under the 6,372-Ft Alternative except for the occurrence of higher flows in June (see Chapter 3A, "Hydrology"). These higher June flows reduce habitat quality in both creeks slightly, with habitat conditions remaining as good in Parker Creek but being reduced to the fair rating in wet and normal years in Walker Creek (Table 3D-17). Similar to the 6,372-Ft Alternative, the 6,377-Ft Alternative would substantially benefit aquatic habitats and resources over the severely degraded conditions present at the point of reference.

In approximately 2 of every 3 years, the 6,377-Ft Alternative would exceed Tennant's recommended flushing and channel maintenance flow requirement during June. Consequently, habitat conditions would not be reduced over time under the 6,377-Ft Alternative and would therefore provide better overall aquatic habitat conditions than would the 6,370-Ft Alternative, which would not meet flushing flow requirements.

Grant Lake Reservoir

Reservoir Fluctuations. Changes in spawning success associated with the 6,377-Ft Alternative would be nearly identical to those associated with the 6,372-Ft Alternative (see page 3D-60). Compared to the 6,372-Ft Alternative, the 6,377-Ft Alternative would have slightly greater beneficial effects on brown trout spawning success during normal and wet water years (Table 3D-18).

Reservoir Productivity. Operation of Grant Lake reservoir under the conditions of the 6,377-Ft Alternative would decrease average monthly water surface elevations for the April-October period by 5 feet and cause average monthly reservoir surface area to decrease by approximately 77 acres, relative to point-of-reference conditions (Table 3D-19). Impacts on fish productivity would be less than significant because reservoir surface area would decrease by only 9% relative to point-of-reference conditions.

Upper Owens River

Physical Habitat

Brown Trout. Under the 6,377-Ft Alternative, brown trout adult habitat would be reduced 28% in dry years and 10% in normal years and would exhibit negligible change in wet years relative to point-of-reference levels (Table 3D-20). Brown trout spawning habitat would be reduced 19% in dry years, 6% in normal years, and 20% in wet years (Table 3D-20).

Rainbow Trout. Adult rainbow trout habitat would be reduced 26% in dry years and 10% in dry years and would exhibit negligible change in wet years relative to point-of-reference levels (Table 3D-20). Rainbow trout spawning habitat would increase 3% in dry years, 19% in normal years, and 18% in wet years (Table 3D-20).

Water Temperature. Under the 6,377-Ft Alternative, monthly flows less than 75 cfs during June through September would occur more frequently than under point-of-reference or the 6,372-Ft Alternative conditions but would still be limited to dry years (lowest 20% flows) (see Chapter 3A, "Hydrology"). Temperature impacts would be similar to those under the 6,372-Ft Alternative.

Water Quality. Under the 6,377-Ft Alternative, potential water quality impacts would be similar to those under the 6372-Ft Alternative (see page 3D-61).

Channel Morphology and Spawning Gravel Characteristics. Under the 6,377-Ft Alternative, monthly flows exceeding 200 cfs would occur 50% of the time (July) compared to 80% of the time (April) under point-of-reference conditions (see Chapter 3A, "Hydrology). The frequency of overbank flows and potential erosion impacts would decrease accordingly. Potential habitat degradation would be avoided in some years, but general channel and substrate conditions would not change significantly.

Fish Population Characteristics. Under the 6,377-Ft Alternative, brown and rainbow trout adult populations may be reduced significantly in response to significant reductions in adult brown trout and rainbow trout habitat in dry and normal water years (Table 3D-20). Significant changes in the amount of available brown and rainbow trout spawning habitat under this alternative would probably have no significant effects on trout populations because spawning habitat does not appear to be limiting production in the Upper Owens River.

Lake Crowley Reservoir

Operation of Lake Crowley reservoir under the conditions of the 6,377-Ft Alternative would decrease average monthly water surface elevations during the April-October period and cause average reservoir surface area to decrease by approximately 33 acres (less than 1%) relative to the point of reference (Table 3D-21). Similarly, average surface area during the November-March period would decrease by approximately 21 acres (less than 1%) compared to the point of reference (Table 3D-21). No significant impacts on fish productivity would occur under the 6,377-Ft Alternative because surface areas would be reduced by less than 1% relative to the point of reference. The 6,377-Ft Alternative would slightly reduce fish productivity in Lake Crowley reservoir compared to the alternatives discussed earlier.

Middle Owens River

Physical Habitat

Brown Trout. The 6,377-Ft Alternative would significantly increase overall brown trout spawning habitat in Segments 1-3 relative to the point-of-reference level (Figures 3D-13 through 3D-16). Average spawning WUA increased from 7% in Segment 1 to 18% in Segment 2 (Tables 3D-22 through 3D-25). Changes in WUA at individual spawning transects ranged from a 12% reduction to a 6% increase (Table 3D-26).

Aquatic Invertebrates. Aquatic invertebrate habitat under the 6,377-Ft Alternative would be increased relative to the 6,372-Ft Alternative (Figure 3D-17). Average WUA would be substantially greater (53%) than the point-of-reference level (Table 3D-27).

Largemouth Bass. A further reduction in spring and summer flows under the 6,377-Ft Alternative would increase largemouth bass spawning habitat relative to the 6,372-Ft Alternative (Figures 3D-18 through 3D-21); average spawning WUA would be increased substantially (53%) relative to the point-of-reference level (Table 3D-28). Little change in fry, juvenile, and adult habitat availability would occur.

Water Temperature. Under the 6,377-Ft Alternative, lower flows would result in a maximum of 2-3 additional days per month (June and August) in which the mean daily water temperature at Five Bridges Road would exceed the optimum range for brown trout relative to the 6,372-Ft Alternative (see page 3D-62). Maximum daily water temperatures would remain below 72°F throughout the summer. In October, the number of days with mean daily water temperatures within the optimum range for brown trout spawning and incubation would be increased by 1-2 days. No measurable impacts on brown trout reproduction, growth, or survival would be expected from these small changes.

Lower flows in Segment 4 would slightly improve water temperatures for largemouth bass production relative to point-of-reference conditions, but the changes in frequency and magnitude of water temperatures would not be sufficient to provide measurable benefits.

Channel Morphology and Spawning Gravel Characteristics. Channel and streambed conditions under the 6,377-Ft Alternative would be similar to those occurring under point-of-reference conditions.

Fish Population Characteristics

Brown Trout. Potential changes in the brown trout population would be similar to those described for the 6,372-Ft Alternative (see page 3D-63).

Largemouth Bass. Potential changes in the largemouth bass population would be similar to those described for the 6,372-Ft Alternative (see page 3D-63).

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

Impacts on fishery resources under the 6,377-Ft Alternative would be the same as those described above under the No-Restriction Alternative (see page 3D-54).

Los Angeles Aqueduct and Irrigation Canals

Impacts on fishery resources under the 6,377-Ft Alternative would be similar to those under the 6,372-Ft Alternative (see page 3D-63).

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,377-Ft Alternative)

Rush Creek

- Causes resource changes similar to those of the 6,372-Ft Alternative (see page 3D-63), except for increased streambank erosion, habitat restoration impacts, and spawning gravel losses.

Mitigation Measures. The frequency of flows exceeding 100 cfs in June should be reduced by increasing diversions and limiting flows to a maximum of 80 cfs, as measured at Mono Gate #1, except in years when the need for a flushing and channel maintenance flow is identified. The 80-cfs recommendation considers expected Parker and Walker Creek inflows, which were not considered in DFG's 100 cfs recommendation. Spawning gravels should be added periodically to Segments 2 and 3 to offset gravel losses. The quantities, locations, and timing of spawning gravel placement should be determined by a fisheries biologist.

Proposed habitat restoration work in lower Rush Creek includes the use of current deflectors, woody debris, and vegetation to protect and stabilize eroding streambanks and the use of diversions and secondary channels to limit the effect of high flows on unstable channel reaches (Trihey & Associates 1991). These measures are consistent with the mitigation requirements for protecting Segment 6 from increased erosion, but reducing the frequency of high flows under this alternative is critical for the short-term and long-term success of habitat restoration efforts.

Lee Vining Creek

- Increases brown trout spawning (218%), juvenile (62%), and adult (93%) physical habitat.

- Causes no significant changes in water temperature and ice-related effects on fisheries resources.

- Improves aquatic habitat and spawning gravel quality, but increases spawning gravel losses from Segment 2 and increases adverse impacts on habitat restoration.

Mitigation Measures. Habitat restoration impacts should be minimized by limiting peak flows to 100 cfs and determining the need for channel maintenance and flushing flows through periodic spawning gravel surveys. This mitigation measure would reduce the loss of gravels from Segment 2, although continued gravel replenishment may be necessary. Spawning gravel surveys should be continued to monitor gravel quality, quantity, and distribution in the affected reaches. If additional spawning gravel is needed, the quantities, locations, and timing of gravel placement should be determined by a fisheries biologist.

- Reduces brown trout abundance and biomass through downstream displacement and loss of trout from major spawning area.

Mitigation Measures. Recommended mitigation is to reduce the frequency, magnitude, and duration of high spring and summer flows by exporting additional flow when possible and avoiding rapid flow fluctuations associated with operation and maintenance of the LADWP diversion dam. To reduce significant impacts on the brown trout population, flows in lower Lee Vining Creek during the spring and summer runoff period should not exceed 100 cfs except in wet years when the diversion capacity cannot physically meet this requirement or when periodic channel maintenance flows are required. Under this flow regime, sluicing activities at the LADWP diversion dam should be discontinued and other means of removing sand from the diversion pond should be sought. Ramping rates during flow changes should not exceed the unimpaired historical rates observed above the LADWP diversion dam.

Additional mitigation measures include constructing adequate refuge habitat, such as pools, backwaters, and overflow channels, in combination with overhead cover, to allow the stream to reoccupy former channels and to restore channel and bank stability in the reach below Highway 395. These measures are currently being implemented as part of a stream habitat and riparian restoration plan developed for Rush and Lee Vining Creeks (Trihey & Associates 1991). The success of habitat restoration efforts in the future will determine the degree to which flows can be increased above 100 cfs.

Parker and Walker Creeks

- Creates and maintains good fish habitat. Resource conditions would benefit substantially as described for the 6,372-Ft Alternative (see page 3D-64) but would not degrade over time because of inadequate flushing flows.

Grant Lake Reservoir

- Improves brown trout spawning success by decreasing lake level fluctuations.
- Reduces fish productivity (9% decrease in reservoir surface area).

Upper Owens River

- Significantly reduces brown trout adult habitat in dry (-28%) and normal (-10%) years and spawning habitat in dry (-19%) and wet (-20%) years

Mitigation Measures. Expected brown trout habitat losses should be minimized by modifying LADWP operations of Grant Lake reservoir and the Mono Craters tunnel to augment Upper Owens River flows within the context of balancing other water and resource needs. Based on projected water supply, an annual operation strategy should be developed and implemented each year to provide nearly constant year-round East Portal releases that maximize Upper Owens River flows; flows should not exceed 200 cfs below East Portal or 270 cfs below the Hot Creek confluence (EBASCO Environmental et al. 1993). Maximizing Upper Owens River flows would be most important during dry and normal water years and may be partially accomplished by using carry-over storage in Grant Lake reservoir (e.g., storing water in wet years and releasing it to the Upper Owens River in dry or normal years). The magnitude of flow augmentation should be determined by

April 1 and releases should be started by July 1 and continue for one year. Depending on specific operational schedules, this mitigation measure may partially or totally mitigate for reduced physical habitat under this alternative.

Fixed minimum instream flows were identified that would reduce the adult brown trout habitat impacts to less-than-significant levels (allowing for a 9% reduction from point-of-reference conditions). Spawning habitat is not considered to be a limiting factor under most conditions and was considered in establishing minimum flows to reduce significant impacts. Minimum flows of approximately 150 cfs in Segment 1 (below East Portal), 135 cfs in Segment 2 (above Hot Creek), and 180 cfs in Segment 3 (below Hot Creek) would reduce impacts to less-than-significant levels for brown trout.

- Significantly reduces rainbow trout adult habitat in dry (-26%) and normal (-10%) years, and increases spawning habitat in normal (19%) and wet (18%) years.

Mitigation Measures. Mitigation measures identified above for reduced brown trout habitat generally apply to impacts on rainbow trout habitat. Minimum flows of approximately 150 cfs in Segment 1 (below East Portal), 135 cfs in Segment 2 (above Hot Creek), and 170 cfs in Segment 3 (below Hot Creek) would reduce impacts to less-than-significant levels for rainbow trout.

- Adversely affects water temperature conditions in dry years similar to the 6,370-Ft Alternative, but impacts on fisheries production are considered less than significant.

- Degrades water quality conditions but impacts on fisheries production considered less than significant.

- Maintains channel and streambed conditions.

- Significantly reduces adult brown and rainbow trout abundance.

Mitigation Measures. Mitigation measures identified above for reduced physical habitat apply to impacts on trout abundance.

Lake Crowley Reservoir

- Slightly decreases fish productivity (less than 1%).

Middle Owens River

- Aquatic habitat and resources would not differ significantly from the 6,372-Ft Alternative (see page 3D-65).

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

- Maintains fish productivity.

Los Angeles Aqueduct and Irrigation Canals

- Reduces fisheries habitat by less-than-significant levels.

IMPACTS AND MITIGATION MEASURES FOR THE 6,383.5-Ft ALTERNATIVE

Changes in Resource Conditions

Rush Creek

Changes in resource conditions under the 6,383.5-Ft Alternative would be similar to those occurring under the 6,377-Ft Alternative (see page 3D-66) except for increased severity of streambank erosion, habitat restoration impacts, and loss of spawning gravels. Flows equal to or exceeding 250 cfs would occur with the same frequency under the point of reference.

Lee Vining Creek

Changes in resource conditions under the 6,383.5-Ft Alternative would be similar to those occurring under the 6,377-Ft Alternative (see page 3D-67).

Parker and Walker Creeks

Changes in resource conditions associated with the 6,383.5-Ft Alternative would be similar to those associated with the 6,377-Ft Alternative (see page 3D-68).

Grant Lake Reservoir

Reservoir Fluctuations. Changes associated with the 6,383.5-Ft Alternative would be similar to those associated with the 6,377-Ft Alternative (see page 3D-69).

Reservoir Productivity. Average monthly reservoir elevations for the April-October period under the 6,383.5-Ft Alternative would be reduced by 6 feet relative to point-of-reference levels. Lower average monthly reservoir levels would reduce average monthly reservoir surface area by 93 acres (11%). During the 1940-1989 hydrologic period, reservoir simulations indicate there would be approximately 23 years with significant impacts on fish production. The 6,383.5-Ft Alternative would have significant impacts on fish productivity in Grant Lake reservoir.

Upper Owens River

Physical Habitat

Brown Trout. Under the 6,383.5-Ft Alternative, brown trout adult habitat would be reduced 33% in dry years, 26% in normal years, and 3% in wet years relative to point-of-reference levels (Table 3D-20). Brown trout spawning habitat would be reduced 21% in dry years, 5% in normal years, and increased 40% in wet years (Table 3D-20).

Rainbow Trout. Adult rainbow trout habitat would be reduced by 32% in dry years, 25% in normal years, and 3% in wet years relative to point-of-reference levels (Table 3D-20). The amount of rainbow trout spawning habitat would be nearly the same in dry years, but would be increased 24% in normal years and 35% in wet years (Table 3D-20).

Water Temperature. Under the 6,383.5-Ft Alternative, the frequency of monthly flows less than 75 cfs during June through September would occur in 20-30% of the years compared to less than 10% of the years under the point of reference (see Chapter 3A, "Hydrology"). A corresponding increase in the frequency of suboptimum water temperatures would reduce the amount of suitable habitat in the lower reaches of the Upper Owens River, especially in the reach below the Hot Creek confluence. Significant impacts on trout populations, particularly below Hot Creek, may occur during summer months.

Water Quality. Water quality conditions under the 6,383.5-Ft Alternative would be further degraded relative to the 6,372-Ft Alternative (see page 3D-61). The increased frequency of low flows under the 6,383.5-Ft Alternative may cause significant impacts on fisheries in Segment 3 relative to point-of-reference conditions.

Channel Morphology and Spawning Gravel Characteristics. Under the 6,383.5-Ft Alternative, the frequency of flows exceeding 200 cfs would be decreased further (30% of the time) relative to the 6,377-Ft Alternative (see Chapter 3A, "Hydrology"), and potential habitat losses associated with increased bank erosion and meander cutoffs would be avoided in a greater number of years. Changes in channel and substrate conditions are not expected to change significantly from point-of-reference conditions.

Fish Population Characteristics. Further reductions in flows under the 6,383.5-Ft Alternative would significantly reduce adult brown trout and rainbow trout habitat in dry and normal water years, potentially reducing adult populations in many years relative to point-of-reference levels. Significant changes in the amount of available brown and rainbow trout spawning habitat under this alternative would probably have no significant effects on trout populations because spawning habitat does not appear to be limiting production in the Upper Owens River. Trout populations in Segment 3 also would be adversely affected by increased exposure to high summer water temperatures and poor water quality during periods of low flow.

Lake Crowley Reservoir

Lake Crowley reservoir operations under the 6,383.5-Ft Alternative would decrease average monthly water surface elevations during the April-October period and cause average reservoir surface area to decrease by approximately 108 acres (2%) relative to the point of reference (Table 3D-21). Similarly, average surface area during the November-March period would decrease by approximately 77 acres (2%) compared to point-of-reference levels (Table 3D-21). Lower reservoir elevations under the 6,383.5-Ft Alternative during either period would adversely affect fish productivity in Lake Crowley reservoir because of reduced reservoir surface areas. No significant impacts would occur under the 6,383.5-Ft Alternative because surface area would be reduced relative to the point of reference by less than the 10% significance criterion in both the summer and winter periods. The 6,383.5-Ft Alternative would have slightly greater impacts on fish productivity in Lake Crowley reservoir than would the alternatives discussed earlier.

Middle Owens River

Physical Habitat

Brown Trout. Under the 6,383.5-Ft Alternative, brown trout spawning habitat would be significantly increased relative to point-of-reference levels (Figures 3D-13 through 3D-16). Increases in spawning WUA would range from 12% in Segment 1 to 23% in Segment 2 (Tables 3D-22 through 3D-25), and changes in WUA at individual spawning transects would range from an 8% decrease in Segment 3 to a 10% increase in Segment 2 (Table 3D-26). Changes in fry, juvenile, and adult WUA would not be significant.

Aquatic Invertebrates. Aquatic invertebrate habitat under the 6,383.5-Ft Alternative would be increased relative to the 6,377-Ft Alternative (Figure 3D-17); average WUA would be substantially greater (66%) than the point-of-reference level (Table 3D-27).

Largemouth Bass. Under the 6,383.5-Ft Alternative, largemouth bass spawning habitat would be increased relative to the 6,377-Ft Alternative; average spawning WUA would be substantially greater (73%) than the point-of-reference level (Table 3D-28). Changes in fry, juvenile, and adult WUA would be less than 9%.

Water Temperature. The magnitude and frequency of water temperatures under the 6,383.5-Ft Alternative would be similar to those occurring under the 6,377-Ft Alternative (see page 3D-70).

Channel Morphology and Spawning Gravel Characteristics. Under the 6,383.5-Ft Alternative, mean monthly Pleasant Valley Reservoir releases above 600 cfs would occur less frequently (approximately 30% of the years) than under the point-of-reference (approximately 40% of the years) (see Chapter 3A, "Hydrology"). No substantial changes in channel and streambed conditions would be expected.

Fish Population Characteristics

Brown Trout. Substantial increases in brown trout spawning habitat under the 6,383.5-Ft Alternative would potentially increase brown trout fry production and recruitment relative to point-of-reference levels. However, fry abundance and subsequent abundance of older age classes may frequently be limited by the amount of suitable fry habitat, which would remain virtually unchanged over the range of alternatives, and not spawning habitat. The Middle Owens River channel in the principal brown trout rearing area is generally confined between steep banks, and shallow-water habitat with low water velocities is scarce over a broad flow range; during direct observation surveys at flows between 100 cfs and 200 cfs in May 1991, brown trout fry were found only in a several locations where such habitat was present (Jones & Stokes Associates 1992). Limited fry habitat was also identified as a potential cause of exceptionally low brown trout recruitment in 1979 (Deinstadt and Wong 1980b). Consequently, measurable increases in brown trout populations under the 6,383.5-Ft Alternative would not be expected; potential changes in the brown trout population would be similar to those described for the 6,372-Ft Alternative (see page 3D-63).

Largemouth Bass. Potential changes in the largemouth bass population would be similar to those described for the 6,372-Ft Alternative (see page 3D-63).

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

Impacts on fishery resources under the 6,383.5-Ft Alternative would be the same as those described for the No-Restriction Alternative (see page 3D-54).

Los Angeles Aqueduct and Irrigation Canals

Impacts on fishery resources under the 6,383.5-Ft Alternative would be similar to those under the 6,372-Ft Alternative (see page 3D-63).

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,383.5-Ft Alternative)

Rush Creek

- Causes resource changes similar to those of the 6,377-Ft Alternative (see page 3D-71), except for increased severity of streambank erosion, habitat restoration impacts, and spawning gravel losses.

Mitigation Measures. Mitigation measures are identical to those specified for the 6,377-Ft Alternative (see page 3D-72).

Lee Vining Creek

- Causes resource changes similar to those of the 6,377-Ft Alternative (see page 3D-72).

Mitigation Measures. Mitigation measures are identical to those specified for the 6,377-Ft Alternative (see page 3D-72).

Parker and Walker Creeks

- Creates and maintains good fish habitat. Substantial benefits to resource conditions under the 6,383.5-Ft Alternative would be identical to those associated with the 6,377-Ft Alternative (see page 3D-73).

Grant Lake Reservoir

- Improves brown trout spawning success by decreasing lake level fluctuations.
- Significantly reduces fish productivity (11%).

Mitigation Measures. Declines in Grant Lake reservoir surface elevation would average about 11% under the 6,383.5-Ft Alternative. Impacts on fish productivity could be lessened by the improved brown trout spawning success, however, if spawning habitat is limiting Grant Lake reservoir fish populations. Grant Lake reservoir also is presently stocked by DFG, and this stocking program partially mitigates the effects of lower water surface elevations. Given these factors, the overall impact on Grant Lake reservoir fishery resources is less than significant and mitigation is not required. Establishing a specific minimum pool, while decreasing the flexibility for managing water resources for instream or out-of-stream beneficial uses, could be used to enhance Grant Lake reservoir fishery resources.

A fish stocking program could be developed, negotiated, and implemented for Grant Lake reservoir by LADWP and DFG. The details of a fish stocking program would require that success criteria be established, such as number or weight of annual trout yield to anglers, to maintain game fish populations at point-of-reference levels. Some considerations for a fish stocking program include:

- estimated point-of-reference annual trout yield;
- size of fish to be stocked (fingerling, subcatchable, or catchable);
- strain of trout to be stocked (rainbow and brown trout);
- stocking density, frequency, and duration of season; and
- existing California Fish and Game Commission fish planting policies.

Upper Owens River

- Significantly reduces brown trout adult habitat in dry (-33%) and normal (-26%) years and spawning habitat in dry years (-21%), and increases spawning habitat in wet years (40%).

Mitigation Measures. Mitigation measures are identical to those specified for the 6,377-Ft Alternative (see page 3D-73).

- Significantly reduces rainbow trout adult habitat in dry (-26%) and normal (-10%) years, and increases spawning habitat in normal (19%) and wet (18%) years.

Mitigation Measures. Mitigation measures are identical to those specified for the 6,377-Ft Alternative (see page 3D-74).

- Significantly degrades water temperature conditions below the Hot Creek confluence.

Mitigation Measures. Maintaining a minimum flow of 75 cfs, as measured below East Portal, would mitigate this impact to a less-than-significant level. Maintaining a minimum flow of approximately 150 cfs, as measured below East Portal, would mitigate this impact completely, assuming current diversion rates in the Upper Owens River.

- Significantly degrades water quality conditions below the Hot Creek confluence.

Mitigation Measures. Impacts from increased arsenic concentrations below Hot Creek are difficult to accurately assess and mitigate without further study. The minimum flow of 75 cfs, as measured below East Portal and recommended above to mitigate water temperature impacts to less-than-significant levels, would likely be satisfactory mitigation to reduce water quality impacts to less-than-significant levels, assuming current diversion rates in the Upper Owens River. Maintaining a minimum flow of approximately 150 cfs, as measured below East Portal, would likely mitigate these impacts completely, assuming current diversion rates in the Upper Owens River.

- Maintains channel and streambed conditions.
- Significantly reduces adult brown and rainbow trout abundance.

Mitigation Measures. Mitigation measures identified above for reduced physical habitat, increased water temperatures, and reduced water quality apply to impacts on trout abundance.

Lake Crowley Reservoir

- Decreases fish productivity by less than 3%.

Middle Owens River

- Causes resource changes similar to those of the 6,372-Ft Alternative (see page 3D-65).

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

- Causes no significant changes in fish productivity.

Los Angeles Aqueduct and Irrigation Canals

- Reduces fisheries habitat by less-than-significant levels.

IMPACTS AND MITIGATION MEASURES FOR THE 6,390-FT ALTERNATIVE

Changes in Resource Conditions

Rush Creek

Changes in resource conditions under the 6,390-Ft Alternative would be similar to those occurring under the 6,377-Ft Alternative (see page 3D-66), except for increased severity of streambank erosion, habitat restoration impacts, and spawning gravel losses.

Lee Vining Creek

Changes in resource conditions under the 6,390-Ft Alternative would be similar to those occurring under the 6,377-Ft Alternative (see page 3D-67).

Parker and Walker Creeks

Changes in resource conditions associated with the 6,390-Ft Alternative would be similar to those associated with the 6,377-Ft Alternative (see page 3D-68).

Grant Lake Reservoir

Reservoir Fluctuation. Changes associated with the 6,390-Ft Alternative would be similar to those associated with the 6,377-Ft Alternative (see page 3D-69).

Reservoir Productivity. Changes in fish productivity associated with the 6,390-Ft Alternative would be nearly identical to those associated with the 6,383.5-Ft Alternative (see page 3D-75). Average monthly reservoir elevations for the April-October period under the 6,390-Ft Alternative would be reduced by 6 feet relative to point-of-reference levels. Lower average monthly reservoir levels would reduce average monthly reservoir surface area by 100 acres (11%). Reservoir simulations for the 1940-1989 hydrologic period indicate there would be approximately 25 years with significant impacts on fish production.

Upper Owens River

Physical Habitat

Brown Trout. Under the 6,390-Ft Alternative, brown trout adult habitat would be reduced 37% in dry years, 31% in normal years, and 9% in wet years relative to point-of-reference levels (Table 3D-20). Brown trout spawning habitat would be reduced 26% in dry years and 5% in normal years and increased 40% in wet years (Table 3D-20).

Rainbow Trout. Adult rainbow trout habitat would be reduced 35% in dry years, 29% in normal years, and 9% in wet years relative to point-of-reference levels (Table 3D-20). Rainbow trout spawning habitat would be reduced 5% in dry years, increased by 23% in normal years, and increased by 45% in wet years (Table 3D-20).

Water Temperature. Under the 6,390-Ft Alternative, the frequency of monthly flows less than 75 cfs during June through September would occur in 30-40% of the years compared to less than 10% of the years under the point of reference (see Chapter 3A, "Hydrology"). Water temperature conditions, particularly in the reach below Hot Creek, would be further degraded relative to the 6,383.5-Ft Alternative. The increased frequency of low flows would significantly increase fisheries impacts, especially below the Hot Creek confluence, during summer months.

Water Quality. Water quality conditions under the 6,390-Ft Alternative would be further degraded relative to the 6,383.5-Ft Alternative (see page 3D-76). Significant impacts on fisheries may occur in Segment 3 relative to point-of-reference conditions.

Channel Morphology and Spawning Gravel Characteristics. Channel and streambed conditions under the 6,390-Ft Alternative would be similar to those occurring under the 6,383-Ft Alternative (see page 3D-76).

Fish Population Characteristics. Under the 6,390-Ft Alternative, adverse impacts to adult brown and rainbow trout abundance would be similar to those under the 6,383.5-Ft Alternative (see page 3D-76), but somewhat exacerbated.

Lake Crowley Reservoir

Changes associated with the 6,390-Ft Alternative would be identical to those associated with the 6,383.5-Ft Alternative (see page 3D-77).

Middle Owens River

Physical Habitat

Brown Trout. Changes in the amount of physical habitat available to brown trout life stages would be similar to those occurring under the 6,383.5-Ft Alternative (Figures 3D-13 through 3D-16). Relative to the point of reference, spawning WUA would increase by 13% in Segment 1 and by 26% in Segment 2 (Tables 3D-22 through 3D-25), and WUA changes at individual spawning transects would range from a 6% decrease to a 12% increase relative to the point of reference (Table 3D-26).

Aquatic Invertebrates. Aquatic invertebrate habitat available under the 6,390-Ft Alternative would be increased relative to the 6,383.5-Ft Alternative (Figure 3D-17); average WUA would be substantially greater (74%) than the point-of-reference level (Table 3D-27).

Largemouth Bass. Under the 6,390-Ft Alternative, largemouth bass spawning habitat would be increased relative to the 6,383.5-Ft Alternative; average spawning WUA would be substantially greater (78%) than the point-of-reference level (Table 3D-28). Changes in fry, juvenile, and adult WUA would be less than 10%.

Water Temperature. The frequency of suboptimum water temperatures under the 6,390-Ft Alternative would be increased slightly relative to the 6,377-Ft Alternative (see page 3D-70). Mean daily water temperatures at Five Bridges Road would exceed the optimum range for brown trout more frequently in June and August (4-5 more days per month) compared to the point of reference. Maximum daily water temperatures would remain below the upper tolerance limit at all times in the principal brown trout rearing area. The frequency and magnitude of water temperatures in October would be similar to those occurring under the 6,377-Ft Alternative. No measurable impacts on brown trout reproduction, growth, or survival would be expected.

Under the 6,390-Ft Alternative, water temperatures would be slightly improved for largemouth bass relative to the 6,377-Ft Alternative (see page 3D-70) but would remain below optimum ranges during the spring and summer months. No measurable benefits would be expected.

Channel Morphology and Spawning Gravel Characteristics. Under the 6,390-Ft Alternative, mean monthly Pleasant Valley Reservoir releases above 600 cfs would occur less frequently (30% of the years) than under the point of reference (40% of the years) (see Chapter 3A, "Hydrology"). No substantial changes in channel and streambed conditions would be expected.

Fish Population Characteristics

Brown Trout. Potential changes in the brown trout population under the 6,390-Ft Alternative would be similar to those described under the 6,372-Ft Alternative (see page 3D-63).

Largemouth Bass. Potential changes in the largemouth bass population would be similar to those described for the 6,372-Ft Alternative (see page 3D-63).

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

Impacts on fishery resources under the 6,390-Ft Alternative would be the same as those described for the No-Restriction Alternative (see page 3D-54).

Los Angeles Aqueduct and Irrigation Canals

Impacts on fishery resources under the 6,390-Ft Alternative would be similar to those under the 6,372-Ft Alternative (see page 3D-63).

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,390-Ft Alternative)

Rush Creek

- Causes resource changes similar to those of the 6,377-Ft Alternative (see page 3D-71), except for increased severity of streambank erosion, habitat restoration impacts, and spawning gravel losses.

Mitigation Measures. Mitigation measures are identical to those specified for the 6,377-Ft Alternative (see page 3D-72).

Lee Vining Creek

- Causes resource changes similar to those of the 6,377-Ft Alternative (see page 3D-72).

Mitigation Measures. Mitigation measures are identical to those specified for the 6,377-Ft Alternative (see page 3D-72).

Parker and Walker Creeks

- Creates and maintains good fish habitat. Significant benefits to resource conditions under the 6,390-Ft Alternative would be identical to those associated with the 6,377-Ft Alternative (see page 3D-73).

Grant Lake Reservoir

- Improves brown trout spawning success by decreasing lake level fluctuations.
- Significantly reduces fish productivity (-11%).

Mitigation Measures. Mitigation measures associated with the 6,390-Ft Alternative are not required, as discussed for the 6,383.5-Ft Alternative. Enhancement opportunities are available, as discussed for the 6,383.5-Ft Alternative (see page 3D-79).

Upper Owens River

- Causes significant adverse resource changes similar to those of the 6,383.5-Ft Alternative (see page 3D-80).

Mitigation Measures. Mitigation measures are identical to those specified for the 6,383.5-Ft Alternative (see page 3D-80).

Lake Crowley Reservoir

- Slightly decreases fish productivity (less than 3%).

Middle Owens River

- Causes resource changes similar to those of the 6,372-Ft Alternative (see page 3D-65).

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

- Causes no significant changes in fish productivity.

Los Angeles Aqueduct and Irrigation Canals

- Reduces fisheries habitat by less-than-significant levels.

IMPACTS AND MITIGATION MEASURES FOR THE 6,410-FT ALTERNATIVE

Changes in Resource Conditions

Rush Creek

Changes in resource conditions under the 6,410-Ft Alternative would be similar to those occurring under the 6,377-Ft Alternative (see page 3D-66), except for increased magnitude and duration of flows capable of inducing streambank erosion in Segment 6 (causing adverse effects on habitat restoration efforts), loss of spawning gravels in Segments 2 and 3, and a substantial increase in available brown trout spawning habitat in October and November. Because adult habitat was not increased to a similar extent, the potential benefits of additional spawning habitat would be limited by the amount of adult habitat available during spring and summer, which does not change appreciably under lake-level alternatives at or above the 6,372-foot lake elevation.

Lee Vining Creek

Changes in resource conditions under the 6,410-Ft Alternative would be similar to those occurring under the 6,377-Ft Alternative (see page 3D-67), except for a relatively large increase in available brown trout spawning habitat resulting from higher flows in October and November (Table 3D-13, Figure 3D-9). The overall increase in spawning habitat largely reflects WUA increases in Segments 5 and 6. Spawning WUA in Segment 2, however, would decrease relative to the 6,377-Ft Alternative (Table 3D-13). Because of the importance of Segment 2 for brown trout spawning and recruitment in lower Lee Vining Creek, the 6,410-Ft Alternative would potentially reduce brown trout production relative to the 6,377-Ft Alternative, but available spawning habitat would still be significantly greater than that available under point-of-reference conditions.

Parker and Walker Creeks

Changes in resource conditions associated with the 6,410-Ft Alternative would be similar to those associated with the 6,377-Ft Alternative (see page 3D-68).

Grant Lake Reservoir

Reservoir Fluctuations. Changes in spawning success associated with the 6,410-Ft Alternative would be similar to those associated with the 6,377-Ft Alternative (see page 3D-69).

Reservoir Productivity. Changes in fish productivity associated with the 6,410-Ft Alternative would be nearly identical to those associated with the 6,383.5-Ft Alternative (see page 3D-75). Average monthly reservoir elevations for the April-October period under the 6,410-Ft Alternative would be reduced by 7 feet relative to the point-of-reference level. Lower average monthly reservoir levels would reduce average monthly reservoir surface area by 114 acres (13%). Reservoir simulations for the 1940-1989 hydrologic period indicate there would be approximately 26 years with significant impacts on fish production.

Upper Owens River

Physical Habitat

Brown Trout. Under the 6,410-Ft Alternative, brown trout adult habitat would be reduced 39% in dry years, 38% in normal years, and 30% in wet years relative to point-of-reference levels (Table 3D-20). Brown trout spawning habitat would be reduced 28% in dry years and 25% in normal years and increased 38% in wet years (Table 3D-20).

Rainbow Trout. Adult rainbow trout habitat would be reduced 37% in dry years, 36% in normal years, and 29% in wet years relative to point-of-reference levels

(Table 3D-20). Rainbow trout spawning habitat would be reduced by 6% in dry years, and increased by 22% in normal years and 48% in wet years (Table 3D-20).

Water Temperature. Under the 6,410-Ft Alternative, the frequency of monthly flows less than 75 cfs during June through September would occur in 30-60% of the years compared to less than 10% of the years under the point of reference (see Chapter 3A, "Hydrology"). Water temperature conditions, particularly in the reach below Hot Creek, would be further degraded relative to the 6,390-Ft Alternative. Fisheries impacts are considered significant relative to point-of-reference conditions.

Water Quality. Water quality conditions under the 6,410-Ft Alternative would be further degraded relative to the 6,383.5-Ft Alternative (see page 3D-76). Significant impacts on fisheries may occur in Segment 3 relative to point-of-reference conditions.

Channel Morphology and Spawning Gravel Characteristics. Under the 6,410-Ft Alternative, mean monthly flows would nearly always fall within the optimum range for maintaining channel and streambed conditions (see Chapter 3A, "Hydrology"). Benefits would likely occur relative to point-of-reference conditions.

Fish Population Characteristics. Under the 6,410-Ft Alternative, significant reductions in brown and rainbow trout habitat and increased exposure to adverse water temperature and water quality conditions in Segment 3 in most years would result in additional adverse impacts on trout populations relative to the 6,383.5-Ft Alternative (see page 3D-76).

Lake Crowley Reservoir

Lake Crowley reservoir operations under the 6,410-Ft Alternative would decrease average monthly water surface elevations during the April-October period and cause average reservoir surface area to decrease by approximately 212 acres (5%) relative to the point-of-reference level (Table 3D-21). Similarly, average surface area during the November-March period would decrease by approximately 192 acres (4%) compared to the point-of-reference level (Table 3D-21). Lower reservoir elevations under the 6,410-Ft Alternative during either period would adversely affect fish productivity in Lake Crowley reservoir but only at less-than-significant levels. The 6,410-Ft Alternative would have slightly greater impacts on fish productivity in Lake Crowley reservoir compared to the alternatives discussed earlier.

Middle Owens River

Physical Habitat

Brown Trout. Under the 6,410-Ft Alternative, brown trout spawning, juvenile, and adult habitat would be increased relative to the 6,390-Ft Alternative and would be significantly increased relative to point-of-reference levels (Figures 3D-13 through 3D-16). Spawning, juvenile, and adult WUA would be increased by 31%, 13%, and 13%, respectively from the point-of-reference levels (Tables 3D-22 through 3D-25). Spawning WUA would be increased by 25% in Segment 1 and by 38% in Segment 2, and WUA at individual spawning transects would increase up to 25% (Table 3D-26). Fry habitat would still show little change from point-of-reference levels.

Aquatic Invertebrates. The amount of suitable aquatic invertebrate habitat under the 6,410-Ft Alternative would be increased relative to the 6,390-Ft Alternative (Figure 3D-17); average WUA would be substantially greater (92%) than the point-of-reference value (Table 3D-27).

Largemouth Bass. Under the 6,410-Ft Alternative, largemouth bass spawning habitat would be increased relative to the 6,390-Ft Alternative; average spawning WUA would be substantially greater (96%) than the point-of-reference value (Table 3D-28). Adult WUA would increase by 12%, while fry and juvenile WUA would remain virtually unchanged.

Water Temperature. Water temperatures would be similar to those occurring under the 6,390-Ft Alternative (see page 3D-84) except that suboptimum water temperatures would occur more frequently during the warmest summer periods. The number of days with mean daily water temperatures above the optimum range at Five Bridges Road would increase up to approximately 7 days in August. Maximum daily water temperatures would remain below the upper tolerance limit at all times throughout the principal brown trout rearing area. Measurable impacts on brown trout survival, growth, or reproduction would not be expected.

Under the 6,410-Ft Alternative, water temperatures would be slightly improved for largemouth bass relative to the 6,377-Ft Alternative (see page 3D-70) but would remain below optimum ranges during the spring and summer months. No measurable benefits would be expected.

Channel Morphology and Spawning Gravel Characteristics. Under the 6,410-Ft Alternative, mean monthly Pleasant Valley Reservoir releases above 600 cfs would occur less frequently (approximately 20% of the years) than under the 6,390-Ft Alternative (approximately 30% of the years) or point-of-reference conditions (approximately 40% of the years) (see Chapter 3A, "Hydrology"). No substantial changes in channel and streambed conditions would be expected.

Fish Population Characteristics

Brown Trout. Relative to point-of-reference conditions, brown trout production would be potentially increased by significant increases in spawning, juvenile, and adult habitat under the 6,410-Ft Alternative. Fry habitat, however, would continue to be a major limiting factor in many years. The brown trout population would not likely differ significantly from the population under the 6,372-Ft Alternative (see page 3D-63).

Largemouth Bass. Potential changes in the largemouth bass population would be similar to those described for the 6,372-Ft Alternative (see page 3D-63).

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

Impacts on fishery resources under the 6,410-Ft Alternative would be the same as those described above under the No-Restriction Alternative (see page 3D-54).

Los Angeles Aqueduct and Irrigation Canals

Impacts on fishery resources under the 6,410-Ft Alternative would be similar to those under the 6,372-Ft Alternative (see page 3D-63).

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,410-Ft Alternative)

Rush Creek

- Causes resource changes similar to those of the 6,377-Ft Alternative (see page 3D-71).

Mitigation Measures. Mitigation measures are identical to those specified for the 6,377-Ft Alternative (see page 3D-72).

Lee Vining Creek

- Causes resource changes similar to those of the 6,377-Ft Alternative (see page 3D-72), except for a significant reduction in spawning habitat in Segment 2.

Mitigation Measures. Mitigation measures are identical to those specified for the 6,377-Ft Alternative (see page 3D-72).

Parker and Walker Creeks

- Creates and maintains good fish habitat. Substantial benefits to resource conditions under the 6,410-Ft Alternative would be identical to those associated with the 6,377-Ft Alternative (see page 3D-73).

Grant Lake Reservoir

- Improves brown trout spawning success by decreasing lake level fluctuations.
- Significantly reduces fish productivity (13%).

Mitigation Measures. Mitigation measures associated with the 6,410-Ft Alternative are identical to those discussed for the 6,383.5-Ft Alternative (see page 3D-79).

Upper Owens River

- Causes significant adverse resource changes similar to those of the 6,383.5-Ft Alternative (see page 3D-80), but somewhat exacerbated.

Mitigation Measures. Mitigation measures are identical to those specified for the 6,383.5-Ft Alternative (see page 3D-80).

Lake Crowley Reservoir

- Slightly decreases fish productivity (less than 5%)

Middle Owens River

- Causes resource changes similar to those of the 6,372-Ft Alternative (see page 3D-65).

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

- Maintains fish productivity.

Los Angeles Aqueduct and Irrigation Canals

- Reduces fisheries habitat by less-than-significant levels.

IMPACTS AND MITIGATION MEASURES FOR THE NO-DIVERSION ALTERNATIVE

Changes in Resource Conditions

Rush Creek

Changes in resource conditions under the No-Diversion Alternative would be similar to those occurring under the 6,410-Ft Alternative (see page 3D-86).

Lee Vining Creek

Changes in resource conditions under the No-Diversion Alternative would be similar to those occurring under the 6,410-Ft Alternative (see page 3D-87), except for the occurrence of higher winter flows, which could significantly increase the risk of winter trout mortality associated with ice formation and downstream displacement of trout (Aquatic Systems Research 1992). Some evidence indicates that brown trout in lower Lee Vining Creek may be more susceptible to downstream displacement and increased mortality during the winter. Flows ranging from 18 cfs to 54 cfs (mean 35 cfs) from December 1989 through March 1990 were associated with a decline in survival and abundance of 1-year-old and 2-year-old trout, coinciding with apparent downstream trout movements from the reach above U.S. 395 to the reach below U.S. 395 (EA Engineering, Science, and Technology 1990b). These changes contrasted with relatively stable trout abundance and distribution observed during flows of 5-10 cfs since 1987.

Parker and Walker Creeks

Average monthly flows in Parker and Walker Creeks under the No-Diversion Alternative would be significantly higher than levels under all other alternatives in most water years and months (see Chapter 3A, "Hydrology"). Flows in the driest years would be identical or similar to those of other lake-level alternatives at or above the 6,372-foot lake elevation but would be significantly higher in other water-year types, particularly in wet years.

Habitat impact analyses based on the Tennant Method indicate overall good aquatic habitat conditions with excellent habitat conditions occurring in Walker Creek during normal water years (Table 3D-17). Compared to all other alternatives, the No-Diversion Alternative improves habitat conditions during all but the high-flow months (Appendix O, Table O-1). The No-Diversion Alternative would significantly benefit aquatic habitats and resources compared to point-of-reference conditions in both Parker and Walker Creeks. There would also be significant resource benefits in Walker Creek during normal years compared to other lake alternatives at or above the 6,372-foot lake elevation.

Flushing flows would occur frequently in June and July (every other year on average) in Walker Creek and nearly 80% of the years in Parker Creek (see Chapter 3A, "Hydrology"). In wet years, the June and July flows in both Parker and Walker Creeks would greatly exceed the recommended flushing flows. Given the unstable channel configuration of certain reaches of both Parker and Walker Creeks, high flows resulting from the No-Diversion Alternative would adversely affect resource conditions through channel erosion. Despite these adverse effects, aquatic habitat conditions would nonetheless benefit substantially under the No-Diversion Alternative when compared to point-of-reference conditions. Rush Creek may also be adversely affected by the increased frequency and magnitude of high flows in Parker and Walker Creeks, which could exacerbate erosion impacts in Segments 5 and 6 of lower Rush Creek.

Grant Lake Reservoir

Reservoir Fluctuation. Under the No-Diversion Alternative, no adverse impacts on brown trout spawning success from reservoir fluctuations would occur for any water year. Compared to the other alternatives, the No-Diversion Alternative would have the greatest beneficial effect on brown trout spawning success in Grant Lake reservoir.

Reservoir Productivity. Grant Lake reservoir operations under the No-Diversion Alternative would increase average monthly water surface elevations for the April-October period by 23 feet and increase average monthly reservoir surface area by approximately 220 acres, relative to point-of-reference conditions (Table 3D-19). The No-Diversion Alternative would have substantial beneficial effects on reservoir fish populations from approximately 25% increases in reservoir surface area relative to point-of-reference conditions. Reservoir simulations for the 1940-1989 hydrologic period indicate there would be approximately 35 years with substantial benefits to fish production. The No-Diversion Alternative would provide the most beneficial conditions for Grant Lake reservoir fish productivity compared to the other alternatives.

Upper Owens River

Physical Habitat

Brown Trout. Under the No-Diversion Alternative, brown trout adult habitat would be reduced 39% in dry years, 39% in normal years, and 31% in wet years relative to point-of-reference levels (Table 3D-20). Brown trout spawning habitat would be reduced 32% in dry years and 28% in normal years and increased by 27% in wet years (Table 3D-20).

Rainbow Trout. Adult rainbow trout habitat would be reduced 38% in dry years, 37% in normal years, and 30% in wet years relative to point-of-reference levels (Table 3D-20). Rainbow trout spawning habitat would be reduced 9% in dry years and increased 20% in normal years and 52% in wet years (Table 3D-20).

Water Temperature. Summer water temperature impacts under the No-Diversion Alternative would be nearly identical to those under the 6,410-Ft Alternative (see page 3D-88).

Water Quality. Water quality conditions under the No-Diversion Alternative would be nearly identical to those under the 6,410-Ft Alternative (see page 3D-88).

Channel Morphology and Spawning Gravel Characteristics. Channel and streambed conditions under the No-Diversion Alternative would be nearly identical to those occurring under the 6,410-Ft Alternative (see page 3D-88).

Fish Population Characteristics. Under the No-Diversion Alternative, significant reductions in brown and rainbow trout habitat and increased exposure to adverse water temperature and water quality conditions in Segment 3 in most years would result in slight additional adverse effects on trout populations relative to the 6,383.5-Ft Alternative (see page 3D-76).

Lake Crowley Reservoir

Changes in lake productivity associated with the No-Diversion Alternative would be nearly identical to those associated with the 6,410-Ft Alternative (see page 3D-88), except that reservoir surface area during the November-March period would be slightly lower (Table 3D-21). The No-Diversion Alternative would have the greatest impacts on fish productivity in Lake Crowley reservoir compared to the alternatives discussed earlier; however, reservoir surface area would still be reduced by less than 5%, so that impact is considered less than significant.

Middle Owens River

Physical Habitat

Brown Trout. Changes in spawning, juvenile, and adult brown trout habitat under the No-Diversion Alternative would be similar to those under the 6,410-Ft Alternative (Figures 3D-13 through 3D-16). Increases in spawning, juvenile, and adult habitat would be 37%, 14%, and 14%, respectively (Tables 3D-22 through 3D-25). Spawning WUA would increase by 31% in Segment 1 and by 38% in Segment 2, and changes in WUA at individual spawning transects would exhibit increases up to 29% (Table 3D-26).

Aquatic Invertebrates. Aquatic invertebrate habitat under the No-Diversion Alternative would increase relative to the 6,410-Ft Alternative (Figure 3D-17); average WUA would be substantially greater (101%) than the point-of-reference level (Table 3D-27).

Largemouth Bass. Largemouth bass physical habitat available under the No-Diversion Alternative would be similar to that available under the 6,410-Ft Alternative except for an increase in spawning habitat (Figures 3D-18 through 3D-21). Average spawning WUA would be substantially greater (112%) than the point-of-reference level (Table 3D-28).

Water Temperature. The magnitude and frequency of water temperatures under the No-Diversion Alternative (Tables 3D-32 and 3D-33) would be similar to those occurring under the 6,410-Ft Alternative (see page 3D-89).

Channel Morphology and Spawning Gravel Characteristics. Channel and streambed conditions under the No-Diversion Alternative would be similar to those occurring under the 6,410-Ft Alternative (see page 3D-89).

Fish Population Characteristics

Brown Trout. Potential increases in brown trout production would be similar to those described for the 6,410-Ft Alternative, but fry habitat would continue to limit populations. The brown trout population under the No-Diversion Alternative would not differ significantly from the population under the 6,372-Ft Alternative (see page 3D-63).

Largemouth Bass. Potential changes in the largemouth bass population would be similar to those described for the 6,372-Ft Alternative (see page 3D-63).

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

Impacts on fishery resources under the No-Diversion Alternative would be the same as those described for the No-Restriction Alternative (see page 3D-54).

Los Angeles Aqueduct and Irrigation Canals

Impacts on fishery resources under the No-Diversion Alternative would be similar to those under the 6,372-Ft Alternative (see page 3D-63).

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (No-Diversion Alternative)

Rush Creek

- Causes resource changes similar to those of the 6,377-Ft Alternative (see page 3D-71).

Mitigation Measures. Mitigation measures are identical to those specified for the 6,377-Ft Alternative (see page 3D-72).

Lee Vining Creek

- Causes resource changes similar to those of the 6,410-Ft Alternative (see page 3D-90), except for higher winter mortality.

Mitigation Measures. Mitigation measures are identical to those specified for the 6,377-Ft Alternative (see page 3D-72). In addition, diversions during October through March could be modified to prevent flows in lower Lee Vining Creek from exceeding 20 cfs; this change would reduce the increased risk of winter trout mortality associated with higher flows and would reduce overall brown trout habitat in Lee Vining Creek. It is unknown whether the benefits of reduced winter trout mortality at lower flows would be offset by population impacts from reduced habitats.

Parker and Walker Creeks

- Creates and maintains good fish habitat. The No-Diversion Alternative would have substantial benefits to resource conditions in Parker and Walker Creeks compared to point-of-reference conditions. In addition, habitat conditions would be significantly improved in Walker Creek under the No-Diversion Alternative compared to other lake level alternatives between the 6,372- and 6,410-foot lake elevations; however, habitat benefits would be minimized or eliminated because of adverse effects from high peak flows on unstable channel reaches.

Mitigation Measures. Control of flushing flows is infeasible under this alternative. Unstable reaches could be stabilized over the long term through habitat restoration efforts; peak flows resulting from the No-Diversion Alternative after that time would not create the adverse effects that would occur short-term. Habitat restoration efforts could be focused on enhancing natural channel stabilization features, such as restricting livestock grazing, restoring riparian vegetation, effectively using side channels for water conveyance during peak flow conditions, and establishing bank protection and habitat improvement structures compatible with the stream channel morphology. Because conditions under this alternative would be improved relative to point-of-reference conditions, however, no mitigation measures are required.

Grant Lake Reservoir

- Improves brown trout spawning success by decreasing lake level fluctuations.
- Substantially increases fish productivity (25%).

Upper Owens River

- Causes significant adverse resource changes similar to those of the 6,383.5-Ft Alternative (see page 3D-80).

Mitigation Measures. Mitigation measures are identical to those specified for the 6,383.5-Ft Alternative (see page 3D-80).

Lake Crowley Reservoir

- Slightly decreases fish productivity (less than 5%).

Middle Owens River

- Causes resource changes similar to those of the 6,372-Ft Alternative (see page 3D-65).

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

- Maintains fish productivity.

Los Angeles Aqueduct and Irrigation Canals

- Slightly reduces fisheries habitat by less-than-significant levels.

CUMULATIVE IMPACTS OF THE ALTERNATIVES

Related Impacts of Earlier Stream Diversions by LADWP

Mono Basin Tributaries

Substantial changes in aquatic habitat and fish populations occurred in Rush, Lee Vining, Parker, and Walker Creeks from LADWP diversions and are described in detail by numerous scientists (Beak Consultants 1991; Trihey & Associates 1991; Aquatic Systems Research 1992; Stine 1992a, 1992b). Significant diversions beginning in the late 1940s caused prolonged periods of little or no flow that severely degraded aquatic and riparian habitats and virtually eliminated the trout populations below the diversion facilities (Beak Consultants 1991, Trihey & Associates 1991, Aquatic Systems Research 1992). Much of the former habitat values that existed in the lower reaches of these creeks (i.e., complex channel structure and habitat features in the bottomlands) was lost as a result of catastrophic geomorphic changes that occurred in response to riparian vegetation losses, declines in Mono Lake levels, and large uncontrolled spills (Stine 1992a, 1992b). In general, these changes adversely affected fish habitat by creating a steeper, broader, shallower main channel; stranding historical side channels; eliminating pools and woody cover; and coarsening streambed sediments (Trihey & Associates 1991; Aquatic Systems Research 1992; Stine 1992a, 1992b).

Additional impacts contributing to the poor fish populations in the four streams include likely short-term LADWP operations detrimental to fish populations and habitat, gravel recruitment losses from LADWP diversion facilities, streamflow reductions and fish entrainment attributable to in-basin irrigation diversions, and migration limitations from road crossings and LADWP diversion facilities.

Grant Lake Reservoir

In the late 1930s, LADWP enlarged the area of Grant Lake reservoir to 1,094 acres and its capacity to 47,525 af (Sada 1977). With the construction of the Lee Vining conduit and the Mono Craters Tunnel, Grant Lake reservoir was operated as the main diversion pool for delivering water from Rush, Lee Vining, Parker, and Walker Creeks to the Owens River basin. The enlargement of Grant Lake reservoir provided increased lacustrine habitat for planted and resident trout, but large lake level fluctuations reduced lake productivity and created adverse effects on spawning success in the reservoir inundation zone (Sada 1977).

Upper Owens River

During 1941 through 1989, water exports from Mono Basin increased average annual discharge in the Upper Owens River from 76 to 168 cfs and led to increased channel erosion, widening, and straightening, and construction of artificial channels to bypass additional high flows. The higher flow regime has been accompanied by a reduced number of channel meanders and reduced channel length between East Portal and the Hot Creek confluence. Changes in channel meanders and bank stability are attributed to a combination of increased flows since 1941 and continued livestock grazing. (EBASCO Environmental et al. 1993.)

Despite physical changes to the Upper Owens River, fish population surveys conducted recently and in the 1980s indicate that trout population densities in the Upper Owens River are comparable or higher than densities estimated in other eastern Sierra Nevada streams (EBASCO Environmental et al. 1993). Trout collected in 1990 were in excellent condition and showed rapid growth (EBASCO Environmental et al. 1993). Although pre-1941 data are extremely limited, existing trout populations are in excellent condition; therefore trout populations likely have been maintained or perhaps increased by LADWP flow augmentations into the Upper Owens River. The increased flows since 1941 significantly increased adult trout habitat and reduced adverse water temperature and water quality effects in the Upper Owens River, particularly below Hot Creek.

Lake Crowley Reservoir

The formation of Lake Crowley reservoir in 1941 created habitat for a unique and highly productive fishery. Lake Crowley reservoir has been the focus of an intense hatchery stocking program, supporting one of the largest trout fisheries in California. The large inundation area, high alkalinity, relatively shallow depth, and moderate lake level fluctuations have all contributed to the reservoir's high productivity (Pister 1965), which likely exceeds that provided by the former stream environment. Substantial spawning habitat remains in the Upper Owens River for Lake Crowley reservoir trout, despite inundation of a section of the lower end of the Upper Owens River. The native Owens sucker is still abundant in Lake Crowley reservoir, but the tui chub has hybridized with the Lahontan subspecies that was introduced as bait by anglers (Moyle 1976).

Middle Owens River

Mono Basin water exports and the construction and operation of Long Valley Dam and Pleasant Valley Dam changed the Middle Owens River flow regime substantially. Flow augmentation and regulation increased average annual discharges and created a more variable flow regime characterized by more rapid flow fluctuations than existed historically (Hickson and Hecht 1992). Since 1947, these changes, along with spraying, burning, and removal of riparian vegetation by grazing interests, were accompanied by increases in channel width and loss of bank cover. Further flow increases beginning in 1970 are reported to have accelerated bank erosion and collapse of many of the existing undercut banks by 1971 (Ponder and Deinstadt 1978). A recent investigation of geomorphic and vegetative changes indicates that the Owens River channel between Pleasant Valley Dam and Five Bridges Road has not undergone large or systematic changes in channel pattern, hydraulic geometry, and geomorphic characteristics since 1971 (Hickson and Hecht 1992).

The construction of Pleasant Valley Dam blocked gravel recruitment to spawning areas below the dam and formed a complete barrier to fish migration. A combination of reduced gravel recruitment and high flows below the dam reduced the amount of suitable spawning gravels, degraded the streambed, and armored the streambed with coarser materials (Williams 1975). Fish kills or "near" fish kills occurred below the dam in the 1970s from low dissolved oxygen levels in Pleasant Valley Reservoir. An aerating device was subsequently installed at the dam to avoid future fish kills (Ponder and Deinstadt 1978).

Changes in the Middle Owens River flow regime may have contributed to declines in native fish species, but the earlier introduction of nonnative species, such as brown trout, probably had the greatest impact on native fish distribution and abundance. In the late 1960s, fisheries management changed from a predominantly put-and-take fishery maintained by hatchery rainbow trout to a wild brown trout fishery. The 16-mile reach below Pleasant

Valley Dam was designated a wild trout management area in 1972 and became California's top brown trout stream in terms of total angler use and number of trout harvested (Deinstadt and Wong 1980a). Periodic creel surveys since 1967 detected a general decline in angler use and catch during the 1970s followed by a return to higher levels in the 1980s; catch per unit effort exhibited no apparent trend between 1967 and 1988 (Deinstadt 1988, Deinstadt and Wong 1980a). Although brown trout populations have evidently not declined during this period, high flows during the spawning and early rearing period were identified as having negative effects on brown trout recruitment (Deinstadt and Wong 1980a, 1980b).

Lower Owens River

Few specific data are available on Lower Owens River fish populations and habitat and how these resources were affected by LADWP operations. LADWP's modified flow regimes, in concert with the large number of nonnative species introduced into the Lower Owens River system, were major factors contributing to the decline in native fish fauna and the establishment of the existing fishery. Dewatered conditions in the Lower Owens River below the LA Aqueduct had substantial adverse effects on native fish populations before 1941, but these impacts were associated with other LADWP water export projects.

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

Pleasant Valley and Tinemaha Reservoirs impounded Owens River flows and inundated former stream habitat. The reservoirs' habitats are more favorable to introduced species, and impacts were primarily on native fish species. Construction of Haiwee Reservoir, an off-river storage impoundment, resulted in creation of warmwater fisheries habitat.

Los Angeles Aqueduct and Irrigation Canals

These LADWP conveyance facilities have provided new habitat for limited populations of introduced warmwater and coldwater fish species.

Related Impacts of Other Past, Present, or Anticipated Projects or Events

Mono Basin Tributaries

In-basin agricultural diversions contributed to altered streamflow and habitat conditions in Mono Basin tributaries prior to and during LADWP diversions. Irrigation diversions significantly reduced summer flows along portions of Lee Vining, Rush, Parker, and Walker Creeks (Trihey & Associates 1992a; EBASCO Environmental and Water

Engineering and Technology 1991b, 1991c). Summer flow reductions, especially during drought periods, would have had a significant adverse effect on the quality and quantity of aquatic habitat immediately below the diversion points and farther downstream as well, depending on specific diversion quantities and locations. The diversion structures and unscreened conveyance facilities from these diversions would have caused passage problems and direct losses of trout fry, juveniles, and adults and aquatic invertebrate drift.

In Lee Vining Creek, regulation of flows for power production reduced natural flows during spring and summer and augmented natural flows during winter. Storage and peaking operations at upstream reservoirs and hydroelectric facilities on Lee Vining Creek would have modified flow regimes and had some undocumented effect on fisheries populations.

Road crossings by LADWP and others have interrupted natural trout migrations and movements in all four streams.

Although quantitative information on pre-1941 aquatic habitat conditions and fish populations is extremely limited, historical records and accounts indicate that lower Lee Vining Creek and Rush Creek were characterized by a multiple channel system, dense riparian vegetation, and diverse aquatic habitat (Stine 1992a, 1992b; Trihey & Associates 1991). Lee Vining Creek and Rush Creek supported good to excellent fisheries; catchable-size rainbow and brown trout were abundant (McAfee 1990; Vestal 1990, Court Testimony, Volumes I and II). Parker and Walker Creeks also supported fisheries, but information on their fisheries is less definitive than for Lee Vining and Rush Creeks. These excellent fishery conditions existed in Mono Basin tributaries despite ongoing in-basin agricultural diversions, livestock grazing, and hydroelectric power operations. Not until LADWP activities were underway were fisheries resources in the four major streams substantially altered.

Grant Lake Reservoir

Before LADWP diversions, Grant Lake's natural outlet was dammed and water was diverted into several irrigation canals (Stine 1992b). The resulting impoundment was relatively small but supported a fishery for hatchery-reared trout and wild brown trout produced in upstream spawning areas in Rush Creek or in the lake inundation zone. Consequently, Grant Lake reservoir provided generally similar habitats both before and after LADWP activities. Before LADWP's enlargement of Grant Lake reservoir, the reservoir's smaller size would have minimized adverse effects on natural production resulting from brown trout spawning within the reservoir inundation area. Future reductions in inflow to Grant Lake reservoir resulting from new or increased in-basin water diversions would be a cumulative impact on available water supply for meeting beneficial uses identified in the EIR.

Upper Owens River

Impacts on aquatic and riparian habitat in the Upper Owens River before LADWP Mono Basin exports were largely related to in-basin agricultural diversions and livestock grazing. Agricultural diversions decreased flows along portions of the Upper Owens River and caused additional water quality impacts associated with agricultural return drainage. Livestock grazing reduced riparian vegetation, increased streambank erosion, and was the primary source of nutrient loading to the river. Future reductions in inflows from in-basin agricultural diversions would contribute to significant cumulative water quality and temperature impacts on aquatic resources.

Lake Crowley Reservoir

Impacts on fish habitat and populations in the Upper Owens River before the formation of Lake Crowley reservoir occurred seasonally because of diversions for agricultural and grazing purposes. Impacts were probably localized and limited to drought periods. Unscreened diversions probably caused direct losses of fish, and in some cases, seasonally dewatered portions of the channel or significantly reduced flows.

Lake Crowley reservoir is an LADWP-controlled impoundment, and other past, present, or anticipated projects or events have had limited effects on the fish populations or habitats present since Lake Crowley reservoir was constructed.

Middle Owens River

Changes in channel form and riparian habitat reported in 1971 were likely triggered by intensive grazing, clearing of dense riparian vegetation, and further increases in streamflows associated with Mono Basin diversions. Additional water available for agricultural use also increased nutrient loading to the river as a result of increased agricultural return drainage. The relative importance of each of these factors is unclear, but all factors likely degraded habitat conditions since 1941.

Lower Owens River

Most impacts are similar to impacts on the Middle Owens River, including intensive grazing and removal of riparian vegetation.

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

These reservoirs are all LADWP-controlled impoundments, and other past, present, or anticipated projects or events have had limited effects on the fish populations or habitats present in these reservoirs.

Los Angeles Aqueduct and Irrigation Canals

These conveyance facilities are all LADWP-controlled facilities, and other past, present, or anticipated projects or events have limited effects on the fish populations or habitats present in these facilities.

Significant Cumulative Impacts for All Alternatives

Mono Basin Tributaries

- Long-term LADWP operations have resulted in significant cumulative impacts on geomorphology and fish populations in Rush, Lee Vining, Parker, and Walker Creeks.

None of the proposed EIR alternatives would succeed in restoring aquatic habitat and fish populations to prediversion levels within the reasonable future. Implementation of the No-Restriction Alternative would dewater lower Lee Vining Creek, lower Rush Creek, Parker Creek, and Walker Creek in many years and return these streams to the degraded state that existed before restoration of permanent flows. Because of additional habitat degradation associated with geomorphic and vegetative changes, mostly associated with LADWP's long-term diversions, restoration of continuous flows under the 6,372-Ft Alternative and higher elevation lake level alternatives would not fully restore the habitat values or fisheries that existed before 1941. All alternatives, therefore, would continue to have significant adverse cumulative impacts on geomorphology and fish populations would remain on major sections of Rush, Lee Vining, Parker, and Walker Creeks, particularly in the lower portions of Rush and Lee Vining Creeks.

- Short-term LADWP operations have resulted in significant cumulative impacts on geomorphology and fish populations in Rush, Lee Vining, Parker, and Walker Creeks.

None of the proposed EIR alternatives would succeed in restoring aquatic habitat and fish populations if short-term LADWP operations include rapid flow changes as occurred on Lee Vining Creek in May 1990. These types of events likely occurred periodically since 1941, causing significant cumulative effects by minimizing or completely eliminating the benefits of restored minimum flows or habitat restoration efforts.

- LADWP diversion facilities have resulted in significant cumulative impacts on gravel recruitment in Rush, Lee Vining, Parker, and Walker Creeks.

Downstream gravel recruitment from upstream sources is impeded at all LADWP's diversion structures. None of the proposed EIR alternatives would succeed in restoring gravel recruitment to the four affected streams. Higher flows will not address this impact because gravels will still be trapped behind the diversion facilities, and higher flows would serve to transport many of the gravels completely through the system into Mono Lake because of the loss of the complex channel structure that served to retain gravels at high flows.

- Road crossings and LADWP diversion facilities have resulted in significant cumulative impacts on migrating trout populations in Rush, Lee Vining, Parker, and Walker Creeks.

None of the proposed EIR alternatives would correct existing problems from road crossings and LADWP diversion structures that limit or preclude upstream migrations of spawning trout. The overall significance of these barriers is individually relatively small, but, when taken together and with the other impacts on the creeks, these barriers have contributed to the significant adverse effects that have depleted fish populations since 1941.

Grant Lake Reservoir

LADWP's enlargement of Grant Lake reservoir expanded the lacustrine habitat and potential carrying capacity of the lake, which increased fish production over levels that occurred during the prediversion period. Over the range of proposed alternatives, lake levels would fluctuate within the range of historical levels, but production would remain higher than prediversion levels. No significant cumulative adverse effects would occur under any alternative.

Upper Owens River

Under historical conditions, flow augmentation, in combination with continued livestock grazing and channel creation in the Upper Owens River, has altered aquatic habitat conditions from prediversion levels, but changes in game and or nongame native fish populations cannot be ascertained with available data. Given the excellent trout fishery that has been maintained on the Upper Owens River, no significant cumulative impacts on trout resources have occurred.

Several conditions associated with Mono Basin exports and flow augmentation have maintained and even enhanced aquatic habitat and fish populations in the Upper Owens River. The enhanced flow levels substantially increase the amount of suitable trout habitat by increasing available physical habitat throughout the Upper Owens River and improving water temperature and water quality conditions, particularly in the reach below the Hot Creek confluence. The Upper Owens River channel has apparently adjusted to the higher flow regime, and no significant problems are related to channel stability or flushing flows (EBASCO Environmental et al. 1993). Spawning gravels have remained abundant under the higher flow regime. In addition, LADWP's creation of Lake Crowley reservoir and the intensive trout planting program have greatly increased the fish production potential of the basin and provided a productive lake environment for trout produced in the Upper Owens River.

Lake Crowley Reservoir

Game fish in Lake Crowley reservoir have been substantially benefited relative to their preimpoundment habitat and fish populations. No significant cumulative adverse impacts would occur under any alternative.

Middle Owens River

The aquatic habitat conditions that would occur in the Middle Owens River over the range of proposed EIR alternatives generally fall within the range of conditions that have occurred since flows were augmented further by Mono Basin diversions in 1971. While changes in resource conditions since that time have not been significant, impacts related to bank erosion, streambed armoring, and loss of riparian vegetation in earlier years appear to have occurred and may be significant. Without pre-1941 data, however, the effects of these habitat modifications on brown trout or nongame native fish populations cannot be ascertained.

Given the current excellent condition of the Middle Owens River brown trout fishery, the habitat impacts that have occurred have not caused significant cumulative impacts on brown trout populations. Since 1971, several changes in the Wild Trout Management Area have minimized cumulative impacts on fisheries resources and habitat. Losses of undercut banks and riparian vegetation have been partially compensated for by substantial increases in the extent of dense riparian vegetation in the lower reaches of the Wild Trout Management Area. Similar increases have not occurred in the upper reaches, possibly because of localized channel incision; past disturbances to soil and vegetation; and continued grazing, recreational use, and dam maintenance activities (Hickson and Hecht 1992). Impacts related to reductions in usable spawning gravels have also been reduced by construction of the Pleasant Valley Spawning Channel, which continues to provide an important spawning area for brown trout. Potential impacts of fluctuating flows on spawning and early rearing success have been reduced by LADWP's efforts to limit and stabilize flows during the migration, spawning, incubation, and early rearing period.

- Multiple factors contribute to significant cumulative adverse impacts on Owens tui chub and Owens speckled dace.

Native Owens tui chub and Owens speckled dace populations apparently had declined by 1940 but were still present in the main river where somewhat stable populations of Owens sucker still occurred. The Owens tui chub and Owens speckled dace populations are still relatively low. The complex interactions between water diversions, water impoundments, modified flow patterns, grazing, and competition from introduced species such as brown trout have been responsible for the declines, but specific data are unavailable to attribute these declines to any specific factor. Continued declines in their populations since 1941 cannot be verified.

Lower Owens River

The dewatering of the Lower Owens River below the LA Aqueduct caused significant cumulative impacts on all fisheries resources in the affected river segment. Owens tui chub, Owens speckled dace, and Owens sucker likely were present in the Lower Owens River, but populations were probably declining before LADWP diversions. The dewatering of the Lower Owens River below the LA Aqueduct is a major contributing factor to the population losses of these species, but because the dewatering occurred before 1940 and is unchanged by any of the EIR alternatives, it is not considered further in this EIR.

The coldwater trout fishery that exists immediately below Tinemaha Reservoir is maintained largely by plantings of catchable-size rainbow trout and would be relatively unaffected by any of the alternatives.

Pleasant Valley, Tinemaha, and Haiwee Reservoirs

No significant cumulative impacts are associated with any of the alternatives to these reservoirs.

Los Angeles Aqueduct and Irrigation Canals

No significant cumulative impacts are associated with any of the alternatives to the LA Aqueduct or irrigation canals.

Mitigation Measures for Significant Cumulative Impacts for All Alternatives

Mono Basin Tributaries and Grant Lake Reservoir

- Long-term LADWP operations have resulted in significant cumulative impacts on geomorphology and fish populations in Rush, Lee Vining, Parker, and Walker Creeks.

Mitigation measures for the significant cumulative impacts to the natural stream channels and fish populations in the four streams cannot fully reduce the impacts in certain stream segments because of the severity of the impacts. This is particularly true for lower Rush and Lee Vining Creeks where complete habitat restoration will require 50 or more years. The severity of the cumulative impacts requires mitigation that goes beyond the standard provision of adequate or optimum flows. Additional stream rehabilitation is necessary to shorten the time frame that would be required to restore habitat to near 1940 conditions.

Establish Minimum Instream Flow Requirements. Minimum instream flow requirements should be established to improve brown trout habitat conditions under existing channel conditions. The minimum instream flow recommendations for lower Rush Creek (Beak Consultants 1991) and Lee Vining Creek (Aquatic Systems Research 1992) generally provide the basis for meeting this objective. The court has specified that licenses require LADWP to "release sufficient water . . . to reestablish and maintain the fisheries that existed in them prior to its diversion of water" (Caltrout II decision). This court order is more specific than California Fish and Game Code Section 5937, which requires sufficient bypass flows to keep in "good condition" any fish that may be planted or exist below the dams.

Preliminary DFG stream evaluation report recommendations below apply to existing channel conditions only, and these recommendations should be reevaluated after 10 years from date of implementation to ensure that such flows are still appropriate (Table 3D-32). Major segments of all four streams are not in dynamic equilibrium, and natural channel dynamics in association with any habitat restoration efforts could substantially change channel morphology over time, which could affect these possible instream flow requirements.

Beak Consultants (1991) specified the following instream flows for Rush Creek under dry, normal, and wet year hydrologic conditions (in cfs):

- April - 35, 59, 60;
- May - 60, 60, 60;
- June - 60, 60, 60;
- July - 45, 60, 60;
- August - 42, 60, 60;
- September - 40, 60, 60;
- October - 36, 58, 60;
- November - 30, 40, 56;
- December - 30, 40, 56;
- January - 31, 44, 57;
- February - 32, 48, 54; and
- March - 34, 52, 54.

Rush Creek minimum instream flow recommendations proposed by DFG (Gibbons pers. comm.), which are based on Beak Consultants (1991) are as follows for dry, normal, and wet year hydrologic conditions (in cfs):

- April - 35, 59, 84;
- May - 75, 100, 100;
- June - 72, 100, 100;

- July - 45, 100, 100;
- August - 42, 93, 100;
- September - 40, 69, 100;
- October - 36, 58, 93;
- November - 30, 40, 71;
- December - 30, 40, 71;
- January - 31, 44, 57;
- February - 32, 48, 54; and
- March - 34, 52, 54.

The Beak Consultants (1991) report did not consider tributary inflow from Parker and Walker Creeks and also established a maximum flow limit (100 cfs) identical to the minimum flow requirement in certain months and water year conditions. Consequently, flows higher than are actually necessary to optimize fishery conditions would occur in lower Rush Creek because of the additional flow requirements from Parker and Walker Creeks. Observed channel losses would also likely decline over time as channel and adjacent groundwater tables are recharged. In addition, such flows would exceed 100 cfs and induce streambank erosion and channel meandering in lower Rush Creek (Beak Consultants 1991). DFG's instream flow recommendations for Rush Creek should be reevaluated to reflect the contributions from Parker and Walker Creeks.

Lee Vining Creek minimum instream flow requirements or the natural flow, whichever is less, as measured immediately below the LADWP diversion dam, should be as follows (Aquatic Systems Research 1992):

- April 1-September 30: 45 cfs and
- October 1-March 30: 40 cfs.

October through March minimal flow requirements between 20 and 40 cfs would reduce winter-related trout mortalities and should also be considered. Flows as low as 20 cfs during this period would minimize winter-related mortalities and optimize available spawning habitat in Segment 2 over the short term because few adults are present in Segments 5 and 6 to use the greater spawning habitat created at higher flows in these segments.

Parker Creek minimum instream flow requirements or the natural flow, whichever is less as measured immediately below the LADWP diversion dam, should be the court-ordered flows as follows (California Department of Fish and Game 1992a):

- October-March - 6 cfs and
- April-September - 9 cfs.

Walker Creek minimum instream flow requirements or the natural flow, whichever is less as measured immediately below the LADWP diversion dam, should be the court-ordered flows as follows (California Department of Fish and Game 1992b):

- October-March - 4.5 cfs and
- April-September - 6 cfs.

Develop and Implement Appropriate Habitat Restoration Plans. The recommended mitigation is to develop and implement certain aspects of the proposed habitat restoration plans for Rush Creek (Trihey and English 1991), Lee Vining Creek (Trihey and English 1991, Aquatic Systems Research 1992), Parker Creek (California Department of Fish and Game 1992a), and Walker Creek (California Department of Fish and Game 1992b). These restoration plans could provide the mechanism for successful mitigation to the degree possible.

The purpose of the habitat restoration programs is to help reestablish aquatic and riparian habitat conditions that benefited fish populations before 1941 (Trihey and English 1991). Such work, however, is intended to partially mitigate for catastrophic losses of aquatic and riparian habitat by accelerating what otherwise would be a very slow natural recovery process (Trihey & Associates 1991). Some of the physical characteristics that benefited pre-1941 fish populations cannot be restored, and compensation for such losses will be achieved by improving some portions of Rush and Lee Vining Creeks beyond their pre-1941 conditions (Trihey & Associates 1991).

The need for channel maintenance and flushing flows should be assessed periodically as part of the habitat restoration monitoring program. With the restrictions on high flows discussed above, gravel quality and channel conditions should be evaluated periodically to determine the need for a controlled flushing flow event. The addition of gravels or scarification of existing gravels should be considered in lieu of high flows if adverse effects on habitat restoration efforts in lower reaches are anticipated. As habitat restoration proceeds and channels and streambanks become more resistant to erosion, channel maintenance and flushing flows should be reevaluated.

Mitigation measures discussed below must be coordinated and integrated with current and future habitat restoration and monitoring efforts to ensure a maximum probability of achieving restoration goals.

Limit Magnitude and Frequency of High Flow Events. An important element of the habitat restoration plans and the analyses conducted in this EIR is to limit the magnitude of potentially damaging high flows in all four creeks by allowing LADWP exports during high flows, dispersing high flows among additional stream channels, or diverting a portion of the flow into irrigation canals for spreading and groundwater recharge. Under existing channel conditions, reducing the frequency and magnitude of peak flows in Mono Basin tributaries will facilitate the progress of habitat restoration efforts, as well as minimize adverse impacts of high flows on the trout population. As geomorphic conditions change on each creek, specific channel maintenance and flushing flow requirements should be reevaluated.

Rush Creek instream flow releases, as measured immediately below the LADWP diversion, should not exceed 80 cfs except when the diversion capacity is unable to limit flows to this level. This maximum flow limitation, which accounts for Parker and Walker Creeks inflow, would minimize streambank erosion and adverse effects on habitat restoration efforts in lower Rush Creek. Periodic channel maintenance and flushing flows should be gradually implemented through the habitat restoration plans, including specific magnitudes, frequencies, and durations. An example channel maintenance and flushing flow schedule for Rush Creek would be to ramp flows up to 125-150 cfs for 3 days once during the 1995-1999 period, up to 150-175 cfs for 5 days once during the 2000-2004 period, and so forth, during natural high flow periods in June and July.

Similar to Rush Creek, Lee Vining Creek instream flow releases, as measured immediately below the LADWP diversion, should not exceed 100 cfs except when the diversion capacity is unable to limit flows to this level. All other conditions described above for Rush Creek apply to Lee Vining Creek, as well. Aquatic Systems Research (1992) recommended a 160-cfs maximum flow, the present court-mandated flushing flow. This flow is too high, however, with respect to the adverse impacts on fish populations observed at streamflows between 112 and 204 cfs in 1990 and 1991. Lee Vining Creek, in its present condition, has extremely limited refuge habitat in the lower portion of the creek, and flows higher than approximately 100 cfs will likely cause much greater direct mortality to trout than the indirect impacts of less-than-adequate flushing flows.

Parker Creek instream flow releases, as measured immediately below the LADWP diversion, should not exceed 25 cfs except when the diversion capacity is unable to limit flows to this level or flushing flows are being released. DFG (1992a) recommends flushing flows of 25-40 cfs for a few days each year during the snowmelt season, with monitoring to determine the actual duration. These flushing flows should be timed initially so that they do not coincide with flushing flows in Rush Creek (which could cause excessive erosion in lower Rush Creek) and should not be implemented until steep, erodible portions of the channel are stabilized and undersized culverts replaced (California Department of Fish and Game 1992a, 1992b). The frequency and magnitude of these annual flushing flows also should be reduced and the flushing flow should be implemented on a more gradual basis. Again, the specific channel maintenance and flushing flows should be developed in the habitat restoration plans, and adjustments should be made as needed as channel conditions dictate.

Walker Creek instream flow releases, as measured below the LADWP diversion, should not exceed 15 cfs except when the diversion capacity is unable to limit flows to this level. DFG (1992b) recommends the court-ordered flushing flows of a 3-day (during dry years) or 30-day (during wetter years) flushing flow of 15 cfs starting no earlier than May 1 and no later than July 1. As with the other Mono Lake tributaries, specific channel maintenance and flushing flows should be developed in the habitat restoration plans, and adjustments should be made as needed as channel conditions dictate.

- Short-term LADWP operations result in significant cumulative impacts on geomorphology and fish populations in Rush, Lee Vining, Parker, and Walker Creeks.

Establish Specific Ramping Rate and Sluicing Criteria for All LADWP Releases. Frequent, and even relatively infrequent, short-term fluctuations in streamflow and sluicing events can have significant long-term adverse effects on fish populations and habitat. Specific ramping rates and sluicing requirements should be developed and implemented on all four streams.

- LADWP diversion facilities result in significant cumulative impacts on gravel recruitment in Rush, Lee Vining, Parker, and Walker Creeks.

Establish Specific Gravel Restoration Plans as Part of the Habitat Restoration Plans for Each Stream. Appropriate gravels and spawning habitat are potentially limiting factors in several stream segments and are currently trapped behind LADWP diversion facilities. Gravel restoration can be successful only if it is integrated with other channel and flow restoration efforts on each of the streams. Consequently, the habitat restoration plans discussed above should contain a specific plan for augmenting each stream with appropriately sized gravels to improve spawning habitat.

- Road crossing and LADWP diversion facilities result in significant cumulative impacts on migrating trout populations in Rush, Lee Vining, Parker, and Walker Creeks.

Establish Specific Measures to Improve Trout Migrations at Existing Instream Facilities. LADWP and other entities maintain instream facilities that adversely affect brown trout migrations and movements. These impacts contribute to the overall significant cumulative adverse effect on fisheries resources on all four streams. Existing habitat restoration plans already contain adequate plans for providing adequate fish passage conditions at diversion facilities, road crossings, and other known or potential barriers.

Owens River Basin

- LADWP exports result in substantial benefits to fisheries of the Upper Owens River under the No-Restriction Alternative.

- The 6,377-Ft Alternative to the No-Diversion Alternative would result in significant adverse impacts on adult brown and rainbow trout habitat, with adverse effects increasing with higher lake levels.

Mitigation Measures. Specific instream flow requirements for the Upper Owens River should be established to reduce impacts to less-than-significant levels as specified for the 6,377-Ft Alternative and other higher lake-level alternatives. Brown and rainbow trout habitat losses could be minimized by modifying LADWP operations of Grant

Lake reservoir and the Mono Craters tunnel to augment Upper Owens River flows, as described in more detail for the 6,377-Ft Alternative.

Fixed minimum instream flows were identified that would reduce the adult brown trout and rainbow trout habitat impacts to less-than-significant levels (allowing for a 9% reduction from point-of-reference conditions). Minimum flows of approximately 150 cfs in Segment 1 (below East Portal), 135 cfs in Segment 2 (above Hot Creek), and 180 cfs in Segment 3 (below Hot Creek) would reduce impacts to less-than-significant levels for brown trout. Minimum flows of approximately 150 cfs in Segment 1 (below East Portal), 135 cfs in Segment 2 (above Hot Creek), and 170 cfs in Segment 3 (below Hot Creek) would reduce impacts to less-than-significant levels for rainbow trout.

Fixed maximum instream flows at no more than 200 cfs below the East Portal and no more than 270 cfs below the Hot Creek confluence (EBASCO Environmental et al. 1993) could be used in association with minimum instream flow requirements to fully mitigate impacts.

- The 6,383.5-Ft Alternative to the No-Diversion Alternative would result in significant adverse effects on water temperature conditions and water quality conditions below the Hot Creek confluence.

Mitigation Measures. Specific minimum instream flow requirements for the Upper Owens River should be established. Maintaining a minimum flow of 75 cfs, as measured below East Portal, would mitigate these impacts to less-than-significant levels, assuming current diversion rates in the upper Owens River. Maintaining a minimum flow of approximately 150 cfs, as measured below East Portal, would mitigate these impacts completely, assuming current diversion rates in the Upper Owens River.

- Multiple factors result in significant cumulative adverse impacts on Owens tui chub and Owens speckled dace in the Middle Owens River.

Establish Specific Ramping Rate Criteria for LADWP Releases below Pleasant Valley Reservoir. Native Owens tui chub and Owens speckled dace populations have been adversely affected by numerous and complex factors. Mitigation to restore these populations on the Middle Owens River would involve infeasible measures such as removing introduced species, including brown trout. Specific ramping rate requirements should be developed to minimize geomorphic impacts from frequent and rapid fluctuations in streamflow.

CONSIDERATION OF PRE-1941 FISHERY STANDARDS SET BY COURT ORDER

Background

This EIR does not determine the required minimum streamflows for fishery protection but provides technical information to assist the SWRCB to make the required determinations after a public hearing process. In addition to meeting its responsibilities under CEQA, the SWRCB must also meet specific criteria established in court orders addressing fisheries resources in Mono Lake tributaries.

Assessing both project and cumulative impacts on environmental resources required that two points of reference, or baseline conditions, be defined in this EIR. Environmental conditions on August 22, 1989, when the El Dorado Superior Court issued a minute order to the SWRCB describing the issuance of a preliminary injunction regarding the water surface level of Mono Lake, define the point of reference for assessing impacts of the diversion alternatives. Environmental conditions prior to the beginning of diversions in Mono Basin in 1941 define the point-of-reference for examining cumulative impacts of the diversion alternatives.

In *California Trout, Inc. v. Superior Court* 218 Cal.App.3d 187 (1990) (Caltrout II), the Court of Appeals held that its opinion in Caltrout I foreclosed any argument that the SWRCB had authority to balance the public interest in competing water uses and to set instream flow requirements insufficient to maintain fish in good condition. The court directed the SWRCB to exercise its ministerial duty to amend LADWP's water right licenses for appropriation of the Mono Lake tributaries to include conditions in accordance with California Fish and Game Code Sections 5937 and 5946. Section 5937 requires sufficient bypass flows around dams, including diversion dams, to keep in good condition any fish that may be planted or exist below a dam. Section 5946 states that no license to appropriate water in portions of Mono or Inyo Counties can be issued after September 9, 1953, unless conditioned on full compliance with Section 5937. Most importantly, the court further specified that licenses require LADWP to "release sufficient water into the streams from its dams to reestablish and maintain the fisheries that existed in them prior to its diversion of water".

Caltrout II, therefore, establishes a specific target resource condition for fisheries that must be met regardless of any public trust balancing conducted by the SWRCB. This standard has an overriding influence on the evaluation and selection of alternative lake levels, as described later in this section.

Definition of Pre-1941 Fishery Conditions

Prediversion fishery conditions are described at the outset of this chapter under "Prediversion Conditions". Most existing information is habitat-based and qualitative; few data are available to quantitatively describe fish populations in any of the Mono Lake tributaries. It is difficult to conclusively establish alternatives, instream flow requirements, or mitigation measures that will meet the court order because the pre-1941 fisheries cannot be described in any quantitative terms, such as fish densities or fish biomass. Nonetheless, the mostly qualitative description of pre-1941 habitat conditions provides information on habitat types that supported larger trout populations than do existing habitat conditions.

Limitations to Reestablishing Pre-1941 Fishery Conditions

Several factors limit reestablishing pre-1941 fishery conditions in the Mono Lake tributary streams. As indicated above, one major limitation is that pre-1941 fishery conditions cannot be accurately described and, consequently, it would be difficult to ascertain whether the objective of reestablishing the pre-1941 conditions was ever met. Recognizing the dearth of pre-1941 data, the Restoration Technical Committee developed a program to help reestablish conditions that benefited the fisheries by emphasizing actions that accelerate the natural recovery of aquatic and riparian habitats, rather than those that might provide a specific number of fish (Trihey & Associates 1991). Additional limitations occur in two specific areas: the practicality of reestablishing pre-1941 conditions and the limitations of existing fisheries studies.

Practicality of Reestablishing Pre-1941 Fishery Conditions

The intent of the court order to reestablish and maintain pre-1941 fishery conditions is clearly understood. It was recognized early in the habitat restoration program ordered by the court, however, that existing conditions may preclude restoration of some specific pre-1941 physical conditions. The Restoration Technical Committee therefore agreed to and adopted the goal of developing and implementing programs to establish aquatic and riparian conditions and resource values equivalent to those existing in the streams prior to 1941 as an acceptable substitute for the overall goal of reestablishing the conditions that benefited the fisheries that existed in the creeks prior to 1941. Establishing even equivalent conditions that benefited the pre-1941 fishery is impossible in the short term and possible in the long term only if aggressive and substantial habitat restoration programs, in concert with major instream flow releases, are undertaken.

Limitation of Existing Fishery Studies

Existing fishery studies, such as IFIM analyses and fish population monitoring, have been developed in certain reaches of the Mono Lake tributaries that have undergone extensive geomorphological changes. In particular, the complex pre-1941 aquatic habitats in lower Rush and Lee Vining Creeks have been substantially modified. The existing fishery studies analyze the new channel characteristics and their effects on the fish populations. Consequently, extrapolation of existing fish population and habitat data, trends, and models to the pre-1941 period is extremely difficult and must be done qualitatively.

Effects of Lake Alternatives on Ability to Restore Pre-1941 Fishery Conditions

Compared to the 1989 point of reference, all alternatives have substantial fishery benefits in the Mono Lake tributaries. Compared to the pre-1941 conditions, however, significant cumulative impacts were identified for all alternatives. Similarly, none of the alternatives can restore and maintain pre-1941 fishery conditions for at least 50 or more years. Major geomorphic alterations are simply too great to allow restoration of the complex habitat functions present in lower Rush and Lee Vining Creeks in the pre-1941 period. Without such major channel changes, pre-1941 fishery conditions could largely be restored by releasing flows of the same monthly magnitude, duration, and pattern that existed in the pre-1941 period. Unfortunately, the geomorphic changes in certain reaches have resulted in new channel configurations that provide different habitat values than would have occurred under the same flow patterns in the pre-1941 period. Successful restoration efforts now will require greater short-term control of high flows while channel and habitat conditions are stabilized and restored.

Effects of Fishery Protection Flows in DFG Stream Evaluation Reports

DFG Stream Evaluation Reports provide fishery protection flows and other measures to optimize fishery conditions in Mono Lake tributaries. It is unclear whether these reports represent DFG's formal recommendations for each stream or are consultants' recommendations only. Nonetheless, the Stream Evaluation Reports represent the best available information provided by DFG for establishing conditions that approach, to the greatest degree possible, the pre-1941 habitat conditions desired by the court. DFG has produced stream evaluation reports for the four diverted tributary streams (Beak Consultants 1991; EBASCO Environmental and Water Engineering and Technology 1991b, 1991c; Aquatic Systems Research 1992) and the Upper Owens River (EBASCO Environmental et al. 1993). These reports contain instream flow recommendations for each stream (Table 3D-34).

The aqueduct model was used to predict long-term Mono Lake surface elevations resulting from these recommended flows, including the specified minimum, maximum, and flushing flow values. As for the alternative simulations, these diversion rules were combined with aqueduct operations constraints and applied to the 1940-1989 historical hydrology. In this simulation, however, no lake level targets and lake release rules were specified.

Two simulations were conducted, the first based on DFG's consultants' original flow recommendations for Rush Creek, which specify a maximum release of 60 cfs during the peak runoff period (Beak Consultants 1991), and the second based on DFG's subsequent flow recommendations, which specify a maximum release of 100 cfs (Gibbons pers. comm.). Recommended flows for Lee Vining, Parker, and Walker Creeks were identical for the two simulations.

The recommendation for flows for the Upper Owens River below the East Portal (a maximum flow limit of 200 cfs and a constant release rate) could not be modeled explicitly because changes would be required in operation of Grant Lake reservoir to distribute exports more evenly throughout the year. Model applications, however, suggest that total annual exports and Mono Lake surface elevations would not change appreciably with this additional constraint.

The recommended flows would cause the surface elevation of Mono Lake to rise to an average elevation of 6,381 feet, for the maximum Rush Creek flow of 60 cfs, or to 6,385 feet for the maximum Rush Creek flow of 100 cfs (Figure 3D-24). The transition period to the dynamic equilibrium would be about 40 years, and lake levels would fluctuate 6-7 feet thereafter. The simulations indicate that uncontrolled spills would not likely occur in the Mono Basin tributaries under the conditions specified. Minimum instream flow recommendations for Rush Creek would be met in most years, but available flows in Lee Vining, Parker, and Walker Creeks would often be insufficient to meet the specified minimum flows in dry and normal runoff years.

These simulated lake level ranges, when compared to the lake level regimes described for each alternative, indicate the degree to which each alternative is capable of meeting the pending DFG instream flow recommendations for protection of fishery resources. The 6,383.5-Ft Alternative is the nearest alternative that satisfies preliminary DFG recommendations developed to optimize fisheries conditions. The average lake level (6,385 feet) based on the 6,383.5-Ft Alternative would meet DFG's pending instream flow requirements.

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Worthley, Fred. Regional manager. California Department of Fish and Game, Region 5, Long Beach, CA. December 2, 1987 - letter to Dr. Carl Mesick, EA Engineering, Science, and Technology, Lafayette, CA.

Table 3D-1. Fish Species Reported to Occur in Mono Basin

Common Name	Scientific Name
Brook trout	*Salvelinus fontinalis*
Cutthroat trout	*Oncorhynchus clarki*
Brown trout	*Salmo trutta*
Golden trout	*Oncorhynchus aguabonita*
Rainbow trout	*Oncorhynchus mykiss*
Owens sucker	*Catostomus fumeiventris*
Mosquitofish	*Gambusia affinis*
Threespine stickleback	*Gasterosteus aculeatus*
Goldfish[a]	*Carassius auratus*

[a] Status uncertain.

Source: Moyle 1976.

Table 3D-2. Fish Species Reported to Occur in the Owens River Basin

Common Name	Scientific Name
Brook trout	*Salvelinus fontinalis*
Cutthroat trout	*Oncorhynchus clarki*
Brown trout	*Salmo trutta*
Golden trout	*Oncorhynchus aguabonita*
Rainbow trout	*Oncorhynchus mykiss*
Common carp	*Cyprinus carpio*
Goldfish[a]	*Carassius auratus*
Tui chub	*Gila bicolor*
Speckled dace	*Rhinichthys osculus*
Owens sucker	*Catostomus fumeiventris*
Channel catfish	*Ictalurus punctatus*
Brown bullhead	*Ictalurus nebulosus*
Owens pupfish	*Cyprinodon radiosus*
Mosquitofish	*Gambusia affinis*
Sacramento perch	*Archoplites interruptus*
Black crappie[a]	*Pomoxis nigromaculatus*
Green sunfish[a]	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Redear sunfish	*Lepomis microlophus*
Largemouth bass	*Micropterus salmoides*
Smallmouth bass	*Micropterus dolomieui*

[a] Status uncertain.

Source: Moyle 1976.

Table 3D-3. Habitat Impact Analysis Criteria for Parker and Walker Creeks Based on a Modified Tennant Method for Maintaining Various Levels of Habitat Conditions

	Parker Creek		Walker Creek	
Habitat Condition	April-September Flow (cfs)	October-March Flow (cfs)	April-September Flow (cfs)	October-March Flow (cfs)
Fair[a]	≥25.2	≥25.2	≥15.0	≥15.0
Good[b]	19.0	19.0	11.3	11.3
Excellent[b]	12.7	12.7	7.6	7.6
Optimum	7.6	7.6	4.5	4.5
Outstanding	7.6[c]	5.0	4.5[c]	3.0
Excellent	6.3	3.8	3.8	2.3
Good	5.0	2.5	3.0	1.5
Fair (degrading)	3.8	1.9[d]	2.3	1.2[d]
Poor (minimum)	1.3	1.3	0.8	0.8
Severe degradation	<1.3	<1.3	<0.8	<0.8

[a] Fair habitat conditions were assumed for flows equal to or exceeding Tennant's flushing or maximum flow recommendations (200% of mean annual flow).

[b] Good and excellent habitat conditions were assumed for flows between Tennant's optimum and flushing or maximum flow recommendations.

[c] Omitted from habitat impact analyses because of overlap with optimum habitat condition.

[d] Tennant's fair habitat conditions were identical to poor habitat conditions; consequently, the midpoint between poor and good habitat conditions was calculated and labeled fair for greater resolution.

Table 3D-4. Principal Months for Evaluating Habitat Conditions for Different Fish Species and Life Stages in Rush Creek, Lee Vining Creek, the Upper Owens River, and Middle Owens River

Habitat	January	February	March	April	May	June	July	August	September	October	November	December
Rush Creek and Lee Vining Creek Brown Trout												
Spawning										■	■	
Incubation	■	■	■	■	■	■				■	■	■
Fry					■	■	■					
Juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Adult	■	■	■	■	■	■	■	■	■	■	■	■
Upper Owens River Brown Trout												
Spawning										■	■	
Incubation	■	■	■	■						■	■	■
Fry			■	■	■	■						
Juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Adult	■	■	■	■	■	■	■	■	■	■	■	■
Upper Owens River Rainbow Trout												
Spawning			■	■	■							
Incubation			■	■	■	■						
Fry					■	■	■					
Juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Adult	■	■	■	■	■	■	■	■	■	■	■	■
Middle Owens River Brown Trout												
Spawning										■	■	■
Incubation	■	■	■	■						■	■	■
Fry				■	■	■						
Juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Adult	■	■	■	■	■	■	■	■	■	■	■	■
Middle Owens River Largemouth Bass												
Spawning				■	■	■						
Incubation				■	■	■						
Fry				■	■	■	■	■				
Juvenile	■	■	■	■	■	■	■	■	■	■	■	■
Adult	■	■	■	■	■	■	■	■	■	■	■	■

Table 3D-5. Water Temperature Suitability Ranges for Brown Trout and Largemouth Bass Life Stages

Fish Species	Fish Life Stage	Optimum Range (°F)	Tolerance Range (°F)
Brown trout[a]	Spawning and incubation	35.6-55.4	32.0-59.8
	Fry	44.6-59.0	41.0-78.0
	Juvenile	44.6-66.2	32.0-80.6
	Adult	53.6-66.2	32.0-80.6
Largemouth bass[b]	Spawning and incubation	68.0-71.6	54.5-78.8
	Fry	78.8-86.0	59.0-89.6
	Juvenile	75.2-86.0	59.0-96.8
	Adult	75.2-86.0	59.0-96.8

[a] Source: Raleigh et al. 1986.

[b] Source: Stuber et al. 1982.

Table 3D-6. Summary Comparison of Aquatic Resource Effects of the Alternatives: Mono Lake Tributary Streams

		Rush Creek			Lee Vining Creek			Modified Tennant Descriptor		
Alternative or Condition	Meets Pre-1941 Habitat Condition Standards Set by Court	% Change in Brown Trout Adult Habitat	% Change in Brown Trout Spawning Habitat	Significant Impacts from High Flows	% Change in Brown Trout Adult Habitat	% Change in Brown Trout Spawning Habitat	Significant Impacts from High Flows	Parker Creek	Walker Creek	Net Effect on Parker and Walker Creeks
Point of reference	No	0	0	N/A	0	0	No	Severe	Severe	N/A
No restriction	No	-75*	-79*	No	-55*	-57*	No	Severe	Severe	None
6,372 Ft	No	+16	+69	No	+91	+209	No	Good	Good	Substantial benefits
6,377 Ft	No	+17	+73	Yes	+93	+218	Yes	Good	Fair-good	Substantial benefits
6,383.5 Ft	No	+18	+75	Yes	+96	+220	Yes	Good	Fair-good	Substantial benefits
6,390 Ft	No	+19	+78	Yes	+98	+228	Yes	Good	Fair-good	Substantial benefits
6,410 Ft	No	+20	+105	Yes	+108	+288	Yes	Good	Fair-good	Substantial benefits
No diversion	No	+20	+107	Yes	+109	+317	Yes	Good	Good-excellent	Substantial benefits
Prediversion		Unknown	Unknown	N/A	Unknown	Unknown	No	Good	Good	N/A

Notes: All effects are summarized without mitigation measures.

Significant cumulative fisheries impacts (√) for Rush, Lee Vining, Parker, and Walker Creeks apply to all alternatives. They include permanently altered channel morphology, constraints on fish passage and spawning gravel movement due to the presence of diversion facilities, and resulting decreases in the prediversion fish populations. These cumulative impacts are partially mitigable through restoration.

* = significant adverse project impact.

N/A = not applicable.

Table 3D-7. Summary Comparison of Aquatic Resource Effects of the Alternatives: Grant Lake Reservoir, Lake Crowley Reservoir, and Middle Owens River

	Grant Lake Reservoir			Lake Crowley Reservoir		Middle Owens River			
Alternative or Condition	% Change in Reservoir Surface Area	Spawning Success	Net Effect	% Change in Reservoir Surface Area	Net Effect	% Change in Brown Trout Spawning Habitat	% Change in Brown Trout Fry Habitat	% Change in in Aquatic Invertebrate Habitat	Net Effect
Point of reference	0	N/A	N/A	0	N/A	0	0	0	N/A
No restriction	+2	Less than significant adverse	No significant change	+2	Minor improvement	-2	0	-18	Less than significant adverse
6,372 Ft	-7	Minor benefits	Less than significant adverse	-1	Less than significant adverse	+8	+1	+36	Minor benefits
6,377 Ft	-9	Minor benefits	Less than significant adverse	-1	Less than significant adverse	+13	+1	+53	Minor benefits
6,383.5 Ft	-11*	Minor benefits	Less than significant adverse	-2	Less than significant adverse	+17	+2	+66	Minor benefits
6,390 Ft	-11*	Minor benefits	Less than significant adverse	-2	Less than significant adverse	+20	+2	+74	Minor benefits
6,410 Ft	-13*	Minor benefits	Less than significant adverse	-5	Less than significant adverse	+31	+2	+92	Minor benefits
No diversion	+25	Minor benefits	Substantial benefits	-5	Less than significant adverse	+37	+2	+101	Minor benefits
Prediversion	Unknown	N/A	N/A	Reservoir not in place	N/A	Unknown	Unknown	Unknown	N/A

Note: Significant cumulative fisheries impacts (√) for the Middle Owens River apply to all alternatives. They include altered channel morphology from LADWP facilities and operations, grazing, and competition from introduced species with native species. Some of these impacts are mitigable.

* = significant adverse impact.

N/A = not applicable.

Table 3D-8. Summary Comparison of Aquatic Resource Effects of the Alternatives: Upper Owens River

Alternative or Condition	Average % Change in Brown Trout Adult Habitat	Average % Change in Brown Trout Spawning Habitat	Average % Change in Rainbow Trout Adult Habitat	Average % Impacts from Rainbow Trout Spawning Habitat	Significant Impacts from Water Temperature Increases	Significant Impacts from Water Quality Degradation
Point of reference	0	0	0	0	N/A	N/A
No restriction	+4	0	+4	-6	No	No
6,372 Ft	-4	-21*	-4	+10	No	No
6,377 Ft	-12*√	-15*	-12*√	+13	No	No
6,383.5 Ft	-21*√	+4	-20*√	+19	Yes√	Yes√
6,390 Ft	-26*√	+3	-24*√	+21	Yes√	Yes√
6,410 Ft	-36*√	-5	-34*√	+21	Yes√	Yes√
No diversion	-36*√	-11*	-34*√	+21	Yes√	Yes√
Prediversion	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

Notes: All effects are summarized without mitigation measures.

Average percentage change in habitat based on averaging percentage changes for wet, normal, and dry hydrologic conditions.

Significant impacts from water temperature and water quality changes apply only below Hot Creek confluence.

Significant project and cumulative impacts are partially or substantially mitigable depending on Grant Lake reservoir operations.

* = significant adverse impact (greater than a 10% habitat reduction).

√ = significant cumulative impact.

N/A = not applicable.

Table 3D-9. Average Brown Trout Spawning Habitat in Segments 3, 5, and 6 of Rush Creek by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-5)

Table 3D-10. Average Brown Trout Fry Habitat in Segments 3, 5, and 6 of Rush Creek by Alternative, 1940-1989 Hydrology Period

(see Figure 3D-6)

Table 3D-11. Average Brown Trout Juvenile Habitat in Segments 3, 5, and 6 of Rush Creek by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-7)

Table 3D-12. Average Brown Trout Adult Habitat in Segments 3, 5, and 6 of Rush Creek by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-8)

Table 3D-13. Average Brown Trout Spawning Habitat in Segments 2, 5, and 6 of Lee Vining Creek by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-9)

Table 3D-14. Average Brown Trout Fry Habitat in Segment 2 of Lee Vining Creek by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-10)

Table 3D-15. Average Brown Trout Juvenile Habitat in Segments 2, 5, and 6 of Lee Vining Creek by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-11)

Table 3D-16. Average Brown Trout Adult Habitat in Segments 2, 5, and 6 of Lee Vining Creek by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-12)

Table 3D-17. Summary of Aquatic Habitat Conditions Using Impact Analyses Based on Tennant Method for Parker and Walker Creeks

Alternative or Condition	Hydrologic Condition	Parker Creek	Walker Creek
No restriction	Wet	Severe	Severe
	Normal	Severe	Severe
	Dry	Severe	Severe
Point of reference	Wet	Severe	Severe
	Normal	Severe	Severe
	Dry	Severe	Severe
6,372 Ft	Wet	Good	Good
	Normal	Good	Good
	Dry	Good	Good
6,377 Ft	Wet	Good	Fair
	Normal	Good	Fair
	Dry	Good	Good
6,383.5 Ft	Wet	Good	Fair
	Normal	Good	Fair
	Dry	Good	Good
6,390 Ft	Wet	Good	Fair
	Normal	Good	Fair
	Dry	Good	Good
6,410 Ft	Wet	Good	Fair
	Normal	Good	Fair
	Dry	Good	Good
No diversion	Wet	Good	Good
	Normal	Good	Excellent
	Dry	Good	Good

Table 3D-18. Change in End of Month Elevation (Feet) at Grant Lake Reservoir under 20%, 50%, and 80% Hydrologic Conditions by Alternative

Alternative and Flow Percentile	October	November	December	January	February	March	April	May	June
No-Restriction Alternative									
20%	-5	0	-2	-1	0	-1	-9	0	0
50%	0	0	0	0	0	0	-2	0	2
80%	0	1	0	1	2	2	0	11	18
Point of Reference									
20%	-6	0	-3	-1	0	-1	-7	0	0
50%	0	0	0	0	0	0	0	0	1
80%	0	0	0	0	1	0	0	6	22
6,372-Ft Alternative									
20%	-7	-6	-2	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	1
80%	0	0	0	0	0	0	0	2	13
6,377-Ft Alternative									
20%	-7	-1	0	0	0	0	0	0	-1
50%	0	0	0	0	0	0	0	0	-1
80%	0	0	0	0	0	0	0	2	0
6,383.5-Ft Alternative									
20%	-1	0	0	0	0	0	0	0	-1
50%	0	0	0	0	0	0	0	0	-1
80%	0	0	0	0	0	0	0	2	0
6,390-Ft Alternative									
20%	-1	0	0	0	0	0	0	0	-1
50%	0	0	0	0	0	0	0	0	-1
80%	0	0	0	0	0	0	0	2	0
6,410-Ft Alternative									
20%	-1	0	0	0	0	0	0	0	-1
50%	0	0	0	0	0	0	0	0	-1
80%	0	0	0	0	0	0	0	2	0
No-Diversion Alternative									
20%	0	0	0	0	0	0	0	0	0
50%	0	0	0	0	0	0	0	0	0
80%	0	0	0	0	0	0	0	0	0

Table 3D-19. Grant Lake Reservoir Average Surface Area for Each Alternative and Percentage Difference Relative to Point of Reference

Alternative or Condition	Average Surface Area (April-October)	Percent Difference from Point of Reference
Point of reference	881.5	0.0
No restriction	896.5	1.7
6,372 Ft	826.8	-6.2
6,377 Ft	804.6	-8.7
6,383.5 Ft	787.8	-10.6
6,390 Ft	781.9	-11.3
6,410 Ft	767.4	-13.0
No diversion	1,101.3	24.9

Table 3D-20. Brown Trout and Rainbow Trout Adult and Spawning Habitat (Weighted Usable Area) in Upper Owens River for Dry (20%), Normal (50%), and Wet (80%) Hydrologic Conditions by Alternative, 1940-1989 Hydrologic Period

Alternative and Flow Percentile	Brown Trout Adult WUA	Percent Difference from Point of Reference	Brown Trout Spawning WUA	Percent Difference from Point of Reference	Rainbow Trout Adult WUA	Percent Difference from Point of Reference	Rainbow Trout Spawning WUA	Percent Difference from Point of Reference
Point of Reference								
20	396,742	0.0	312,223	0.0	410,713	0.0	732,197	0.0
50	493,695	0.0	369,621	0.0	501,671	0.0	610,590	0.0
80	536,347	0.0	243,317	0.0	544,416	0.0	504,925	0.0
No Restriction								
20	421,561	6.3	355,022	13.7	434,370	5.8	725,055	-1.0
50	526,389	6.6	348,997	-5.6	532,205	6.1	554,575	-9.2
80	526,634	-1.8	222,370	-8.6	536,555	-1.4	457,368	-9.4
6,372-Ft								
20	342,029	-13.8	268,677	-13.9	356,981	-13.1	766,937	4.7
50	491,195	-0.5	351,739	-4.8	499,836	-0.4	684,690	12.1
80	542,344	1.1	136,301	-44.0	548,501	0.8	580,082	14.9
6,377-Ft								
20	287,745	-27.5	252,864	-19.0	303,260	-26.2	754,223	3.0
50	443,913	-10.1	347,042	-6.1	454,060	-9.5	728,470	19.3
80	541,583	1.0	195,703	-19.6	547,512	0.6	594,276	17.7
6,383.5-Ft								
20	264,590	-33.3	247,610	-20.7	280,332	-31.7	727,363	-0.7
50	364,666	-26.1	349,508	-5.4	378,999	-24.5	754,169	23.5
80	521,712	-2.7	339,572	39.6	528,399	-2.9	683,214	35.3
6,390-Ft								
20	250,315	-36.9	231,709	-25.8	266,280	-35.2	697,534	-4.7
50	339,674	-31.2	349,508	-5.4	354,181	-29.4	750,032	22.8
80	489,943	-8.7	339,572	39.6	497,668	-8.6	732,975	45.2
6,410-Ft								
20	243,030	-38.7	225,214	-27.9	258,799	-37.0	685,944	-6.3
50	304,237	-38.4	277,825	-24.8	319,175	-36.4	747,303	22.4
80	373,612	-30.3	336,802	38.4	385,931	-29.1	748,778	48.3
No Diversion								
20	241,059	-39.2	212,088	-32.1	256,729	-37.5	669,205	-8.6
50	303,314	-38.6	264,818	-28.4	318,267	-36.6	730,493	19.6
80	371,697	-30.7	307,873	26.5	383,984	-29.5	767,279	52.0

WUA = weighted usable area.

Table 3D-21. Lake Crowley Reservoir Average Surface Area for Each Alternative and Percentage Difference Relative to Point of Reference

Alternative or Condition	Average Surface Area (April-October)	Percentage Difference from Point of Reference	Average Surface Area (November-March)	Percentage Difference from Point of Reference
Point of reference	4,382	0.0	4,362	0.0
No restriction	4,415	0.8	4,415	1.2
6,372 Ft	4,415	0.8	4,382	0.5
6,377 Ft	4,349	-0.7	4,341	-0.5
6,383.5 Ft	4,274	-2.5	4,285	-1.8
6,390 Ft	4,274	-2.5	4,285	-1.8
6,410 Ft	4,170	-4.8	4,170	-4.4
No diversion	4,170	-4.8	4,145	-5.0

Table 3D-22. Average Brown Trout Spawning Habitat in Segments 1-3 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-13)

Table 3D-23. Average Brown Trout Fry Habitat in Segments 1-3 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-14)

Table 3D-24. Average Brown Trout Juvenile Habitat in Segments 1-3 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-15)

Table 3D-25. Average Brown Trout Adult Habitat in Segments 1-3 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-16)

Table 3D-26. Average Brown Trout Spawning Habitat (Weighted Usable Area per 1,000 feet) at Individual Spawning Transects in the Middle Owens River by Alternative, 1940-1989 Hydrologic Period

	Segment 1		Segment 2				Segment 3		
Alternative	RUN T86	RUN T76	RUN T64	MRN T46	LGR T63	LGR T65	RUN T22	MRN T25	LGR T33
Average WUA/1,000 feet (1940-1989)									
Point of reference	10,837	14,430	12,332	11,567	18,865	24,725	11,502	11,954	5,141
No restriction	11,119	14,404	12,411	11,548	18,936	24,743	11,678	12,030	5,116
6,372 Ft	10,385	14,466	12,282	11,619	19,212	24,167	10,337	11,699	5,354
6,377 Ft	10,441	14,632	12,510	11,771	19,779	24,276	10,007	11,627	5,467
6,383.5 Ft	10,611	14,810	12,938	11,946	20,810	24,568	10,561	11,741	5,644
6,390 Ft	10,559	14,879	13,017	12,036	21,092	24,670	10,772	11,781	5,717
6,410 Ft	11,044	15,341	14,025	12,498	23,492	25,396	11,932	12,051	6,173
No diversion	11,127	15,451	14,392	12,678	24,391	25,452	12,343	12,123	6,399
Percentage difference from point of reference									
No restriction	2.6	-0.2	0.6	-0.2	0.4	0.1	1.4	0.6	-0.5
6,372 Ft	-4.2	0.2	-0.4	0.4	1.8	-2.3	-10.1	-2.1	4.1
6,377 Ft	-3.7	1.4	1.4	1.8	4.8	-1.8	-12.4	-2.7	6.3
6,383.5 Ft	-2.1	2.6	4.9	3.3	10.3	-0.6	-8.2	-1.8	9.8
6,390 Ft	-2.6	3.1	5.6	4.1	11.8	-0.2	-6.3	-1.4	11.2
6,410 Ft	1.9	6.3	13.7	8.0	24.5	2.7	3.7	0.8	20.1
No diversion	2.7	7.1	16.7	9.6	29.3	2.9	7.3	1.4	24.5

Notes: RUN = run.
MRN = meander.
LGR = low gradient riffle.

Table 3D-27. Average Aquatic Invertebrate Habitat in Segments 1-3 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-17)

Table 3D-28. Average Largemouth Bass Spawning Habitat in Segment 4 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-18)

Table 3D-29. Average Largemouth Bass Fry Habitat in Segment 4 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-19)

Table 3D-30. Average Largemouth Bass Juvenile Habitat in Segment 4 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-20)

Table 3D-31. Average Largemouth Bass Adult Habitat in Segment 4 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

(see Figure 3D-21)

Table 3D-32. Summary of Simulated Daily Water Temperatures in April and June at Two Locations in the Middle Owens River for the Point of Reference and No-Diversion Alternative

			Owens River at Five Bridges Road			Owens River at Big Pine Canal		
Alternative or Condition	Pleasant Valley Reservoir Release (cfs)	Flow Percentile	Occurrences at 44-59°F[a]	Occurrences at 60-78°F[b]	Occurrences Exceeding 78°F[c]	Occurrences at 44-59°F[a]	Occurrences at 60-78°F[b]	Occurrences Exceeding 78°F[c]
April								
Point of reference	376	20	29	1	0	28	2	0
	480	50	28	2	0	27	3	0
	558	80	29	1	0	28	2	0
No diversion	230	20	29	1	0	27	3	0
	284	50	30	0	0	29	1	0
	465	80	30	0	0	30	0	0
June								
Point of reference	332	20	4	26	0	0	30	0
	475	50	6	24	0	0	30	0
	585	80	10	20	0	0	30	0
No diversion	193	20	0	30	0	0	30	0
	290	50	2	28	0	0	30	0
	428	80	6	24	0	0	30	0

[a] Number of days that mean daily water temperatures fall within the optimum range for brown trout fry.

[b] Number of days that mean daily water temperatures fall within the suboptimum range for brown trout fry.

[c] Number of days that maximum daily water temperatures exceed the upper tolerance limit for brown fry.

Table 3D-33. Summary of Simulated Daily Water Temperatures in August and October at Two Locations in the Middle Owens River for the Point of Reference and the No-Diversion Alternative

Alternative or Condition	Pleasant Valley Reservoir Release (cfs)	Flow Percentile	Owens River at Five Bridges Road			Owens River at Big Pine Canal			
			Occurrences at 53-66°F[a]	Occurrences at 66-80°F[b]	Occurrences Exceeding 80°F[c]	Occurrences Less Than 55°F	Occurrences at 53-66°F[a]	Occurrences at 66-80°F[b]	Occurrences Exceeding 80°F[c]
August									
Point of reference	209	20	12	19	0	--	0	31	0
	521	50	20	11	0	--	2	29	0
	628	80	22	9	0	--	8	23	0
No diversion	153	20	9	22	0	--	0	31	0
	231	50	13	18	0	--	0	31	0
	609	80	22	9	0	--	9	22	0
October									
Point of reference	186	20	31	0	0	1	31	0	0
	332	50	31	0	0	1	31	0	0
	467	80	31	0	0	1	31	0	0
No diversion	121	20	31	0	0	3	31	0	0
	220	50	30	1	0	2	29	2	0
	315	80	31	0	0	1	31	0	0

[a] Number of days that mean daily water temperatures fall within the optimum range for brown trout juveniles and adults reported by Raleigh et al. 1986.

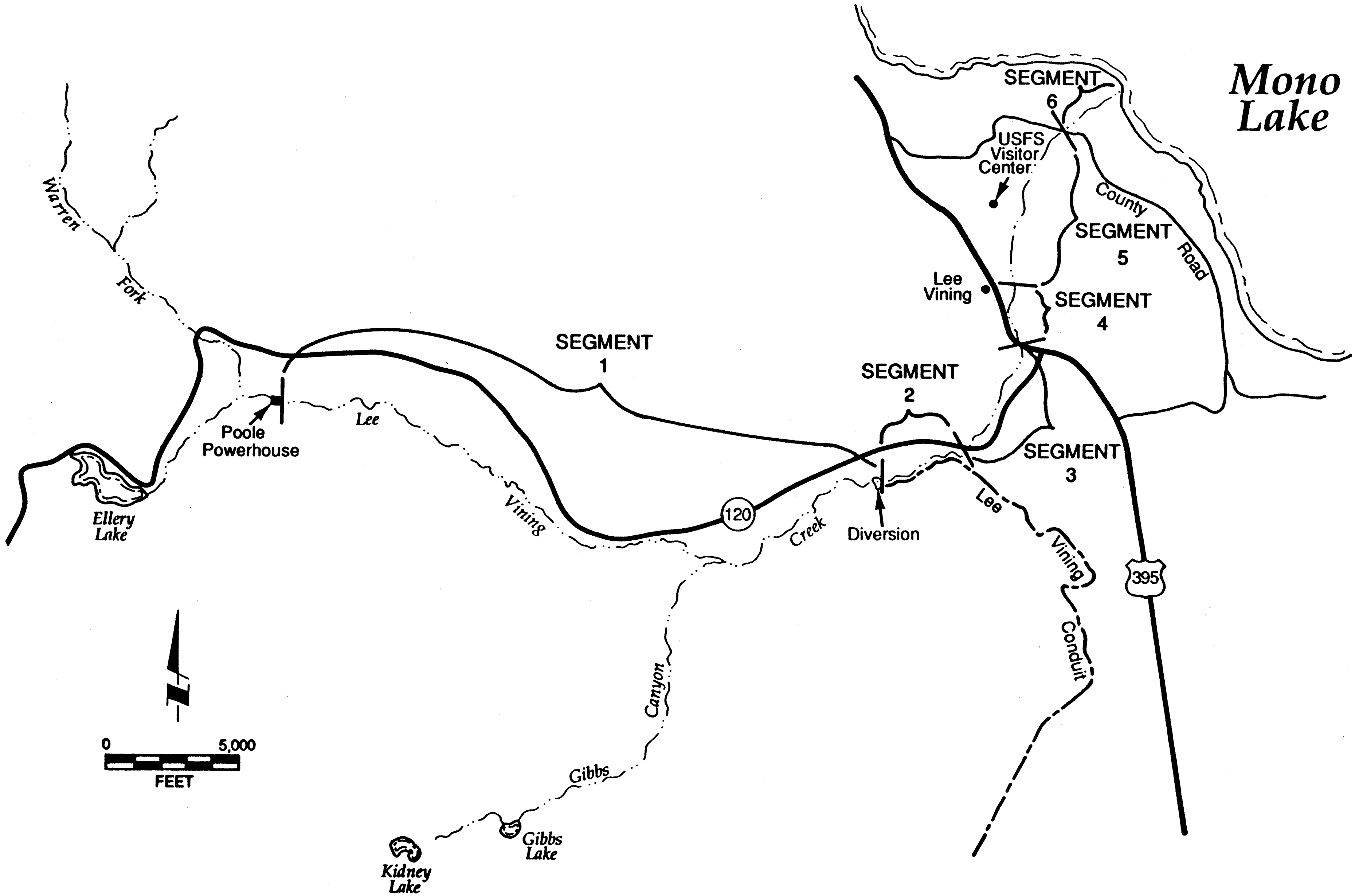
[b] Number of days that mean daily water temperatures fall within the suboptimum range for brown trout juveniles and adults reported by Raleigh et al. 1986.

[c] Number of days that maximum daily water temperatures exceed the upper tolerance limit for brown trout juveniles and adults reported by Raleigh et al. 1986.

[d] Number of days that mean daily water temperatures fall within the optimum range for brown trout spawning and incubation reported by Raleigh et al. 1986.

Table 3D-34. Preliminary Minimum Monthly Streamflows (cfs) for Lee Vining, Walker, Parker, and Rush Creeks from DFG Stream Evaluation Reports

(see Figure 3D-24)

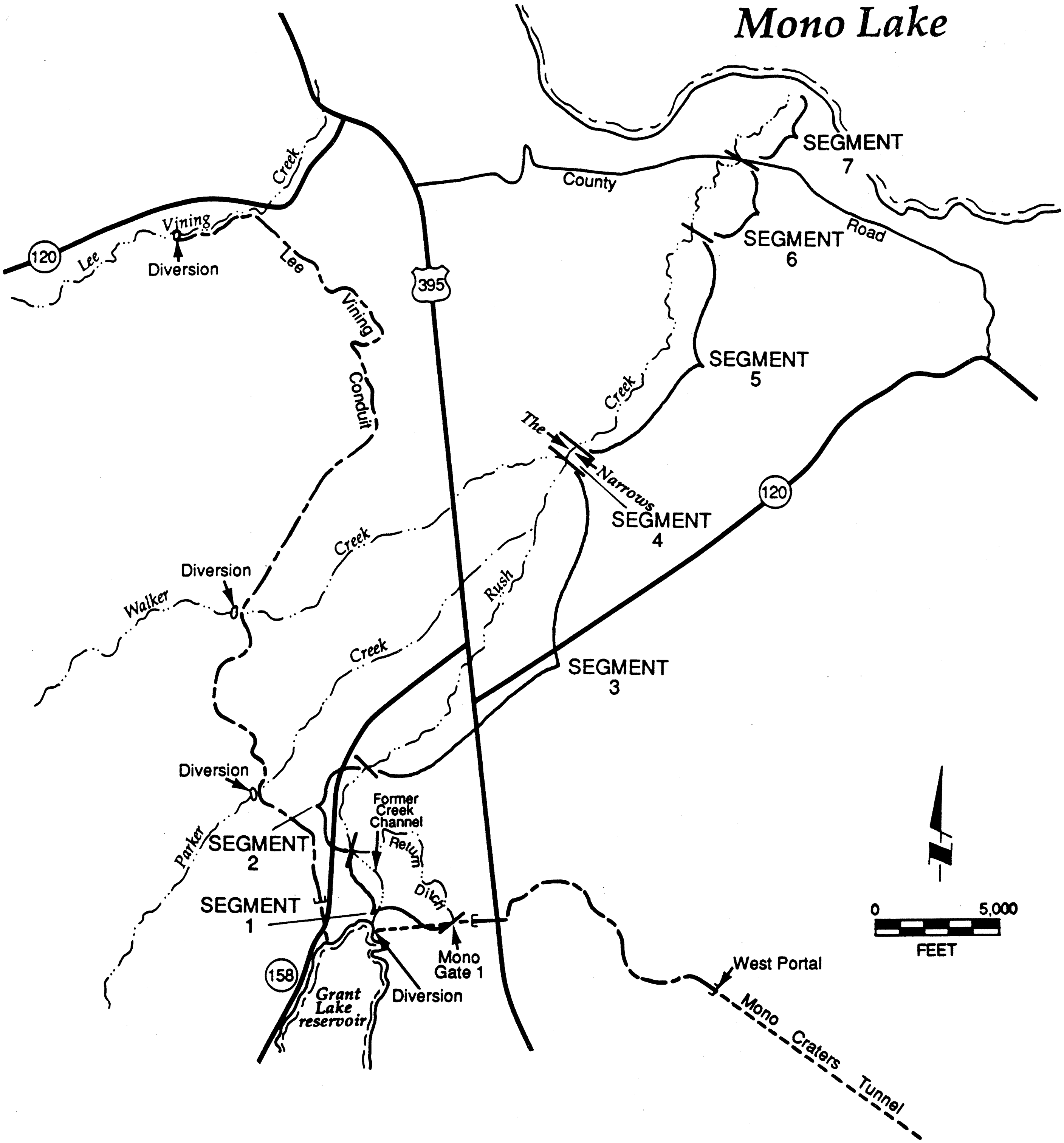


Source: Based on data provided by Aquatic Systems Research 1992

Figure 3D-1.
Lee Vining Creek Study Segments

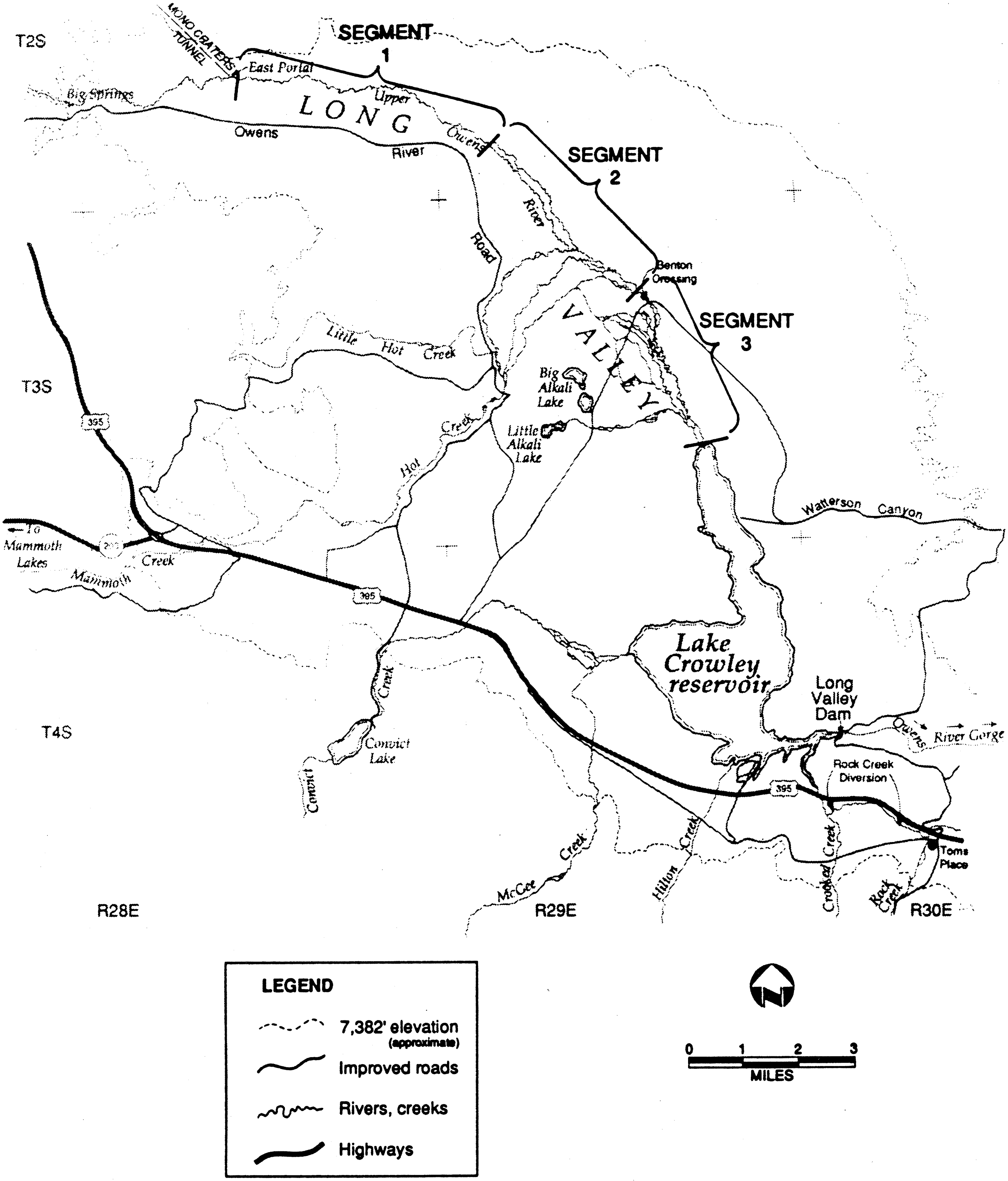
MONO BASIN EIR

Prepared by Jones & Stokes Associates



Source: Based on data provided by Beak Consultants 1991 and Trihey & Associates 1991

Figure 3D-2.
Rush Creek Study Segments



Source: Based on data provided by Ebasco Environmental 1993

Figure 3D-3.
Upper Owens River Study Segments

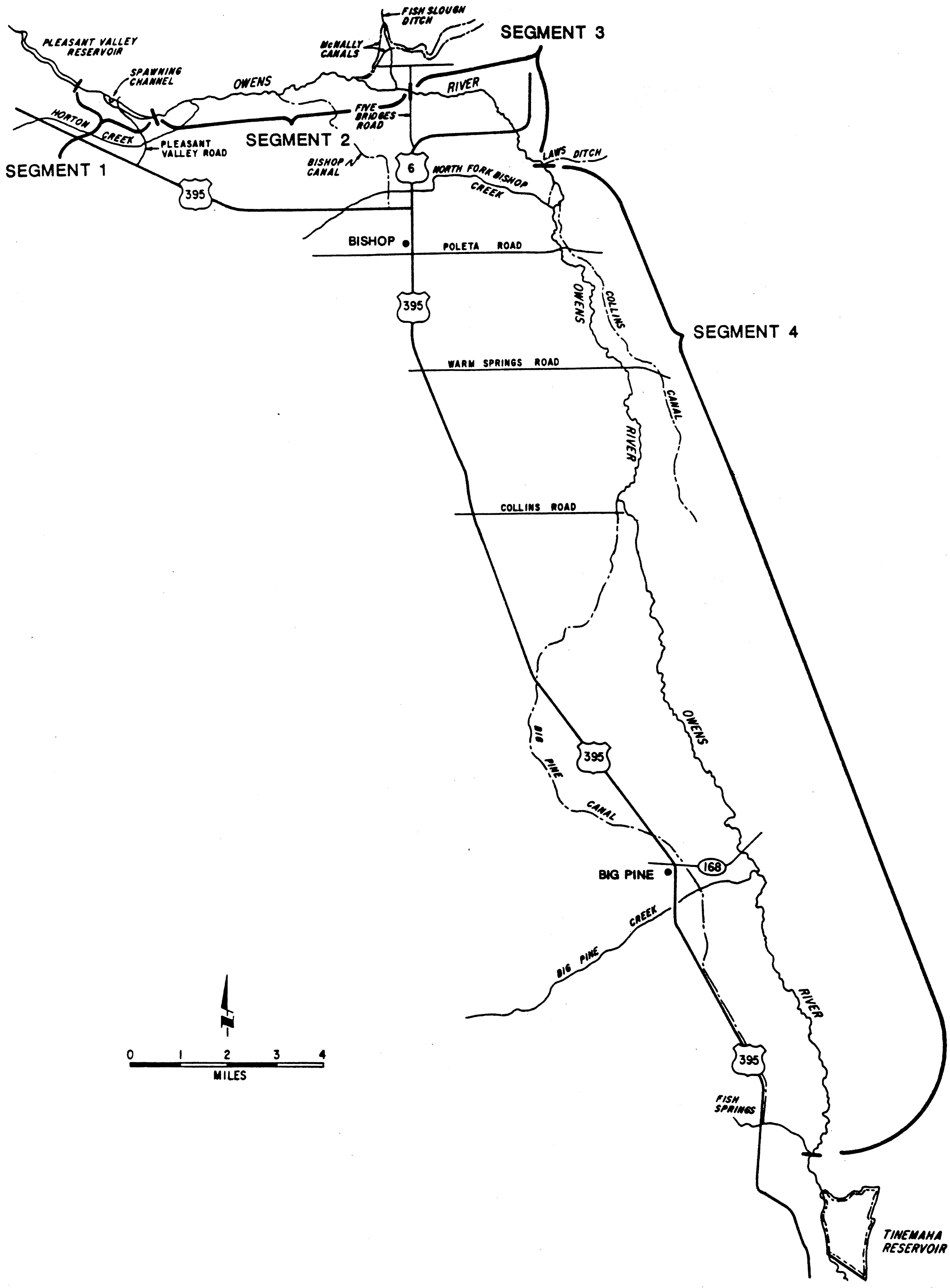


Figure 3D-4.
Middle Owens River IFIM Segmentation

Mono Basin EIR

Prepared by Jones & Stokes Associates

Figure 3D-5.
Simulated Brown Trout Spawning Habitat in Segments 3, 5, and 6 of Rush Creek for the Alternatives, 1940-1989 Hydrologic Period

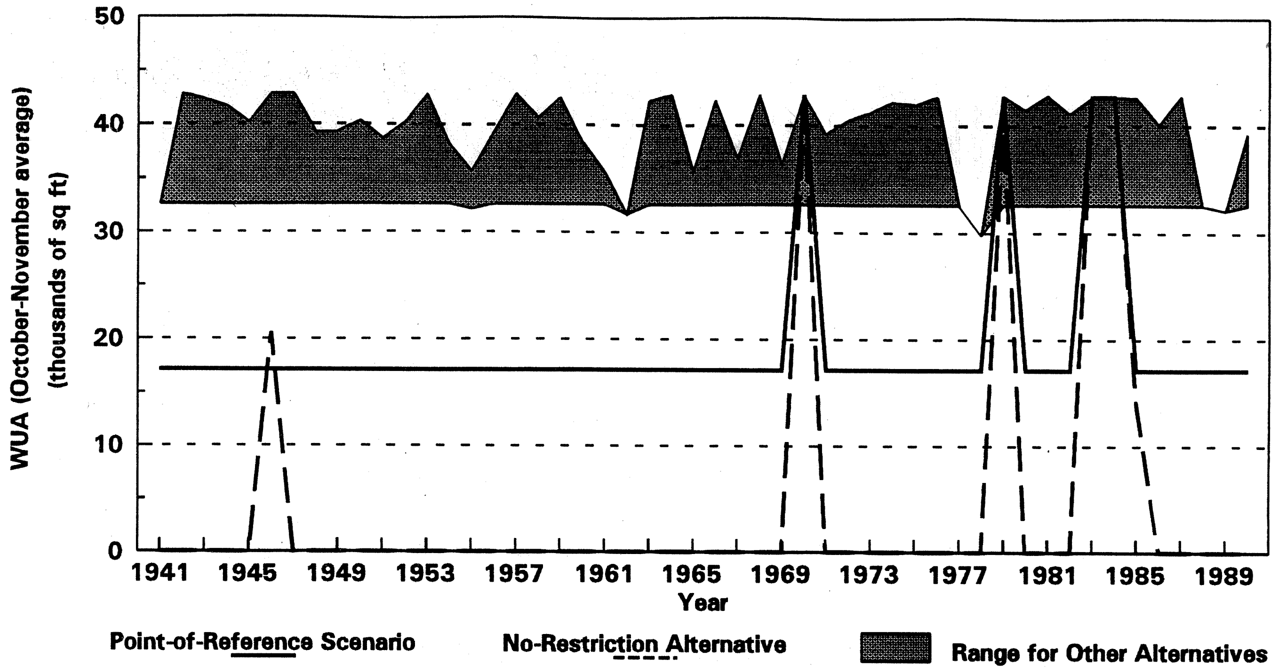


Table 3D-9.
Average Brown Trout Spawning Habitat in Segments 3, 5, and 6 of Rush Creek by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 3	Segment 5	Segment 6	Total
Average WUA (thousands of sq ft)				
Point–of–reference scenario	3,240	8,512	7,419	19,172
No restriction	732	1,558	1,723	4,013
6,372	4,889	15,155	12,422	32,465
6,377	5,015	15,409	12,778	33,201
6,383.5	5,079	15,553	12,939	33,570
6,390	5,144	15,759	13,123	34,026
6,410	6,444	16,679	16,196	39,319
No diversion	6,425	16,984	16,287	39,696
Percent Difference from Point–of–Reference Scenario				
No restriction	−77.4	−81.7	−76.8	−79.1
6,372	50.9	78.0	67.4	69.3
6,377	54.8	81.0	72.2	73.2
6,383.5	56.7	82.7	74.4	75.1
6,390	58.7	85.1	76.9	77.5
6,410	98.9	95.9	118.3	105.1
No diversion	98.3	99.5	119.5	107.1

Figure 3D-6.
Simulated Brown Trout Fry Habitat in Segments 3, 5, and 6 of Rush Creek for the Alternatives, 1940-1989 Hydrologic Period

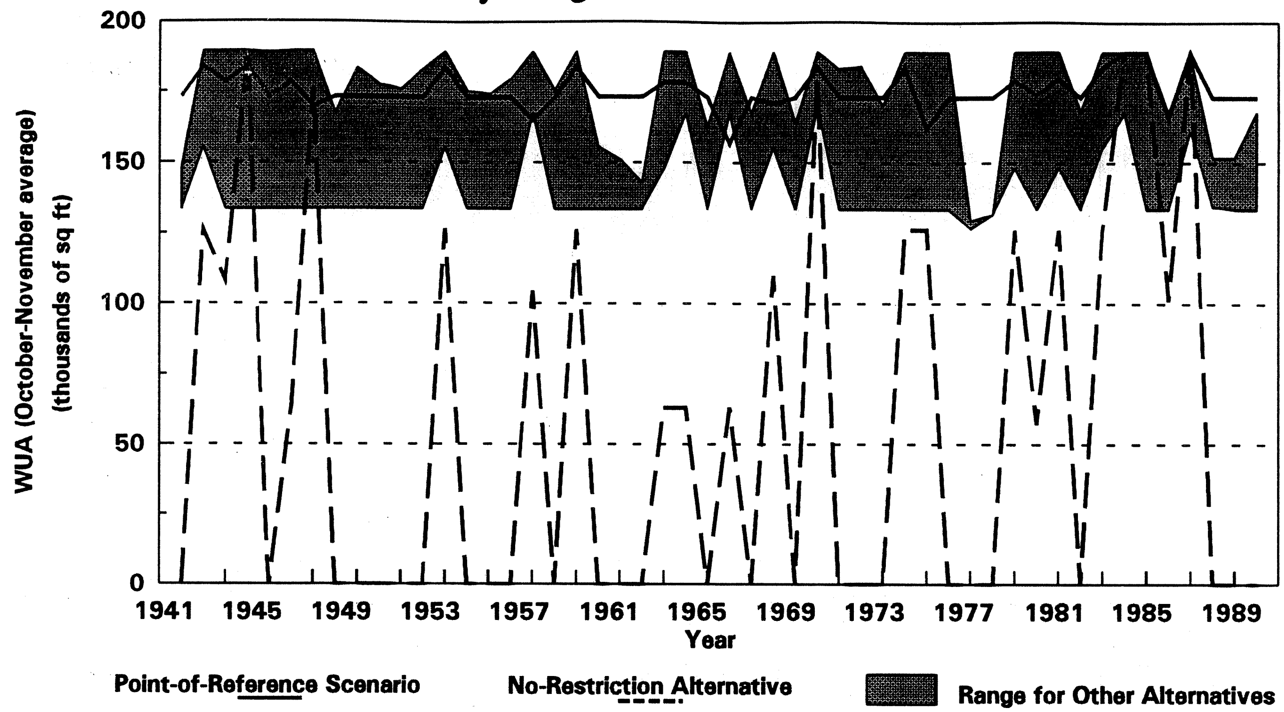


Table 3D-10.
Average Brown Trout Fry Habitat in Segments 3, 5, and 6 of Rush Creek by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 3	Segment 5	Segment 6	Total
Average WUA (thousands of sq ft)				
Point–of–reference scenario	80,869	52,254	42,112	175,234
No restriction	22,902	16,999	17,184	57,086
6,372	63,792	37,918	38,261	139,971
6,377	66,692	43,822	43,335	153,849
6,383.5	69,830	48,935	49,818	168,583
6,390	71,447	51,426	53,393	176,266
6,410	72,253	52,800	54,989	180,042
No diversion	71,480	51,667	53,424	176,570
Percent Difference from Point–of–Reference Scenario				
No restriction	−71.7	−67.5	−59.2	−67.4
6,372	−21.1	−27.4	−9.1	−20.1
6,377	−17.5	−16.1	2.9	−12.2
6,383.5	−13.6	−6.4	18.3	−3.8
6,390	−11.6	−1.6	26.8	0.6
6,410	−10.7	1.0	30.6	2.7
No diversion	−11.6	−1.1	26.9	0.8

Figure 3D-7.
Simulated Brown Trout Juvenile Habitat in Segments 3, 5, and 6 of Rush Creek for the Alternatives, 1940-1989 Hydrologic Period

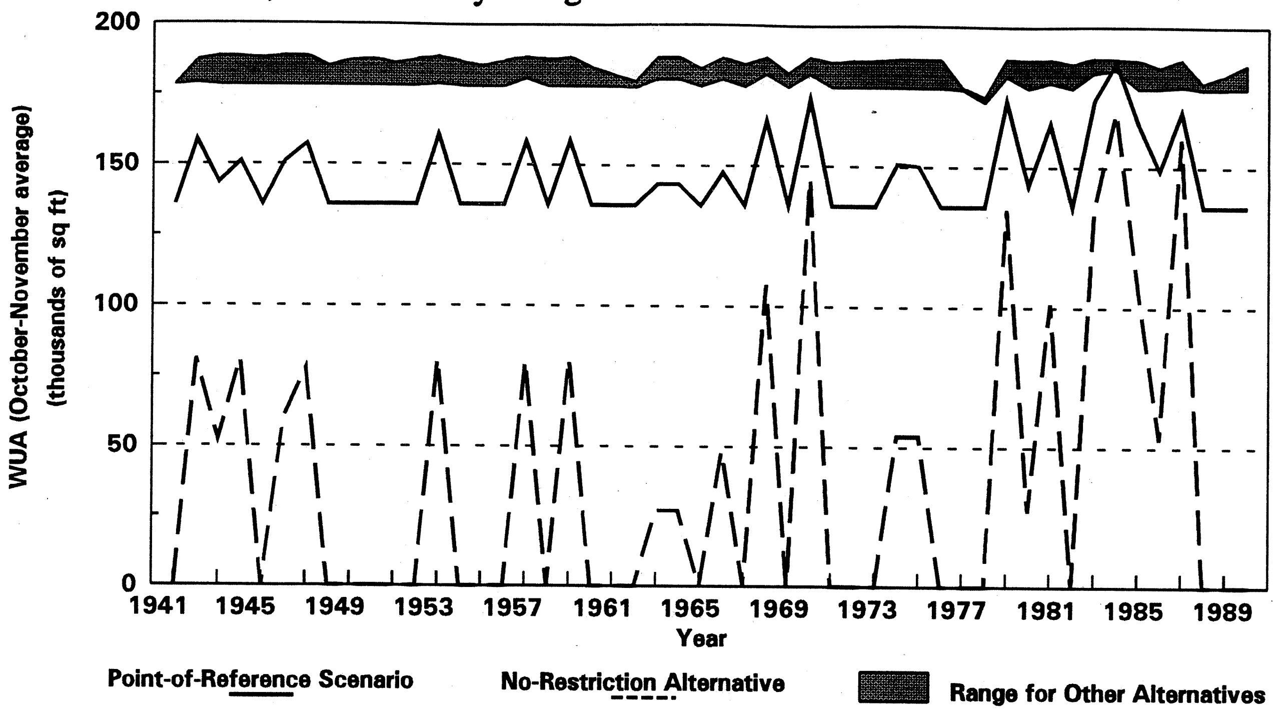


Table 3D-11.
Average Brown Trout Juvenile Habitat in Segments 3, 5, and 6 of Rush Creek by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 3	Segment 5	Segment 6	Total
Average WUA (thousands of sq ft)				
Point-of-reference scenario	53,442	55,428	37,279	146,149
No restriction	13,492	14,203	11,207	38,902
6,372	61,433	69,819	47,368	178,619
6,377	61,876	69,384	48,406	179,667
6,383.5	62,740	69,380	50,176	182,296
6,390	63,284	69,571	51,270	184,125
6,410	64,217	69,889	53,215	187,321
No diversion	63,816	70,035	52,361	186,212
Percent Difference from Point-of-Reference Scenario				
No restriction	−74.8	−74.4	−69.9	−73.4
6,372	15.0	26.0	27.1	22.2
6,377	15.8	25.2	29.8	22.9
6,383.5	17.4	25.2	34.6	24.7
6,390	18.4	25.5	37.5	26.0
6,410	20.2	26.1	42.7	28.2
No diversion	19.4	26.4	40.5	27.4

Figure 3D-8.
Simulated Brown Trout Adult Habitat in Segments 3, 5, and 6 of Rush Creek for the Alternatives, 1940-1989 Hydrologic Period

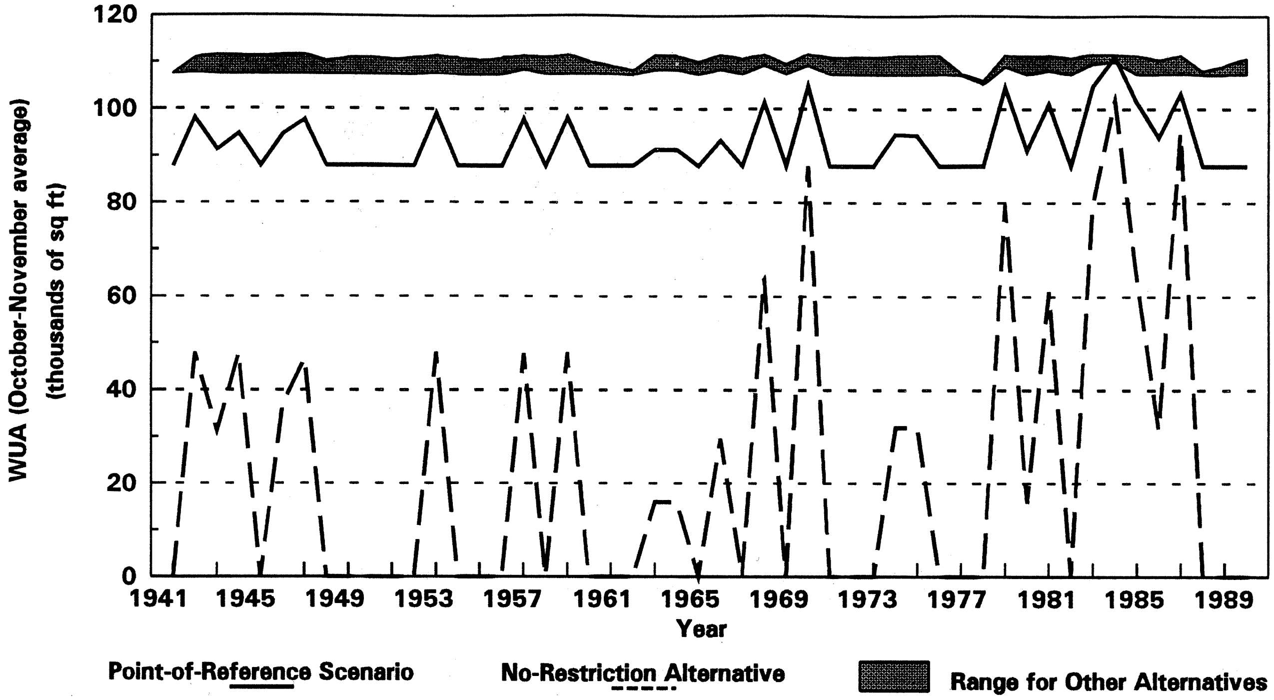


Table 3D-12.
Average Brown Trout Adult Habitat in Segments 3, 5, and 6 of Rush Creek by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 3	Segment 5	Segment 6	Total
Average WUA (thousands of sq ft)				
Point–of–reference scenario	48,344	21,226	22,961	92,531
No restriction	11,538	6,216	5,435	23,190
6,372	54,703	26,384	26,631	107,718
6,377	54,753	26,860	26,509	108,122
6,383.5	54,915	27,848	26,387	109,151
6,390	55,043	28,482	26,344	109,868
6,410	55,248	29,581	26,266	111,095
No diversion	55,196	29,121	26,344	110,661
Percent Difference from Point–of–Reference Scenario				
No restriction	−76.1	−70.7	−76.3	−74.9
6,372	13.2	24.3	16.0	16.4
6,377	13.3	26.5	15.4	16.8
6,383.5	13.6	31.2	14.9	18.0
6,390	13.9	34.2	14.7	18.7
6,410	14.3	39.4	14.4	20.1
No diversion	14.2	37.2	14.7	19.6

Figure 3D-9.
Simulated Brown Trout Spawning Habitat in Segments 2, 5, and 6 of Lee Vining Creek for the Alternatives, 1940-1989 Hydrologic Period

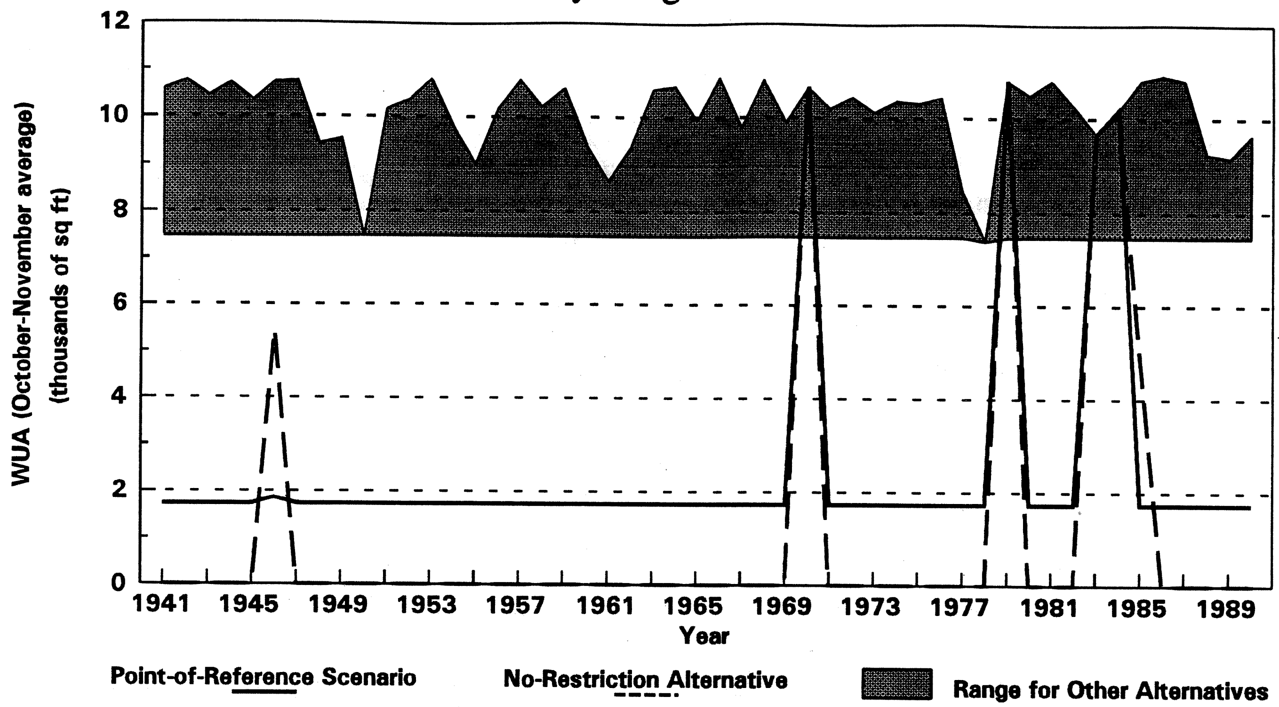


Table 3D-13.
Average Brown Trout Spawning Habitat in Segments 2, 5, and 6 of Lee Vining Creek by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 2	Segment 5	Segment 6	Total
Average WUA (thousands of sq ft)				
Point–of–reference scenario	576	1,165	676	2,417
No restriction	80	562	391	1,033
6,372	2,007	3,371	2,081	7,459
6,377	1,947	3,515	2,214	7,676
6,383.5	1,958	3,536	2,242	7,736
6,390	1,922	3,656	2,356	7,934
6,410	1,449	4,668	3,264	9,381
No diversion	1,261	5,122	3,685	10,068
Percent Difference from Point–of–Reference Scenario				
No restriction	−86.1	−51.8	−42.2	−57.3
6,372	248.4	189.4	207.8	208.6
6,377	238.0	201.7	227.5	217.6
6,383.5	239.9	203.5	231.7	220.1
6,390	233.7	213.8	248.5	228.3
6,410	151.6	300.7	382.8	288.1
No diversion	118.9	339.7	445.1	316.5

Figure 3D-10.
Simulated Brown Trout Fry Habitat in Segment 2 of Lee Vining Creek
for the Alternatives, 1940-1989 Hydrologic Period

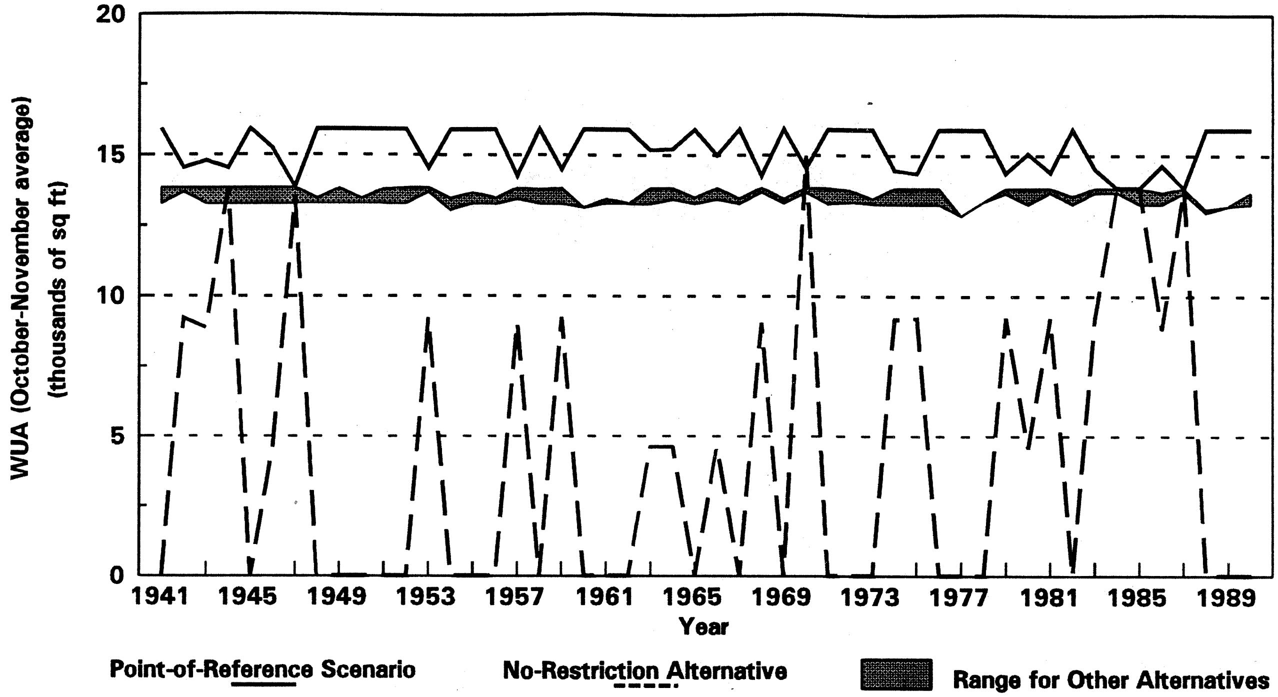


Table 3D-14.
Average Brown Trout Fry Habitat in Segment 2 of Lee Vining Creek by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 2
Average WUA (thousands of sq ft)	
Point–of–reference scenario	15,267
No restriction	4,326
6,372	13,324
6,377	13,322
6,383.5	13,481
6,390	13,559
6,410	13,654
No diversion	13,657
Percent Difference from Point–of–Reference Scenario	
No restriction	−71.7
6,372	−12.7
6,377	−12.7
6,383.5	−11.7
6,390	−11.2
6,410	−10.6
No diversion	−10.5

Figure 3D-11.
Simulated Brown Trout Juvenile Habitat in Segments 2, 5, and 6 of Lee Vining Creek for the Alternatives, 1940-1989 Hydrologic Period

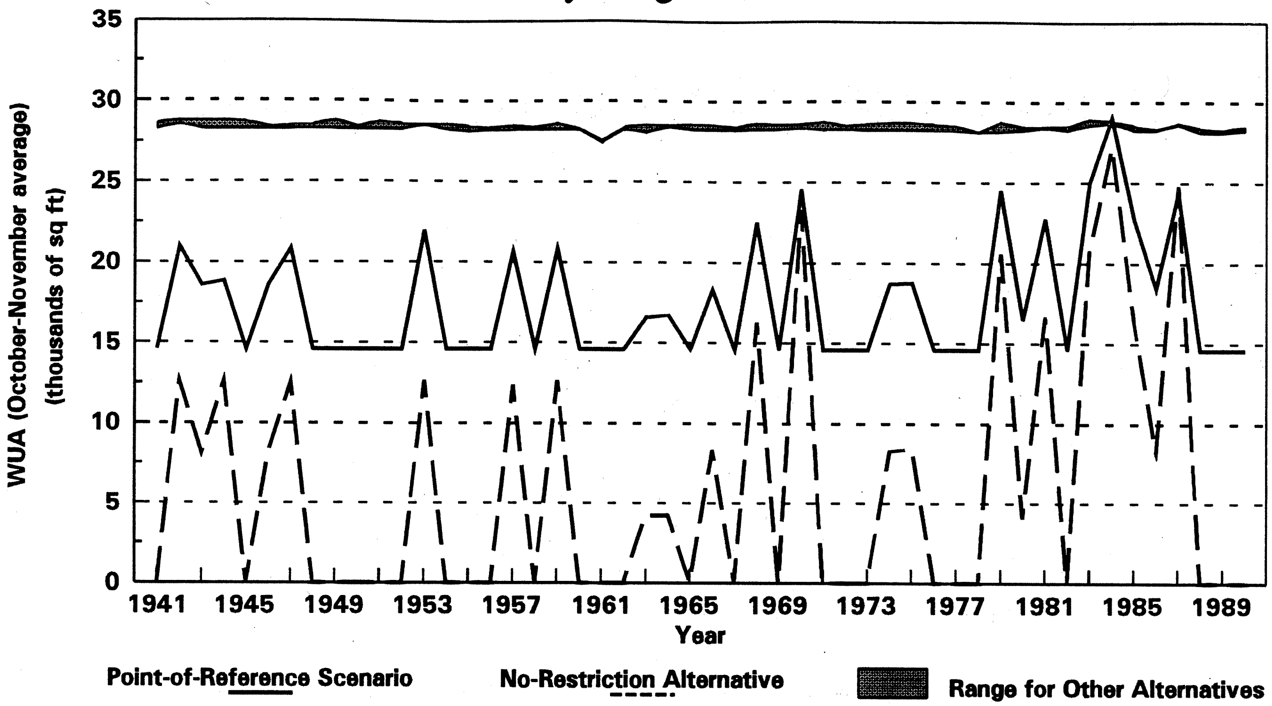


Table 3D-15.
Average Brown Trout Juvenile Habitat in Segments 2, 5, and 6 of Lee Vining Creek by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 2	Segment 5	Segment 6	Total
Average WUA (thousands of sq ft)				
Point–of–reference scenario	14,965	1,765	773	17,503
No restriction	4,604	928	537	6,069
6,372	22,222	3,756	2,270	28,248
6,377	22,191	3,808	2,301	28,300
6,383.5	22,166	3,896	2,337	28,399
6,390	22,122	3,945	2,366	28,433
6,410	21,918	4,111	2,488	28,517
No diversion	21,907	4,121	2,502	28,530
Percent Difference from Point–of–Reference Scenario				
No restriction	−69.2	−47.4	−30.5	−65.3
6,372	48.5	112.8	193.7	61.4
6,377	48.3	115.8	197.7	61.7
6,383.5	48.1	120.7	202.3	62.3
6,390	47.8	123.5	206.1	62.4
6,410	46.5	132.9	221.9	62.9
No diversion	46.4	133.5	223.7	63.0

Figure 3D-12.
Simulated Brown Trout Adult Habitat in Segments 2, 5, and 6 of Lee Vining Creek for the Alternatives, 1940-1989 Hydrologic Period

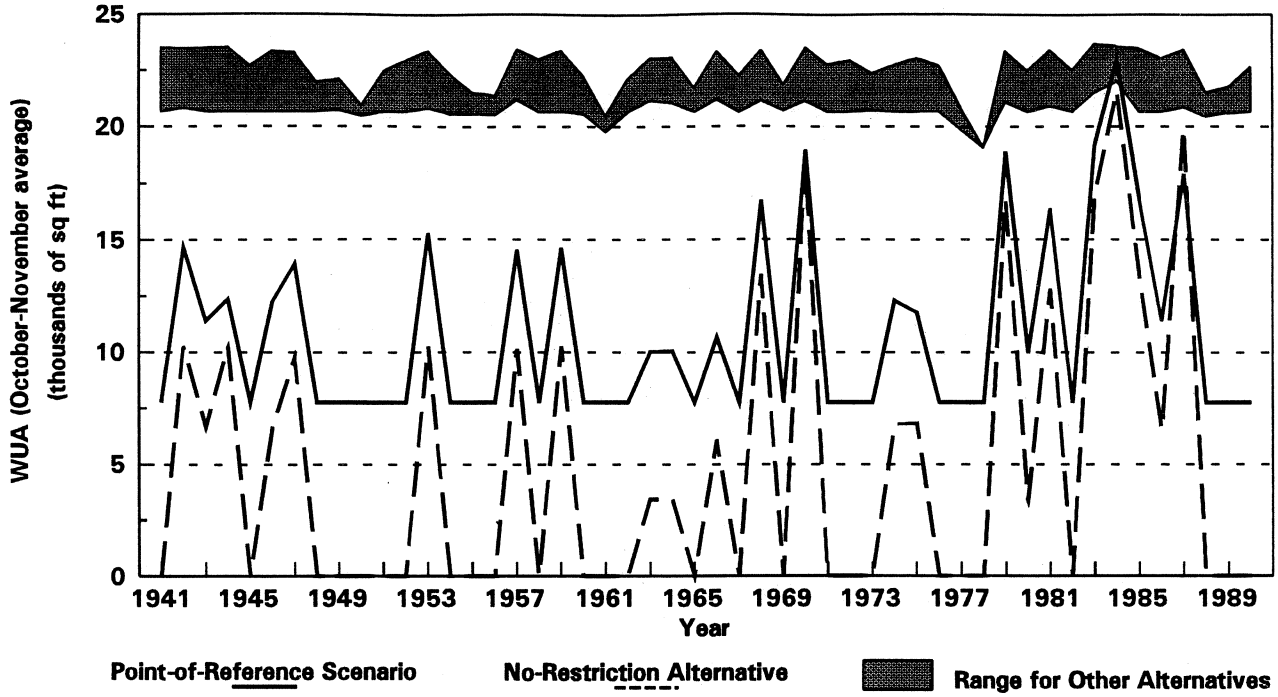


Table 3D-16.
Average Brown Trout Adult Habitat in Segments 2, 5, and 6 of Lee Vining Creek by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 2	Segment 5	Segment 6	Total
Average WUA (thousands of sq ft)				
Point–of–reference scenario	9,992	589	258	10,839
No restriction	4,343	364	170	4,877
6,372	18,538	1,419	737	20,694
6,377	18,709	1,444	744	20,897
6,383.5	18,967	1,485	753	21,205
6,390	19,198	1,509	762	21,469
6,410	20,106	1,596	801	22,503
No diversion	20,199	1,602	806	22,607
Percent Difference from Point–of–Reference Scenario				
No restriction	−56.5	−38.2	−34.1	−55.0
6,372	85.5	140.9	185.7	90.9
6,377	87.2	145.2	188.4	92.8
6,383.5	89.8	152.1	191.9	95.6
6,390	92.1	156.2	195.3	98.1
6,410	101.2	171.0	210.5	107.6
No diversion	102.2	172.0	212.4	108.6

Figure 3D-13.
Simulated Brown Trout Spawning Habitat in Segments 1-3 of Middle Owens River for the Alternatives, 1940-1989 Hydrologic Period

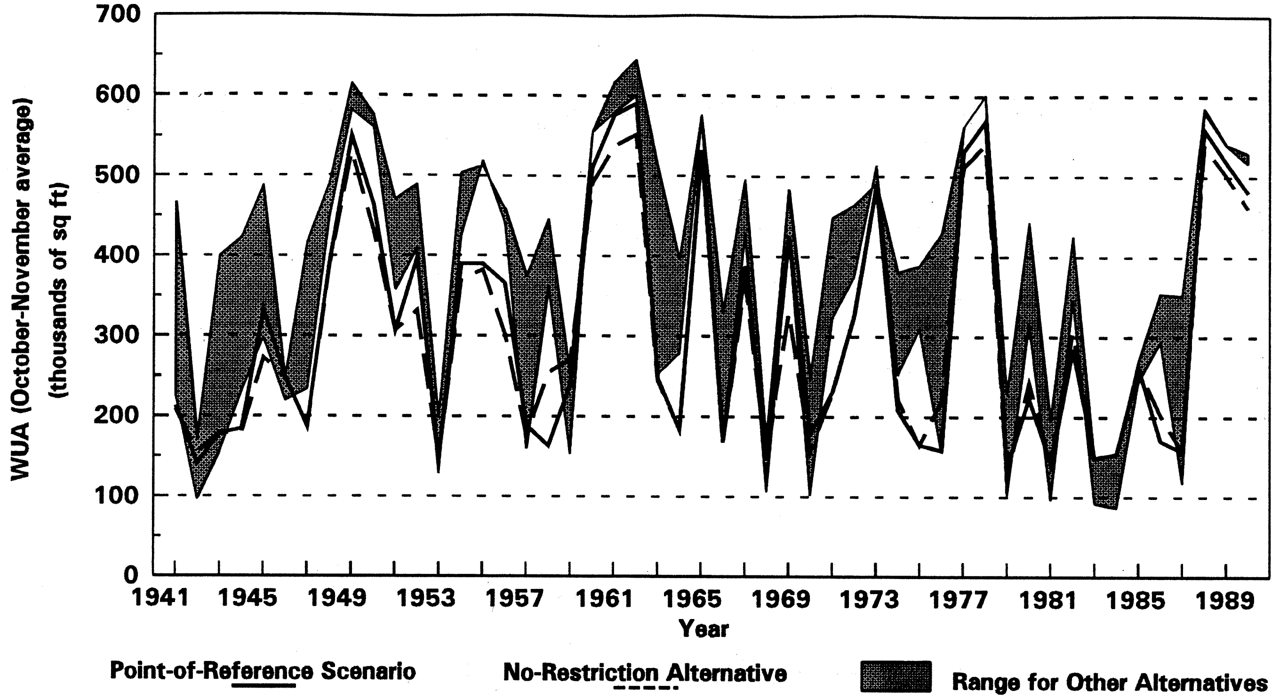


Table 3D-22.
Average Brown Trout Spawning Habitat in Segments 1-3 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 1	Segment 2	Segment 3	Total
Average WUA (thousands of sq ft)				
Point-of-reference scenario	28,803	141,265	136,727	306,795
No restriction	29,225	135,158	135,229	299,612
6,372	30,074	156,448	143,548	330,070
6,377	30,903	166,006	148,532	345,442
6,383.5	32,382	173,645	154,203	360,230
6,390	32,591	177,321	156,601	366,512
6,410	36,030	195,539	171,297	402,866
No diversion	37,800	204,953	177,749	420,502
Percent Difference from Point-of-Reference Scenario				
No restriction	1.5	−4.3	−1.1	−2.3
6,372	4.4	10.7	5.0	7.6
6,377	7.3	17.5	8.6	12.6
6,383.5	12.4	22.9	12.8	17.4
6,390	13.2	25.5	14.5	19.5
6,410	25.1	38.4	25.3	31.3
No diversion	31.2	45.1	30.0	37.1

Figure 3D-14.
Simulated Brown Trout Fry Habitat in Segments 1-3 of Middle Owens River for the Alternatives, 1940-1989 Hydrologic Period

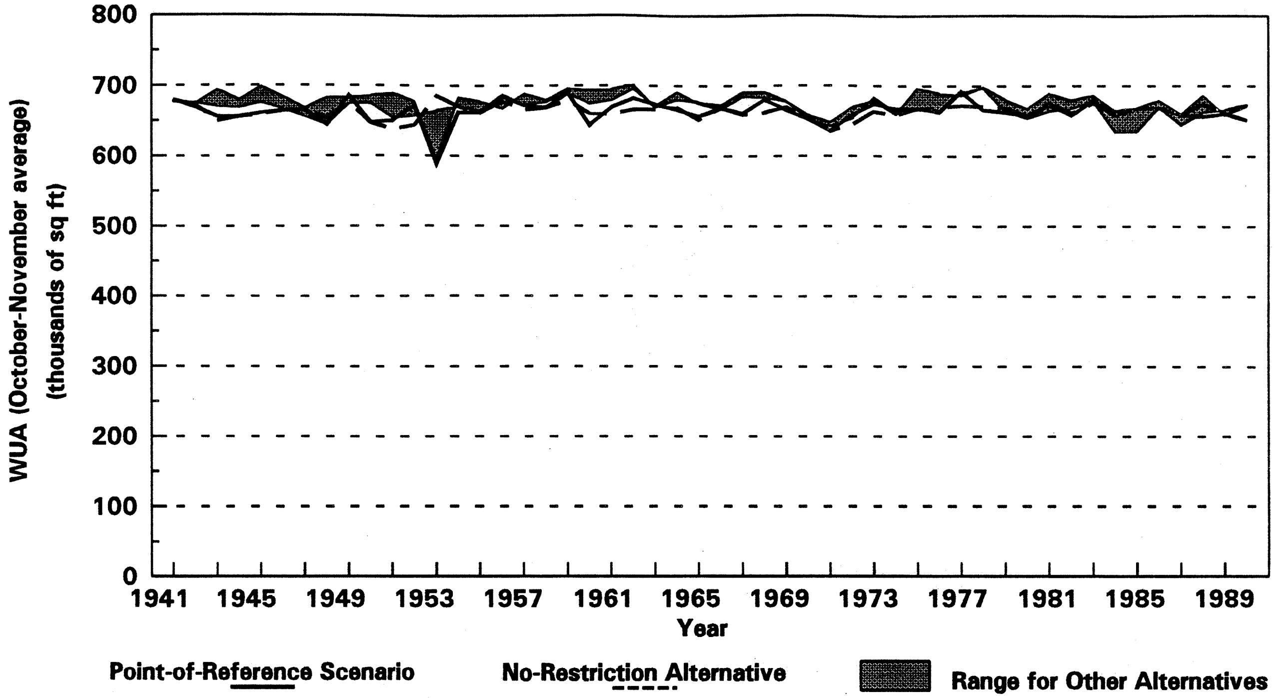


Table 3D-23.
Average Brown Trout Fry Habitat in Segments 1-3 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 1	Segment 2	Segment 3	Total
Average WUA (thousands of sq ft)				
Point–of–reference scenario	77,123	316,543	269,482	663,148
No restriction	77,989	313,501	271,342	662,833
6,372	75,935	322,466	269,895	668,296
6,377	75,786	326,723	270,254	672,763
6,383.5	74,871	331,400	268,172	674,444
6,390	74,412	333,414	268,072	675,898
6,410	74,394	336,627	266,129	677,150
No diversion	74,687	339,001	264,036	677,725
Percent Difference from Point–of–Reference Scenario				
No restriction	1.1	−1.0	0.7	−0.0
6,372	−1.5	1.9	0.2	0.8
6,377	−1.7	3.2	0.3	1.4
6,383.5	−2.9	4.7	−0.5	1.7
6,390	−3.5	5.3	−0.5	1.9
6,410	−3.5	6.3	−1.2	2.1
No diversion	−3.2	7.1	−2.0	2.2

Figure 3D-15.
Simulated Brown Trout Juvenile Habitat in Segments 1-3 of Middle Owens River for the Alternatives, 1940-1989 Hydrologic Period

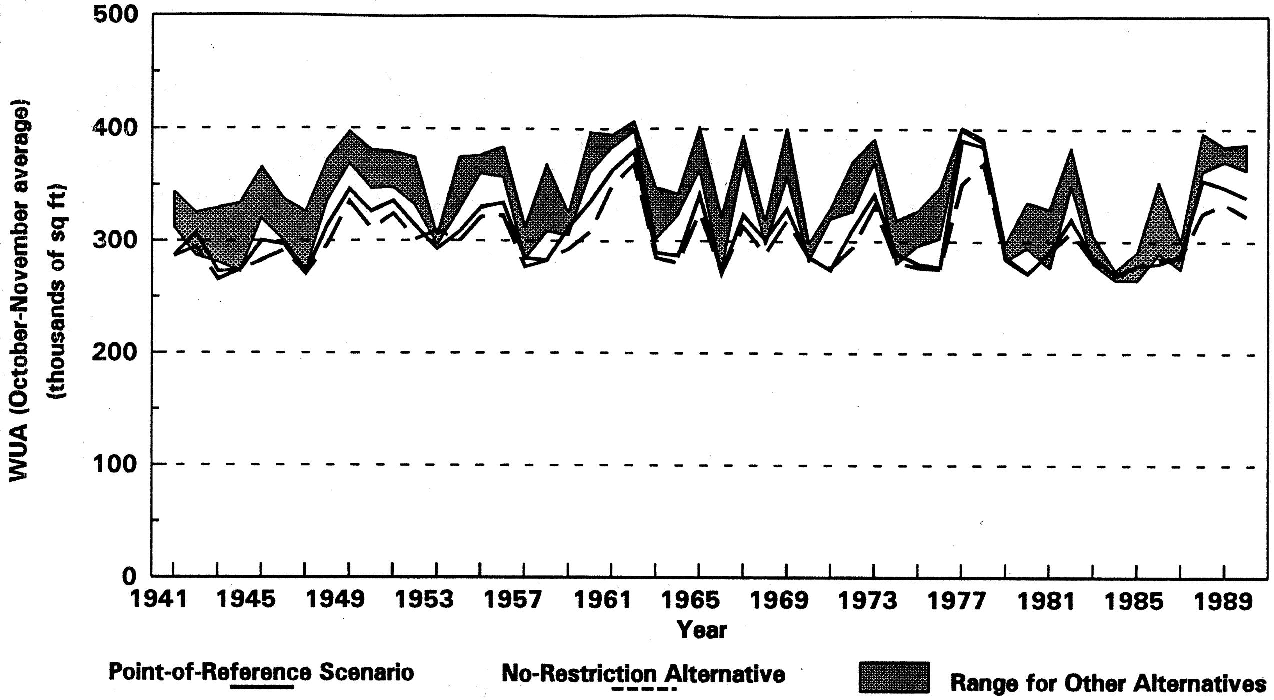


Table 3D-24.
Average Brown Trout Juvenile Habitat in Segments 1-3 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 1	Segment 2	Segment 3	Total
Average WUA (thousands of sq ft)				
Point–of–reference scenario	29,811	222,530	56,576	308,917
No restriction	30,121	214,710	55,545	300,376
6,372	29,080	233,849	58,673	321,602
6,377	28,818	240,647	59,685	329,150
6,383.5	28,693	247,201	60,463	336,357
6,390	28,610	250,966	61,140	340,716
6,410	28,328	258,629	62,354	349,311
No diversion	28,120	261,966	62,856	352,941
Percent Difference from Point–of–Reference Scenario				
No restriction	1.0	−3.5	−1.8	−2.8
6,372	−2.5	5.1	3.7	4.1
6,377	−3.3	8.1	5.5	6.5
6,383.5	−3.8	11.1	6.9	8.9
6,390	−4.0	12.8	8.1	10.3
6,410	−5.0	16.2	10.2	13.1
No diversion	−5.7	17.7	11.1	14.3

Figure 3D-16.
Simulated Brown Trout Adult Habitat in Segments 1-3 of Middle Owens River for the Alternatives, 1940-1989 Hydrologic Period

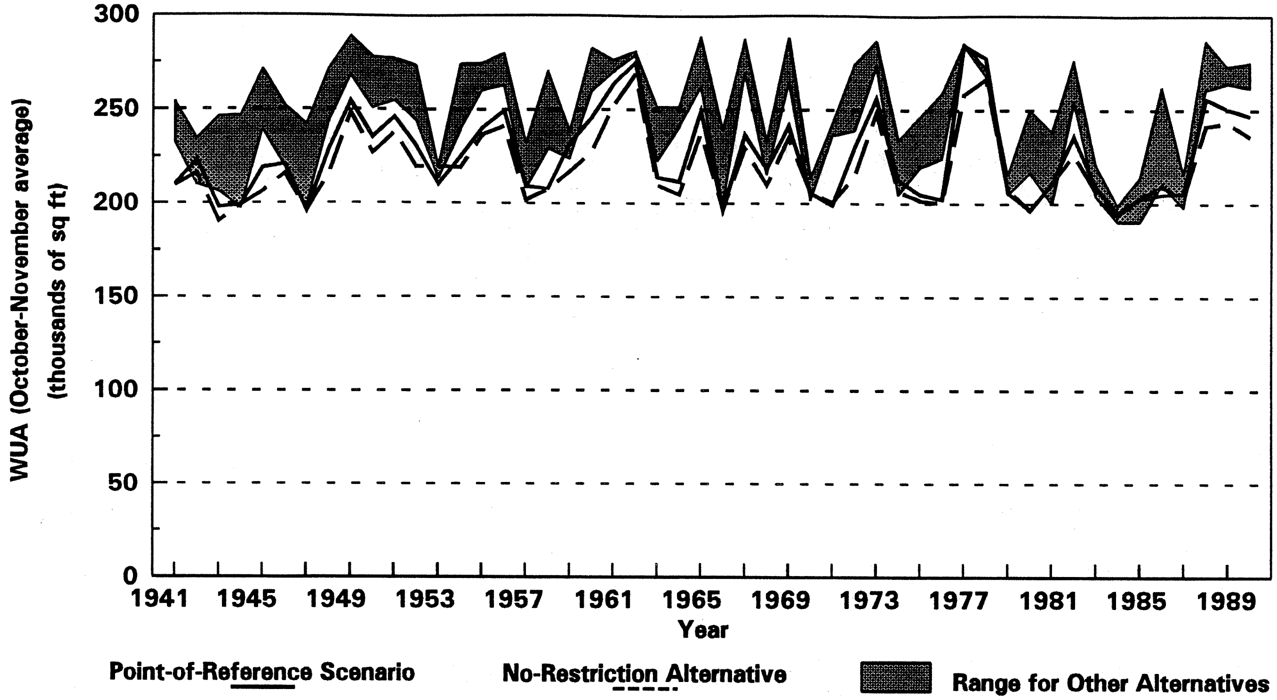


Table 3D-25.
Average Brown Trout Adult Habitat in Segments 1-3 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 1	Segment 2	Segment 3	Total
Average WUA (thousands of sq ft)				
Point-of-reference scenario	25,364	162,013	38,193	225,569
No restriction	26,184	155,237	38,067	219,487
6,372	23,898	171,364	38,550	233,812
6,377	23,200	177,373	38,714	239,288
6,383.5	22,667	183,379	38,839	244,885
6,390	22,389	187,123	38,968	248,480
6,410	21,630	193,751	39,237	254,617
No diversion	21,218	196,350	39,337	256,905
Percent Difference from Point-of-Reference Scenario				
No restriction	3.2	−4.2	−0.3	−2.7
6,372	−5.8	5.8	0.9	3.7
6,377	−8.5	9.5	1.4	6.1
6,383.5	−10.6	13.2	1.7	8.6
6,390	−11.7	15.5	2.0	10.2
6,410	−14.7	19.6	2.7	12.9
No diversion	−16.3	21.2	3.0	13.9

Figure 3D-17.
Simulated Aquatic Invertebrate Habitat in Segments 1-3 of Middle Owens River for the Alternatives, 1940-1989 Hydrologic Period

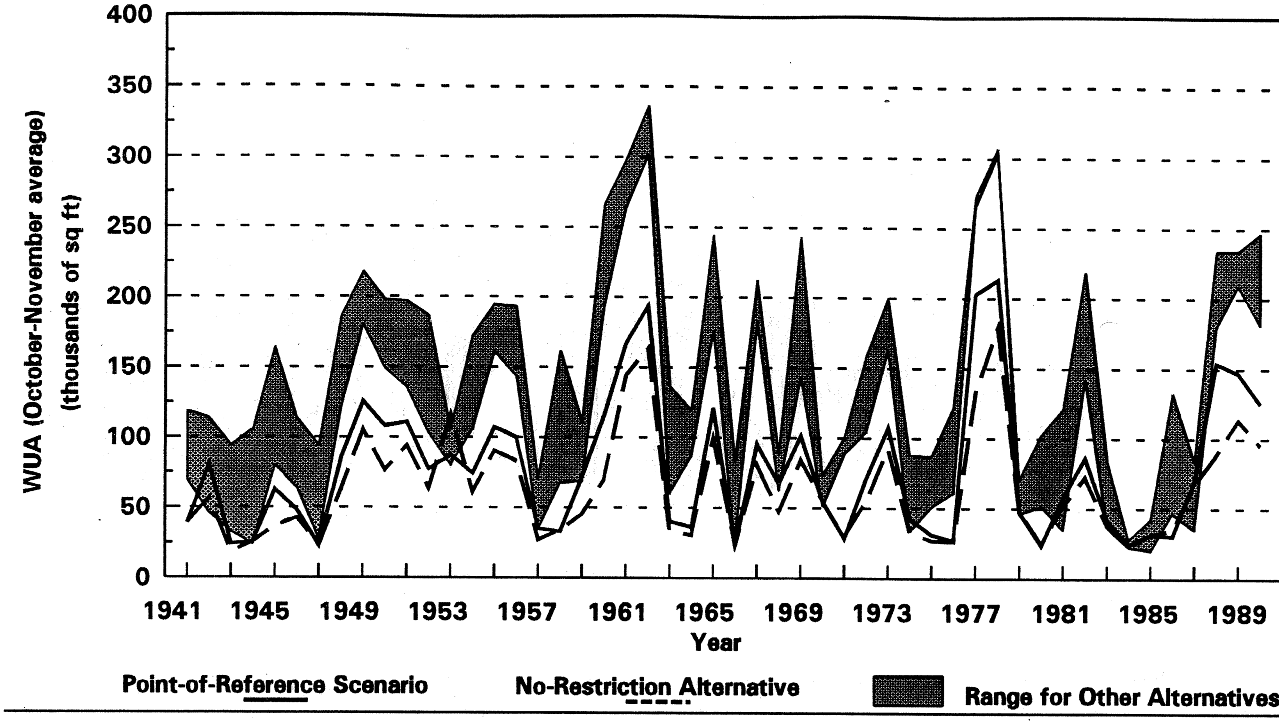


Table 3D-27.
Average Aquatic Invertebrate Habitat in Segments 1-3 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Aquatic Invertebrates
Average WUA (thousands of sq ft)	
Point–of–reference scenario	77,916
No restriction	63,964
6,372	106,274
6,377	119,374
6,383.5	129,682
6,390	135,395
6,410	149,720
No diversion	156,636
Percent Difference from Point–of–Reference Scenario	
No restriction	−17.9
6,372	36.4
6,377	53.2
6,383.5	66.4
6,390	73.8
6,410	92.2
No diversion	101.0

Figure 3D-18.
Simulated Largemouth Bass Spawning Habitat in Segment 4 of Middle Owens River for the Alternatives, 1940-1989 Hydrologic Period

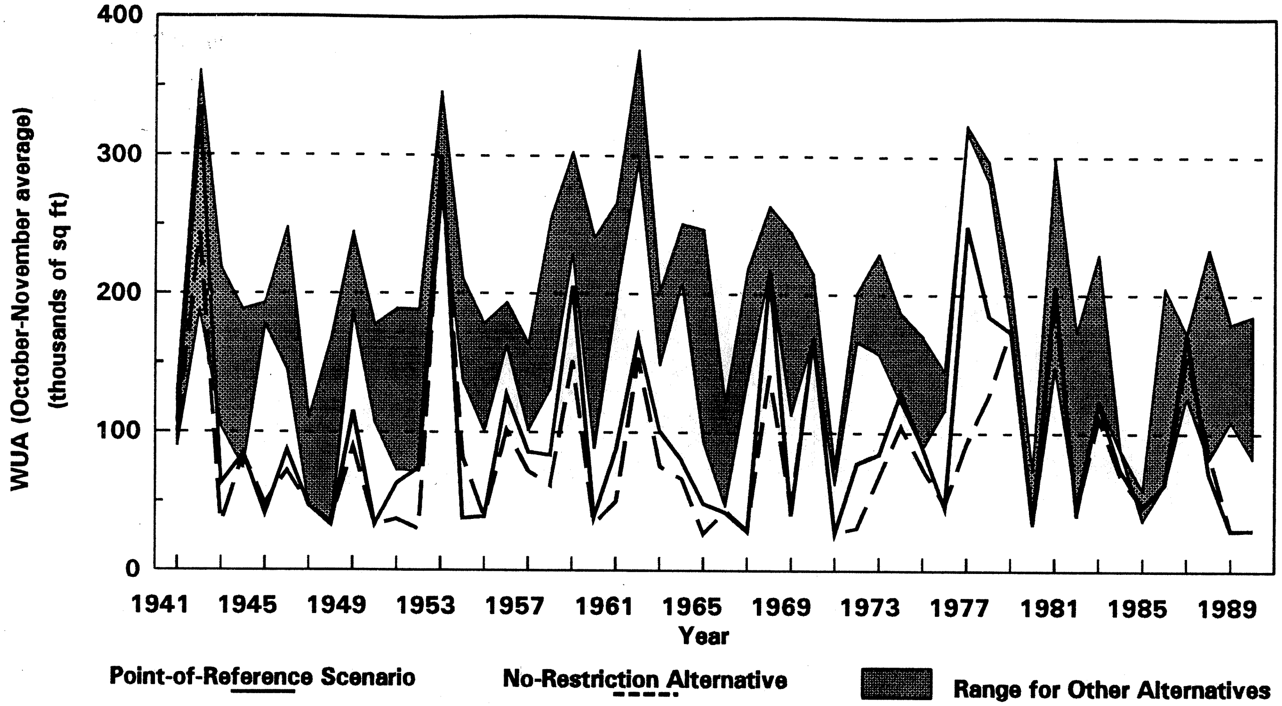


Table 3D-28.
Average Largemouth Bass Spawning Habitat in Segment 4 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 4
Average WUA (thousands of sq ft)	
Point-of-reference scenario	98,523
No restriction	81,948
6,372	131,508
6,377	150,706
6,383.5	170,180
6,390	174,837
6,410	193,006
No diversion	209,105
Percent Difference from Point-of-Reference Scenario	
No restriction	−16.8
6,372	33.5
6,377	53.0
6,383.5	72.7
6,390	77.5
6,410	95.9
No diversion	112.2

Figure 3D-19.
Simulated Largemouth Bass Fry Habitat in Segment 4 of Middle Owens River for the Alternatives, 1940-1989 Hydrologic Period

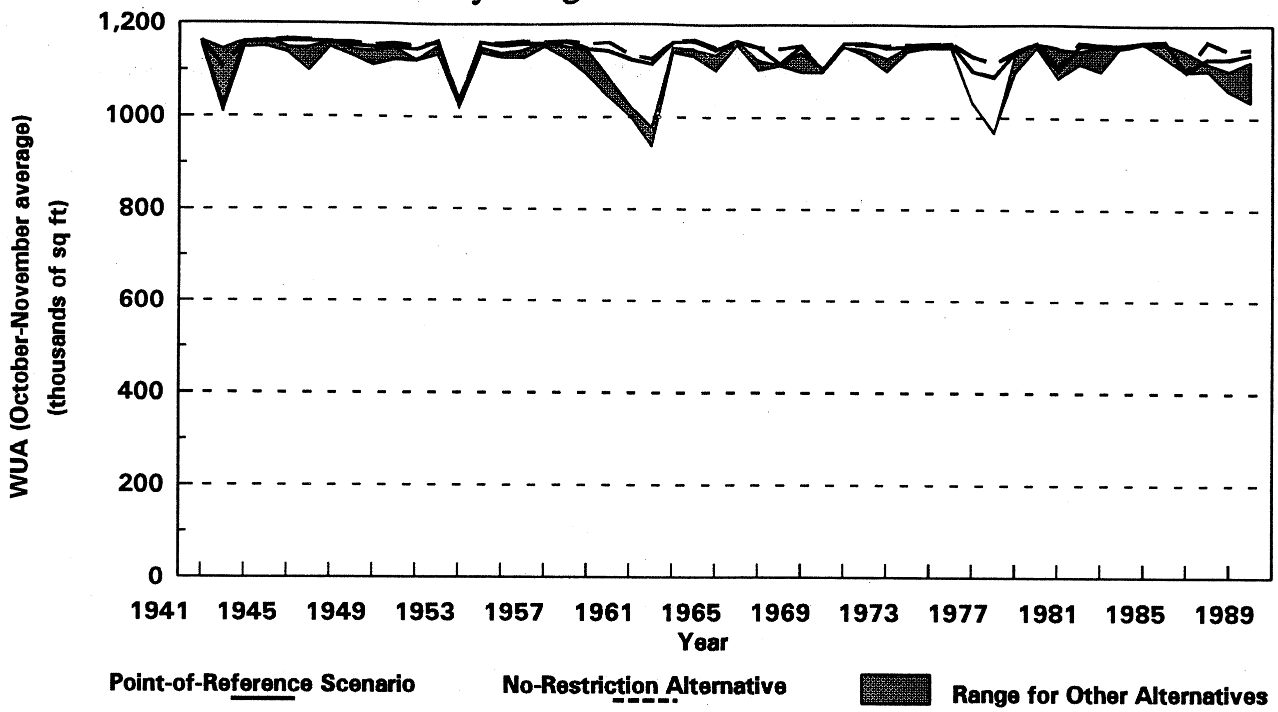


Table 3D-29.
Average Largemouth Bass Fry Habitat in Segment 4 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 4
Average WUA (thousands of sq ft)	
Point–of–reference scenario	1,141,521
No restriction	1,149,261
6,372	1,129,224
6,377	1,121,326
6,383.5	1,115,950
6,390	1,114,169
6,410	1,107,759
No diversion	1,105,790
Percent Difference from Point–of–Reference Scenario	
No restriction	0.7
6,372	−1.1
6,377	−1.8
6,383.5	−2.2
6,390	−2.4
6,410	−3.0
No diversion	−3.1

Figure 3D-20.
Simulated Largemouth Bass Juvenile Habitat in Segment 4 of Middle Owens River for the Alternatives, 1940-1989 Hydrologic Period

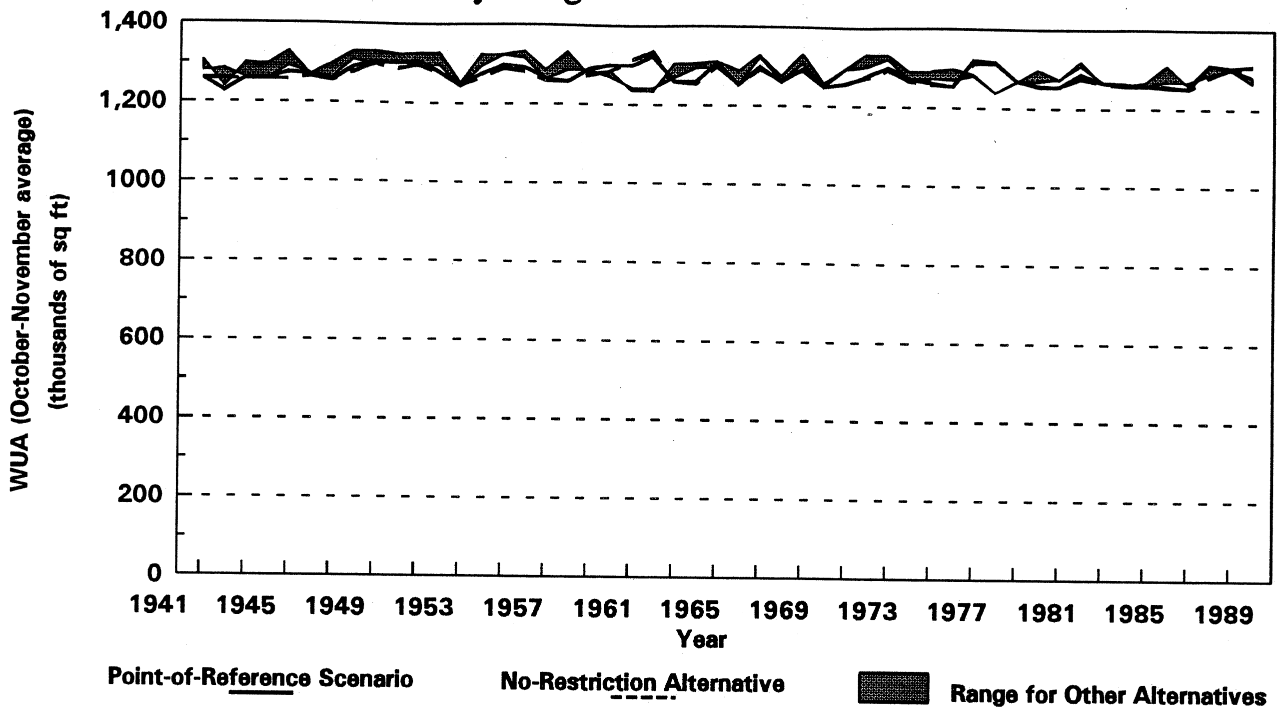


Table 3D-30.
Average Largemouth Bass Juvenile Habitat in Segment 4 of Middle Owens River by Alternative, 1940-1989 Hydrologic Period

Alternative or Condition	Segment 4
Average WUA (thousands of sq ft)	
Point-of-reference scenario	1,276,763
No restriction	1,272,927
6,372	1,279,568
6,377	1,281,481
6,383.5	1,284,333
6,390	1,286,845
6,410	1,291,412
No diversion	1,293,721
Percent Difference from Point-of-Reference Scenario	
No restriction	−0.3
6,372	0.2
6,377	0.4
6,383.5	0.6
6,390	0.8
6,410	1.1
No diversion	1.3

Figure 3D-21.
Simulated Largemouth Bass Adult Habitat in Segment 4 of Middle Owens River
for the Alternatives, 1940-1989 Hydrologic Period

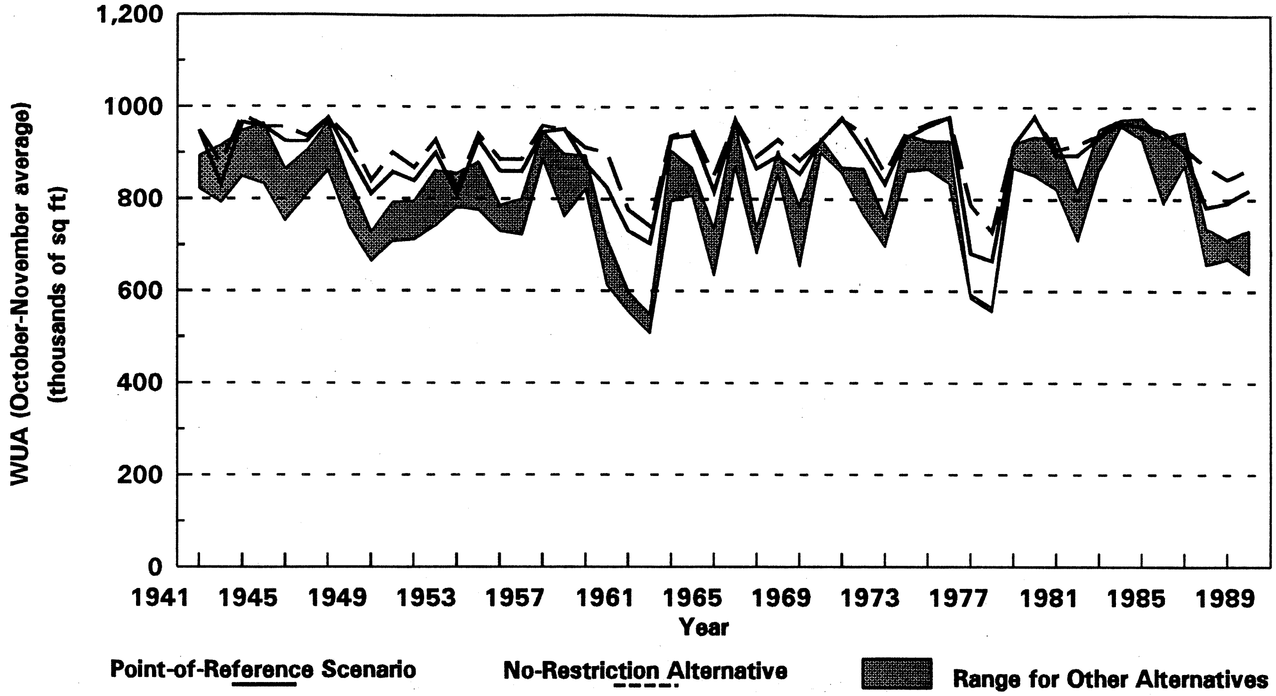
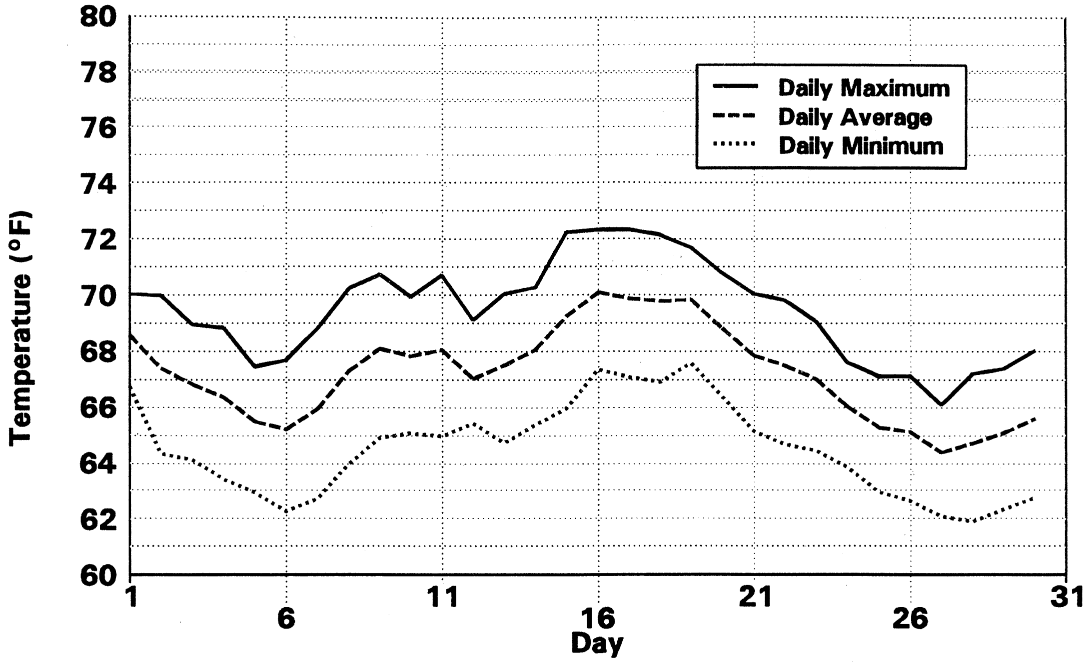


Table 3D-31.
Average Largemouth Bass Adult Habitat in Segment 4 of Middle Owens River
by Alternative, 1940-1989 Hydrologic Period

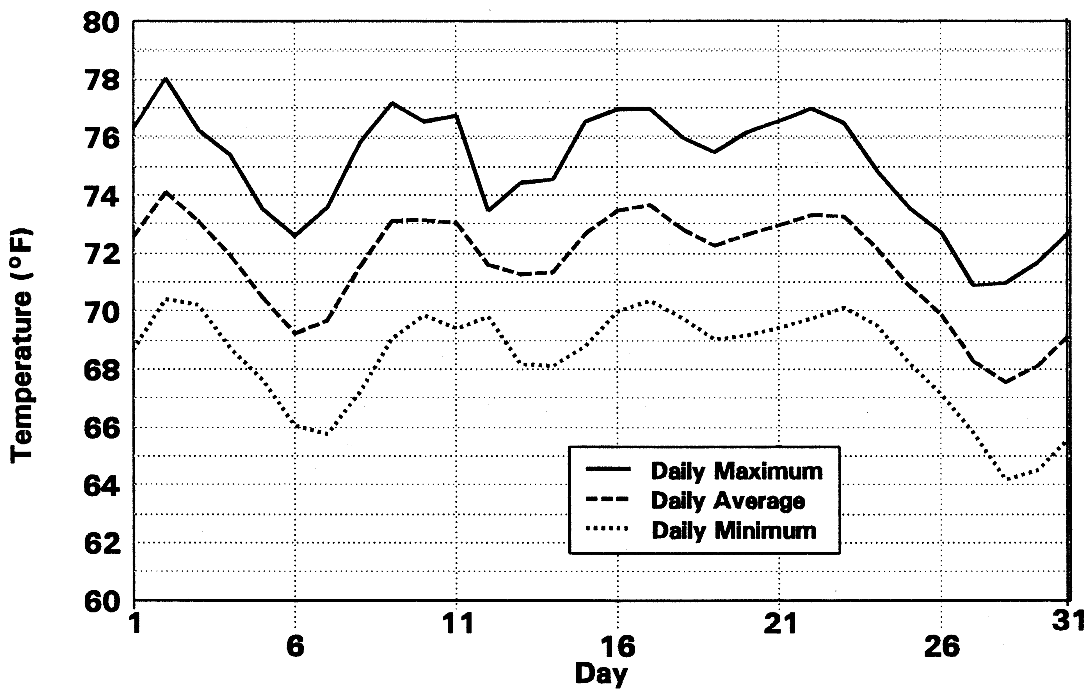
Alternative or Condition	Segment 4
Average WUA (thousands of sq ft)	
Point−of−reference scenario	884,956
No restriction	908,174
6,372	844,362
6,377	824,060
6,383.5	806,946
6,390	798,086
6,410	775,909
No diversion	765,564
Percent Difference from Point−of−Reference Scenario	
No restriction	2.6
6,372	−4.6
6,377	−6.9
6,383.5	−8.8
6,390	−9.8
6,410	−12.3
No diversion	−13.5

Figure 3D-22.
Simulated Daily Water Temperatures in Middle Owens River at Five Bridges Road during August at the Dry-Year Threshold for the No-Diversion Alternative



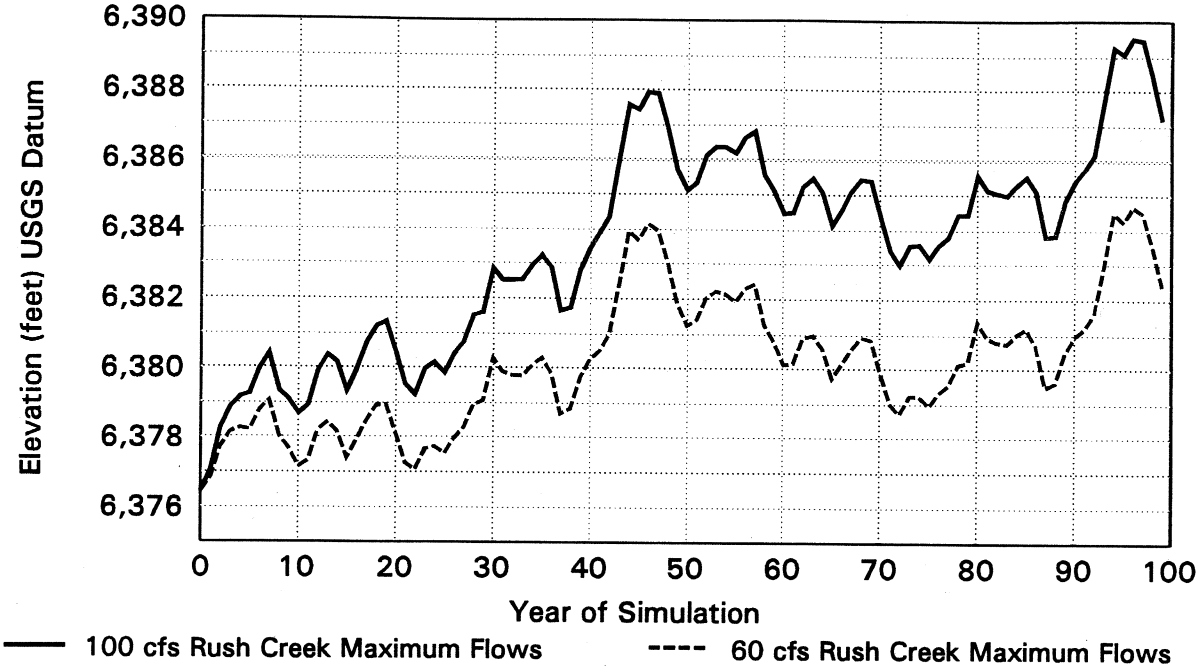
Note: The simulation is based on the 20% cumulative frequency flow of 153 cfs for Pleasant Valley Reservoir release.

Figure 3D-23.
Simulated Daily Water Temperatures in the Middle Owens River at River Mile 42 during August at the Dry-Year Threshold for the No-Diversion Alternative



Note: The simulation is based on the 20% cumulative frequency flow of 153 cfs for Pleasant Valley Reservoir release.

Figure 3D-24.
Simulated Lake Surface Elevation with Preliminary Minimum Monthly Streamflows from DFG Stream Evaluation Reports



Note: Simulation is based on 1940-1989 historical hydrology, beginning at the point-of-reference lake surface elevation.

Table 3D-34.
Preliminary Minimum Monthly Streamflows (cfs) for Lee Vining, Walker, Parker, and Rush Creeks from DFG Stream Evaluation Reports

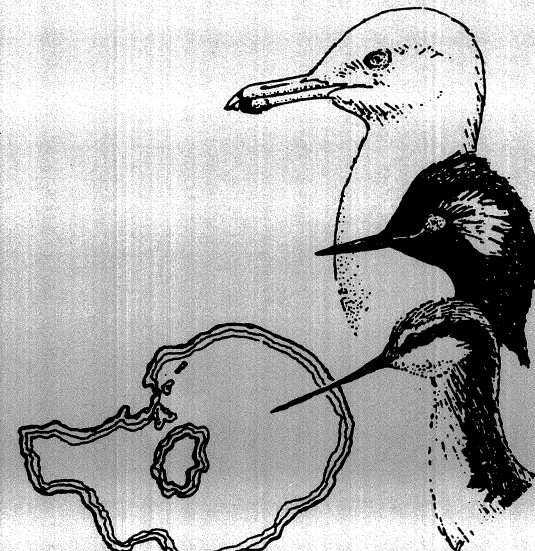
Month	Lee Vining Creek All Years	Walker Creek All Years	Parker Creek All Years	Rush Creek – 100 cfs			Rush Creek – 60 cfs		
				Dry Year	Normal Year	Wet Year	Dry Year	Normal Year	Wet Year
April	45	6	9	35	59	84	35	59	60
May	45	6	9	75	100	100	60	60	60
June	61 [a]	7 [b]	10.5 [c]	72	100	100	60	60	60
July	45	6	9	45	100	100	45	60	60
August	45	6	9	42	93	100	42	60	60
September	45	6	9	40	63	100	40	60	60
October	40	4.5	6	36	58	93	36	58	60
November	40	4.5	6	30	40	71	30	40	56
December	40	4.5	6	30	40	71	30	40	56
January	40	4.5	6	31	44	57	31	44	57
February	40	4.5	6	32	48	54	32	48	54
March	40	4.5	6	34	52	54	34	52	54

Notes:

[a] Dry and normal year flushing flow of 160 cfs for 3 days, wet year June flushing flow of 160 cfs for 30 days.
[b] Dry and normal year flushing flow of 15 cfs for 3 days, wet year June flushing flow of 15 cfs for 30 days.
[c] Dry and normal year flushing flow of 23 cfs for 3 days, wet year June flushing flow of 23 cfs for 30 days.

Sources: Beak Consultants (1991), Ebasco Environmental and Water Engineering and Technology (1991b and 1991c), Aquatic Systems Research (1992), and Gibbons pers. comm.

Chapter 3E. Environmental Setting, Impacts, and Mitigation Measures - Aquatic Productivity of Mono Lake



Chapter 3E. Environmental Setting, Impacts, and Mitigation Measures - Aquatic Productivity of Mono Lake

This chapter concerns biological production within the Mono Lake aquatic ecosystem. A glossary of technical terms is presented in Table 3E-1.

GENERAL DESCRIPTION OF THE MONO LAKE AQUATIC ECOSYSTEM

Introduction

Mono Lake has few species, which is typical of highly saline waters. The lake's most important primary producers (see glossary) are coccoid chlorophytes, coccoid cyanobacteria, and diatoms (Jellison and Melack 1992). In near-shore areas of the lake (littoral zone), where sufficient light reaches the lake bottom, benthic algae are important primary producers, and the Mono Lake alkali fly (*Ephydra hians*) is the dominant consumer species. Other insects, such as the deer fly (*Chrysops* sp.), the long-legged fly (*Hydrophorus plumbeus*), and the biting midge (*Cuciloides occidentalis*), also occupy the littoral zone, but these species are much less abundant than the alkali fly. In open water areas (pelagic zone), the Mono Lake brine shrimp (*Artemia monica*) feeds on phytoplankton and is the only significant consumer (NAS 1987).

The alkali fly and brine shrimp are the major food source of the lake's large bird populations (Winkler 1977). Therefore, this assessment of aquatic productivity in Mono Lake focuses on production of these species.

Sources of Information

The aquatic ecosystem of Mono Lake has been well studied during the past three decades, particularly since about 1980. Mason (1967) documented the physical, chemical, and biological characteristics (limnology) of Mono Lake in the mid-1960s, including brief descriptions of plankton community dynamics and production. Mason's account also provides information on abundance and life history of the brine shrimp but does not discuss the alkali fly. During the summer and early autumn of 1976, a group of scientists conducted a multidisciplinary study of Mono Lake (Winkler 1977) that examined phytoplankton production rates, nutrient limitation, salinity tolerance, and distribution; brine shrimp distribution, abundance, and salinity tolerance; and alkali fly distribution, life history, and salinity tolerance.

Since 1979, the limnology of Mono Lake has been studied intensively by a group of scientists under direction of John Melack of the University of California (UC), Santa Barbara and with funding from LADWP. Lenz (1982, 1984) studied the brine shrimp population from 1979 to 1981, sampling at 1-3 week intervals from late May through July or October, and occasionally in winter and spring. She used ten widely spaced stations in the lake, but occasionally sampled additional stations. Lenz provided detailed accounts of the life history dynamics, temporal and spatial patterns of abundance, and food-web relationships of the brine shrimp.

In 1982, the UC Santa Barbara group began a much broader sampling effort on Mono Lake, which is ongoing. Lakewide surveys are conducted biweekly from March to August and monthly during the remainder of the year, except that winter months were not sampled in 1982-1984 (Jellison et al. 1990). Brine shrimp, water temperature, and dissolved oxygen are sampled on every survey; light penetration, electrical conductivity (a measure of salinity), concentrations of ammonium and chlorophyll *a*, and photosynthetic uptake rates are measured once a month. Two, three, or ten stations are sampled, depending on the parameter. Dana et al. (1990a) presents a detailed description of the sampling and analysis methods.

The UC Santa Barbara group has produced a collection of documents that detail many features of ecosystem structure and function in Mono Lake (Melack 1983, 1985; Jellison et al. 1986, 1989a, 1989b, 1990; Lenz et al. 1986; Jellison 1987; Jellison and Melack 1988, 1991, 1992; Jellison, Dana, and Melack 1991; Jellison, Dana, Romero, and Melack 1991). The group has also provided detailed accounts of the life history, development, growth, grazing rates, production, and salinity tolerance of brine shrimp (Dana and Lenz 1986; Jellison 1987; Dana et al. 1988; Dana et al. 1990b, 1992; Jellison et al. 1989a, 1989b, 1992). Estimates of the numerical abundance of brine shrimp in Mono Lake are presented in Jellison (1987), Jellison et al. (1989a, 1989b, 1990), and Jellison, Dana, Romero, and Melack (1991).

LADWP has carried out limited surveys of phytoplankton and brine shrimp in Mono Lake since 1974 (Thun and Starrett 1982) and has studied factors affecting hatching success of overwintering brine shrimp cysts (Drinkwater and Crowe 1986, Thun and Starrett 1986).

Herbst (1986, 1988, 1990b) studied the alkali fly populations of Mono Lake and Abert Lake, Oregon, from April 1983 to September 1984 and provided detailed accounts of the natural history, physiological ecology, and community ecology of both populations. Herbst and Bradley (1990) used SCUBA at six stations in August and September 1989 to examine how alkali fly abundance in Mono Lake varied with depth. In 1991, Herbst (1992) conducted an intensive study of the Mono Lake alkali fly, sampling different substrates at six stations every 2 or 3 weeks from late April to mid-October and sampling pupae and adults floating on the water surface (drift) biweekly from May through October. He also carried out a series of microcosm experiments to test salinity effects on alkali fly productivity. Herbst (1990a, 1990b), Little et al. (1989), and Stine (1992) described the distribution of the alkali fly and the different types of alkali fly habitat in Mono Lake. Herbst (1992) and Little et al. (1989) provided estimates of numerical abundance of the alkali fly on different substrate types.

The following description of the aquatic ecosystem in Mono Lake is based on a review of the sources discussed above.

Important Features of the Aquatic Ecosystem

Because Mono Lake lies in a closed basin, its water surface elevation naturally fluctuates considerably, ranging from an estimated low of 6,404 feet in 1862 (Vorster 1985) to a high of 6,428 feet in 1919 before diversions began (Figure 1-7). Several physical features of the Mono Lake ecosystem directly related to lake level, such as lake area (Figure 3A-1), volume (Figure 3A-2), and salinity (Figures 3B-1), strongly affect productivity of the alkali fly and brine shrimp populations. Lake area and volume determine the extent of available habitat for the brine shrimp and alkali fly. The high salinity (currently about 90 grams per liter [g/l] of total dissolved solids) and alkalinity (currently 35 g/l of carbonate and bicarbonate ions) of Mono Lake have direct physiological effects on the alkali fly and brine shrimp and influence other important physical and biological features of their habitats, such as patterns of lake mixing, production and species composition of algae, and population levels of potential predators and competitors.

Salinity and alkalinity change seasonally relatively little, decreasing in the spring when large influxes of fresh water enter the lake, and increasing in the summer when water evaporates from the lake surface (Herbst 1986). Year-to-year salinity and alkalinity fluctuations are much greater because lake volume, which determines salt concentrations, varies more over several years than over one season (Figure 3B-1). Although many lakes support insect and brine shrimp populations at salinities higher than those found in Mono Lake, none are as alkaline (NAS 1987).

Salinity, freshwater inflows, and seasonal winds and temperature variations control the circulation patterns of Mono Lake. Large freshwater inflows may lead to periods of chemical stratification (meromixis) that are irregular in frequency and duration. (Meromixis occurs because freshwater is less dense than the lake's saline water. The fresher water layer, or "mixolimnion", floats on top of the more saline water, or "monimolimnion", and resists being mixed with it. The chemical gradient between the two water layers is termed the "chemocline".) A prolonged period of meromixis was observed by UC Santa Barbara researchers from 1983 to 1988 (Figure 3E-1) (Jellison, Dana, Romero, and Melack 1991), but this was the first recorded instance of meromixis in Mono Lake.

Regular seasonal temperature variations in Mono Lake (Figure 3E-2) each year produce one period of thermal stratification (in summer) and one period of lake mixing (in winter). (Thermal stratification occurs because warm water is less dense than cold water. The upper layer, or epilimnion, which is well mixed and generally euphotic from sunlight, is separated from the lower layer, or hypolimnion, by a temperature gradient known as the "thermocline".) When the lake is meromictic, seasonal mixing occurs in the mixolimnion only. When the lake is not meromictic, the entire water column mixes during the mixing season. A circulation pattern with one period of complete mixing and one period of thermal stratification each year is termed "monomixis". Both meromixis, which occurs irregularly, and seasonal thermal stratification, which is predictable, affect habitat conditions in the lake, particularly in the pelagic zone.

The alkali fly and brine shrimp are among the few species that can tolerate conditions of salinity and alkalinity as extreme as those of Mono Lake. Birds are the main predators of the fly and shrimp populations; no fish inhabit the lake. Neither the alkali fly nor brine shrimp has important competitors under present conditions in Mono Lake. Both populations are highly productive (Herbst 1988, Dana et al. 1992).

Because species diversity in Mono Lake is so low, food webs are relatively simple (Mason 1967, Lenz 1982, NAS 1987). The food webs of the pelagic and littoral zones in Mono Lake are largely independent: the alkali fly is the primary consumer of the littoral food web and the brine shrimp is the primary consumer of the pelagic food web. These populations have little effect on each other and therefore can be investigated independently.

Littoral Habitat Zone and Alkali Fly Life History

The littoral habitat zone is the narrow band at the periphery of Mono Lake where sufficient light reaches the bottom to allow growth of benthic algae. Light penetration is dependent on the water's transparency. In Mono Lake, the photosynthetically active zone varies seasonally from about 10 feet vertical depth in winter to almost 60 feet in summer (NAS 1987). Benthic algae have not been sampled quantitatively but have been observed throughout the euphotic littoral zone (Herbst 1990a). The alkali fly is by far the most abundant animal in benthic-littoral habitats.

The alkali fly has a typical insect life cycle, developing from egg to larva before pupating and metamorphosing into a reproducing adult insect (Figure 3E-3). Eggs are laid in mats of benthic algae and hatch in 1-3 days (Herbst 1986). The larvae undergo three distinct development phases (first, second, and third instars). Details of the life history of the alkali fly are given in Appendix I, "Natural History of the Mono Lake Alkali Fly".

Larvae develop in 4 weeks to more than 5 months, depending on temperature, salinity, and food quantity and quality. Laboratory studies show that growth and development at 20°C usually require 4 days for the first instars, 7 days for the second instars, and 36 days for the third instars (Herbst pers. comm.) (Figure 3E-4). Water temperatures at Mono Lake are often lower than 20°C, so larvae may actually develop more slowly. Dry weight increases from 0.02 mg for first instars to 2.85 mg for third instars. Emerging adults, however, weigh only 1.31 mg because pupation and metamorphosis consume much energy (Herbst 1990a).

When the adult Mono Lake alkali fly emerges from the puparium, it ascends to the water surface. It spends the remainder of its life along the lake shore grazing on algal and detrital food sources and reproducing (Herbst 1986). Normal adult life span is 10-14 days, but overwintering adults may survive for months. Food is essential to successful reproduction, and adult flies are capable of submerging to gain access to high quality benthic algae. Mating of the densely aggregated adults seems to be random with no precopulatory behavioral displays (Herbst 1986). The females submerge to deposit their eggs in the benthic algal mats, thus completing the life cycle.

Submerged alkali fly larvae have few predators or competitors. Numbers are limited mainly by food availability and physical habitat constraints. The larvae and pupae use clawed prolegs to cling to hard surfaces; most deaths probably occur when larvae and pupae are dislodged by waves and currents and swept to the middle of the lake or the shore, where they are exposed to starvation, predation, or parasitism (Herbst 1986).

The alkali fly population is the only important link between the bird populations and the substantial food resources of the littoral zone of Mono Lake. Birds prey chiefly on pupae and third instars, which are the most nutritious and accessible life stages, averaging 11.2 and 12.4 calories per individual, respectively, whereas adults contain only 7.2 calories (Herbst 1986). The third instars and pupae are easy prey for birds because they are continually dislodged by waves and either swept out to the middle of the lake by wind and currents, where they collect as drift, or washed ashore in windrows (Herbst 1986). Drift and windrows are important feeding areas for birds, although the distribution of the drift in the lake is patchy (Herbst 1992).

Eggs and young larvae are too small to attract birds. Adult flies congregated on the shore sometimes are eaten by birds (Herbst 1986).

Though birds feed heavily on dislodged larvae and pupae, the impact of predation on the alkali fly population is probably minor (Dana and Herbst 1977). The alkali fly population is regulated mainly by environmental constraints such as temperature, salinity, food, and availability of hard substrate for attachment and shelter.

Temperature Requirements

Temperature strongly affects temporal and spatial patterns of alkali fly abundance. In winter, low ambient temperatures slow metabolic processes of the alkali fly and increase development time and mortality. If temperatures drop below a certain threshold, development ceases (Herbst 1988).

Alkali fly in inactive, nonfeeding life stages, such as pupae and eggs, are especially sensitive to low temperatures. Pupae cannot develop or survive long at water temperatures at or below 5°C (Figure 3E-5) (Herbst 1988). Because winter temperatures in Mono Lake regularly drop below 5°C, pupae presumably suffer high winter mortalities. Eggs also perish in very cold water, but eggs generally are not exposed to severe cold because adult flies do not produce eggs during winter. Larvae can survive the near zero temperatures, however, and overwintering populations consist mainly of slowly growing larvae in the second and third instar phases (Herbst 1988, 1990a).

Increasing water temperatures in spring (March-April) cause rapid growth and development of the overwintering larvae and increase rates of development and survival of the pupae. As a result, the alkali fly population increases exponentially during spring (Figure 3E-6) (Herbst 1986). The population remains abundant through summer, until shorter days and declining temperatures in autumn cause adult flies to cease egg laying (Herbst 1988, Herbst pers. comm.). Pupal densities are highest in early autumn (August-September) probably because, as development rates slow down when temperatures cool, longer periods are spent in this lifestage. Population density drops rapidly in October when cooling temperatures cause high mortalities of all life stages.

The growing season available to the Mono Lake alkali fly is short due to the lake's high-altitude location and cool ambient temperature. However, the fly develops and reproduces rapidly, normally producing 1-3 generations in a season (Herbst 1988).

Water temperatures in Mono Lake also influence the spatial distribution of the alkali fly. Alkali fly larvae and pupae are most abundant in water less than 10 feet deep (Figure 3E-7), and generally are not found below the thermocline, where temperatures are too cold for growth and development (Herbst and Bradley 1990). Littoral temperatures exhibit greater extremes than pelagic temperatures. Selected littoral-benthic areas may freeze in winter and warm to 40°C in summer (Herbst 1986, Herbst pers. comm.). Areas that are sheltered from wind and waves, such as Black Point tufa shoals, have warm water temperatures and a long growing season.

Salinity and Alkalinity Requirements

The alkali fly is well adapted to high salinities, but the energy expended to regulate internal salinity reduces the energy available for growth and development (Herbst 1986). Increasing salinities have a marked negative effect on hatching success, larval growth and development rates, larval survivorship, pupation success, pupal weight, and successful adult emergence of the alkali fly (Bradley 1991). At salinities above 150 g/l (which would correspond to a lake surface elevation of about 6,350 feet), the detrimental effects of osmotic stress become insurmountable (Herbst 1986). Larvae in the early instar phases are particularly sensitive to high salinities (Herbst 1990b).

Increased salinity further harms the alkali fly by reducing food quantity and, possibly, quality (see "Food Requirements" below) (Herbst 1992). As food availability declines, alkali fly growth and development rates decrease correspondingly, resulting in smaller pupae and adults, higher mortality, and less reproductive success (Herbst 1986, 1992). Increased energy must be spent on foraging, so it becomes more difficult for the larvae to counter the physiological effects of high salinity (Herbst 1990b).

The total alkalinity of Mono Lake water is about 40% of the total dissolved solids. Alkalinity in Mono Lake is caused primarily by large concentrations of carbonate and bicarbonate ions (Herbst 1986).

Although lakes exist worldwide supporting insect communities at salinities much higher than those found at Mono Lake, none is as alkaline (NAS 1987). Most species have difficulty adapting to high salinity and high alkalinity, yet Mono Lake alkali fly larvae survive better in alkaline salt water than in nonalkaline water of the same salinity (Herbst 1986). The larvae have a special gland, the lime gland, for removing carbonate ions from the blood.

Benefits of high salinity and alkalinity in Mono Lake include less interspecies competition, less predatory pressure, and less parasitism and diseases, because very few organisms can tolerate such high levels.

Substrate Requirements

Storm-generated waves and undertows in Mono Lake sweep away alkali fly larvae and pupae not firmly attached to or sheltered by rocks. Once adrift in the lake or cast ashore, the larvae and pupae are vulnerable to predation, desiccation, and parasitism. Wave action also shifts benthic sands and silts, potentially burying larvae and pupae. The alkali fly, therefore, must have access to rocky surfaces or vegetation, especially during pupation, to which it can cling.

The benthic-littoral habitat consists of both soft and hard substrates (Table 3E-2, Figure 3E-8). Sands, gravels, and especially muds make up the soft substrates. Littoral sands and occasional gravels encircle Mono Lake above elevations of approximately 6,365 feet (Stine 1992). Tributary creeks are the main sources of littoral deposits of silts, sands, and gravels, but shoreline erosion also contributes some material. Soft substrates are of limited use to the alkali fly because they offer no shelter from waves and no firm attachment sites for larvae and pupae.

Hard substrates consist of mudstone, free-standing tufa, tufa-covered pumice blocks, bedrock, beachrock, and vegetation. Mudstone is the most extensive of the hard substrates in terms of total acreage (Table 3E-2), but is considered a poor habitat because its surface is relatively soft and does not contain small crevices for shelter (Herbst pers. comm.).

Tufa-covered pumice blocks are the second most extensive hard substrate. Tufa-covered blocks constitute a good habitat for the Mono Lake alkali fly because their coarse-textured surfaces provide a foothold and shelter for the larvae and pupae. Most pumice blocks are more than 3 feet across. They are found up to an elevation of 6,390 feet in concentrations mainly near the northern and western shorelines of the lake where they floated after volcanic ejection (Figure 3E-8) (Stine 1992).

Scattered solitary tufa towers, continuous tufa bulwarks, and other free-standing tufa types constitute a very small yet important hard substrate type. Free-standing tufa occurs primarily on the southern portion of the lake at elevations ranging from 6,300 to 6,400 feet, and consists of calcite and aragonite (two forms of calcium carbonate) and other mineral deposits precipitated where fresh spring water from lake bottom orifices mixed with saline lake water (Stine 1992). Some tufa originates from the mineral gaylussite (Herbst and Bradley 1990).

Tufa of all types is the most suitable alkali fly habitat. Field studies found third instar larvae and pupae in far greater densities on tufa than on any other hard or soft substrate (Little et al. 1989).

The alkali fly's preference for tufa has several likely explanations. Tufa provides superior attachment sites because its surface is rough and the towers have deep crevices that shelter larvae and pupae from waves and predation by birds (Little et al. 1989). Towers are elevated above the lake bottom, protecting flies in early life stages from burial or abrasion by shifting bottom sands (Little et al. 1989). Tufa also serves as a good growth site for diatoms and algae. Finally, the freshwater springs associated with tufa groves locally may lower salinities, thereby increasing algal abundance and larval growth and development (Little et al. 1989).

Bedrock of volcanic origin is found on the Negit islets, on several points on Paoha Island, and along earthquake faults on the lake floor (Stine 1992). It is the third most abundant type of hard substrate habitat in terms of total acreage and provides good habitat for the alkali fly. Due to the steepness of the bedrock areas, only a small portion of the bedrock in the lake is within the littoral zone (CORI 1988). Generally, bedrock is coated with tufa deposits.

Beachrock is a rare hard substrate consisting of tufa-cemented sands, gravels, and cobbles, found mainly on the deltas of Mill and Lee Vining Creeks and other smaller tributaries. Beachrock forms when freshwater containing calcium mixes with carbonate- rich lake water and the resulting calcium carbonate cements rocks and gravels together. Today, much of the beachrock habitat is covered with littoral sands. Although beachrock provides good habitat for the Mono Lake alkali fly, it is of relatively little importance because of its limited extent (Little et al. 1989).

Submerged vegetation also provides good attachment sites for larvae and pupae. Density of larvae and pupae in areas of submerged vegetation is about half of that on tufa (Herbst 1990a). Studies show that inundated terrestrial vegetation can persist for up to 10 years before deteriorating. At present, this type of habitat is not extensive because soils near much of the lake are highly alkaline.

Changes in the surface elevation of Mono Lake that affect the availability of different substrates in near-surface waters would affect alkali fly abundance. As noted earlier, alkali fly abundance is strongly influenced by depth, with most of the biomass found in water less than 10 feet deep (Figure 3E-7).

Food Requirements

Benthic algae and algal detritus on the lake bottom are the principal sources of food for alkali fly, but detrital bacteria and protozoa may also be important (NAS 1987). On preferred habitats where larval densities are high, such as tufa, grazing may significantly reduce algal biomass. The reduction in food supply may be partly responsible for an observed decline in the mean body sizes of pupae and adults from spring through autumn (Herbst 1986).

Physical factors affecting food availability are salinity, substrate type, nutrients, and depth. Biomass of benthic algae may decrease as salinity increases (Herbst 1986, 1992). Areas near freshwater inflows have high algal production. Soft substrates have good algal food supplies for young larvae, but algal mats on tufa seem to be the preferred food source. Biomass of benthic algae decreases with depth, so shallow waters have better food availability for the alkali fly.

Pelagic Habitat Zone and Brine Shrimp Life History

The brine shrimp is the only animal that presently inhabits the pelagic zone of Mono Lake. Several bird species feed heavily on adult brine shrimp. The brine shrimp population links the bird populations to the large food resources of the pelagic zone of Mono Lake.

Phytoplankton of the pelagic zone is the only known source of food for the brine shrimp population (NAS 1987). Bacteria may also be an important food, but the Mono Lake bacteria have not been studied. Phytoplankton abundance in Mono Lake is determined by temperature, light, nutrient supply, and the level of brine shrimp grazing (Jellison and Melack 1992). Nitrogen is the limiting nutrient in the pelagic zone and is available to algae primarily in the form of ammonium (NH_4+). During the winter mixing period, ammonium originates from the sediments and, if the lake is meromictic, from the monimolimnion. When the lake stratifies in early spring, the epilimnion is largely cut off from the sediments or monimolimnion. Increasing temperature and sunlight lead to rapid growth of algae. The growth of algae depletes the ammonium in the epilimnion and the high biomass reduces light penetration so that by April or May algal growth is limited (Jellison and Melack 1992).

Increasing temperature in spring leads to growth of the brine shrimp population and increased grazing (Jellison and Melack 1992). Although grazing on the phytoplankton increases during spring, it is never sufficient to suppress algal biomass because the brine shrimp population cannot grow fast enough to keep pace with the algae. Therefore, peak algal abundance is not affected by brine shrimp grazing. Shortly after algal biomass peaks, however, grazing pressure begins to reduce the algae, allowing penetration of light. This clearing phase occurs over a period of 2-3 weeks in late spring and is accompanied by an increase in epilimnetic ammonium concentrations because the brine shrimp excrete ammonium. By early summer, therefore, brine shrimp grazing, not light or ammonium supply, probably limits phytoplankton abundance. Algal biomass increases again in autumn as the brine shrimp population declines.

The spatial distribution of the brine shrimp population across Mono Lake varies seasonally, but it has been fairly consistent during the years for which it has been reported (1980, 1981, and 1990). In early autumn 1980 and 1981, brine shrimp were more abundant in the western sector of Mono Lake than in the eastern sector, but later in the autumn they were more abundant in the eastern sector or the abundances in the two sectors were not significantly different (Lenz et al. 1986). In summer and early autumn 1990, brine shrimp were fairly evenly distributed around Mono Lake, but in early spring and again in late autumn they were more abundant in the eastern sector of the lake (Jellison, Dana, Romero, and Melack 1991).

A commercial fishery on Mono Lake harvests and markets brine shrimp as fish food. The fishery has an annual take of about 500,000 pounds (dry weight) (Dana and Herbst 1977). Estimated peak total numbers of brine shrimp in Mono Lake in 1982 and 1983 were 12,683 billion and 14,458 billion, respectively (Conte et al. 1988). Assuming a dry weight per individual of 0.55 mg (mean dry weight of adults) (Jellison, Melack, Dana 1992), the fishery's annual harvest is only about 3% of peak abundance.

The life cycle of the Mono Lake brine shrimp is complex (Figure 3E-9). Development proceeds through seven naupliar (larval) instar phases, four juvenile instar phases, and one or more adult instar phases. Generally, two generations develop annually: a spring generation originating from overwintering cysts produced during the previous summer and autumn and a summer generation originating ovoviviparously (by live birth) from adults of the spring generation. In some years, a small third generation appears in autumn (Jellison et al. 1989a; Jellison, Dana, Romero, and Melack 1991).

Hatching of the spring generation occurs from January to May and the first adults usually appear in May (Lenz 1984). The females reproduce ovoviviparously for about a month, giving rise to the second generation. In June, adult females of the first generation begin producing cysts (diapause eggs), which settle to the lake bottom until the following year (Jellison et al. 1989b). The second generation matures in July and August and primarily reproduces oviparously (by producing eggs or cysts) (Lenz 1984). The development period, which is strongly affected by temperature, is about 2 days at 20°C for each of the preadult instar phases (Jellison et al. 1989a).

Salinity affects survival, growth, reproduction, and cyst hatching of Mono Lake brine shrimp (Starrett and Perry 1985, Dana and Lenz 1986). In bioassay experiments, increasing salinity had direct negative effects on the shrimp; these effects were continuous over the entire range of salinities tested (76-192 g/l total dissolved solids) (Starrett and Perry 1985, Dana and Lenz 1986). The effect of salinity on cyst hatching may be the most important effect with respect to survival of the Mono Lake population. The percentage of cysts hatched dropped steadily with increasing salinity and no cysts hatched at a salinity of 160 g/l (Dana et al. 1992).

Details of the life history of the brine shrimp and the effects of salinity, temperature, dissolved oxygen concentration, and food supply on brine shrimp production are given in Appendix J, "Natural History of the Mono Lake Brine Shrimp".

Habitat conditions for plankton in Mono Lake, including the brine shrimp, are different during monomictic and meromictic years. The following sections provide descriptions of the pelagic habitat and brine shrimp population under both types of mixing regimes.

Monomictic Mixing Regime

Before 1982, Mono Lake was probably monomictic in all years since the start of water diversions (Jellison and Melack 1991). The lake was again monomictic after 1988.

Under monomictic conditions, complete mixing (holomixis) of the lake occurs in November when water temperature is about 9°C (Jellison, Dana, Romero, and Melack 1991). Mixing reoxygenates the hypolimnion and resupplies nutrients to the epilimnion. The influx of nutrients, particularly ammonium nitrogen, leads to a winter-spring algal bloom. Despite the abundance of algae, brine shrimp numbers are low in the winter (Jellison, Dana, Romero, and Melack 1991).

Temperature of Mono lake is uniform at all depths through winter, but the lake begins stratifying in March (NAS 1987). Because of its high salinity, Mono Lake does not freeze. Once the lake becomes thermally stratified, mixing is restricted to upper depths, where light and temperature conditions are most favorable for growth of algae. High algal production, however, depletes nutrients in the epilimnion and primary production is nitrogen-limited in spring (Jellison, Dana, Romero, and Melack 1991).

Brine shrimp hatch from cysts in late winter and early spring. Cysts are produced in the previous year and require about 3 months of exposure to cold water temperatures for hatching (Dana 1981, Thun and Starrett 1986). The late-winter, early-spring hatch is the first of two or three generations of brine shrimp that are produced each year. The first generation has a superabundant food supply, but it matures slowly because of low water temperatures. Adults first appear in May.

Heavy grazing by the growing brine shrimp population leads to a sharp reduction in algal biomass in May and June. Grazing pressure limits algal abundance at this time; nitrogen requirements are probably satisfied by excretion of ammonium by the brine shrimp. Water transparency increases greatly as the algae are removed. Dissolved oxygen levels in summer are low (2-4 mg/l) because of high respiratory consumption by the shrimp and low production by algae. Dissolved oxygen concentrations lower than 2 mg/l may lead to increased mortality (Dana et al. 1992).

The second generation of brine shrimp is produced ovoviviparously in May and June and matures rapidly (about 3 weeks) because of warm water temperatures. Production of brine shrimp is limited at this time of year by the low biomass of algae, which causes lower fecundity of the first generation and reduced growth and survival of the second generation. Both generations begin producing cysts in summer, when the food supply is low. Settling of cysts and fecal pellets of the brine shrimp, and sinking of algae, removes nitrogen from the epilimnion and enriches the hypolimnion. Decomposition of these materials depletes dissolved oxygen, so the hypolimnion becomes anoxic and unfit for brine shrimp habitation.

In autumn, brine shrimp abundance declines. A third generation, whose origin (i.e., cysts or live births) is uncertain, appears in autumn in some years, but is never abundant (Jellison et al. 1989b; Jellison, Dana, Romero, and Melack 1991). The reason for the autumn decline in brine shrimp abundance is unknown, but predation by grebes, aging of adults, and reduction in birth and survival of nauplii have been suggested as possible causes (Cooper et al. 1984, Jellison et al. 1992, Lenz 1982). The decline causes reduced grazing pressure on the algae, so algal biomass increases and the algae become nitrogen-limited again. The principal source of nitrogen in autumn is ammonium nitrogen from the hypolimnion, which is entrained as thermal stratification weakens and the surface mixed layer deepens. The increase in ammonium leads to further increases in algal biomass.

Meromictic Mixing Regime

Mono Lake was meromictic from 1982 to November 1988. No evidence exists of meromixis at any other time in the lake's recent history (Jellison and Melack 1991).

Habitat conditions and brine shrimp population dynamics during meromictic years differ in several respects from those during monomictic years. Most important of all, autumn mixing reaches only to the chemocline; the monimolimnion is unaffected. Less nitrogen is transported upward to the epilimnion, and algal production is reduced (Jellison and Melack 1992).

If meromixis is not maintained by additional freshwater inflows, the mixolimnion becomes increasingly saline because of evaporative concentration, which weakens the chemical stratification (Figure 3E-1). At the same time, ammonium becomes increasingly concentrated in the monimolimnion (Figure 3E-10). As a result of these processes, the amount of nitrogen entrained by autumn mixing increases as meromixis weakens, and increased nitrogen results in increased primary production.

In Mono Lake, algal biomass in the mixed layer, measured as chlorophyll *a* concentration, increased each year during the meromictic period except 1986, when high freshwater inflow reinforced the chemical stratification (Figures 3E-11 and 3E-1) (Jellison and Melack 1992).

The reduction of primary production as a result of meromixis might be expected to lower productivity of brine shrimp (combined spring and summer generation peaks), but this was not generally borne out by the results of sampling. Brine shrimp abundance was relatively low during some of the meromictic years (e.g., 1983 and 1985), but it was also low in some of the monomictic years (e.g., 1980 and 1990) (Figure 3E-12) (Jellison, Dana, Romero, and Melack 1991). As noted previously, algal biomass peaks in spring before brine shrimp numbers and water temperatures are high enough for the brine shrimp population to exploit the algae effectively. Only a portion of annual primary production influences brine shrimp production, and effects of meromixis on algal production are not necessarily propagated up the food chain to the brine shrimp population.

The ratio of abundance of the spring generation of brine shrimp to that of the summer generation has varied considerably from year to year (Figure 3E-12). The cause of these variations is only partially understood. The size of the spring generation is probably determined by the number of cysts produced in the previous year, the hatching success of these cysts, and rates of development and survival of the nauplii and juveniles. For example, the spring generation in 1988 was unusually abundant (Figure 3E-12). Cyst production was high in 1987, oxygenation of the cysts was good, and spring food supply was relatively high. In contrast, the spring generation in 1989 was low, probably because survival of nauplii was low (Jellison et al. 1990). The breakdown of meromixis occurred late in 1988, so in early spring 1989 oxygen levels and temperatures were low and the concentration of toxic compounds, such as hydrogen sulfide or gaseous ammonia, may have been high (Jellison et al. 1990; Jellison, Dana, and Melack 1991). Hydrogen sulfide and ammonia often accumulate to high concentrations in anoxic water layers.

The size of the summer brine shrimp generation is inversely related to the size of the spring generation. When the spring generation is abundant, it quickly reduces the food supply. At low food levels, fecundity of the adult females and survival of the summer generation nauplii are reduced, leading to relatively low abundance of summer generation adults (Jellison, Dana, Romero, and Melack 1991). When the spring generation is small, however, food remains plentiful and abundance of the summer generation is high. Thus, the size of the summer generation was much larger in 1989 than in 1988 (Figure 3E-12).

The ratio of abundance of the spring and summer generations may have important ecological consequences. Cyst production is higher in years with a large summer generation, and high cyst production should result in a large spring generation in the following year (Figure 3E-12). A large summer generation, however, was not necessarily followed by a large spring generation, perhaps because other factors were more important (Jellison et al. 1989a). The relative sizes of the spring and summer generations could have important effects on eared grebe populations. The grebes feed heavily on Mono Lake brine shrimp, but do not arrive at the lake until late summer or early autumn (Winkler 1977).

PREDIVERSION CONDITIONS

Sources of Information

Observations of some early visitors to Mono Lake, such as J. R. Browne, Mark Twain, I. C. Russel, J. M. Aldrich, W. H. Brewer, and W. K. Fisher provide a general, though limited, picture of the biota and habitat conditions of the lake before LADWP began diverting water from the basin in 1941 (Fisher 1902, Mason 1967, Winkler 1977, Herbst and Bradley 1990). Mason's (1967) study, the earliest limnological account of Mono Lake, includes quantitative descriptions of the plankton. According to LADWP projections, salinity of Mono Lake, which was about 53 g/l in 1941, had increased to about 70 g/l by 1964 when Mason sampled the lake (Mason 1967, NAS 1987). The littoral zone community was not well studied until recently (Dana and Herbst 1977).

Prediversion habitat conditions of Mono Lake may be partially surmised by examining conditions in lakes with similar salinities. Wurtsbaugh and Berry (1990) described species composition of the plankton and abundance of a brine shrimp, *A. franciscana*, in the south arm of the Great Salt Lake in 1987, when salinity was similar to that in Mono Lake in 1941 (although alkalinity and pH were much lower).

Littoral Zone Productivity

Early visitors to Mono Lake noted the presence of many alkali flies (Fisher 1902, Herbst and Bradley 1990). Fisher's (1902) account includes a photograph showing a dense shoreline concentration of alkali flies that, according to Fisher, surrounded the lake. Wallis McPherson (pers. comm.), a resident of Mono Basin since 1917, has stated that the flies were much more abundant during the prediversion period than today. Historical accounts also described windrows of pupae and larvae that may have been larger than those presently found at Mono Lake (Herbst 1990b). Windrowed and nearshore pupae were traditionally harvested by Kuzedika Paiute Indians in early summer and late autumn and constituted an important part of their diet.

Salinities in the prediversion period were lower than today, and productivity of the alkali fly may have been higher. Although the alkali fly is well adapted to high salinities, the additional metabolic energy required to regulate these high salt levels is great and reduces the total energy available for growth and development, thus reducing productivity (Herbst 1986). On the other hand, productivity of the alkali fly might have been lower when the lake was less saline because interspecific competition, predatory pressure, parasitism, and diseases increase at lower salinities. Abert Lake in Oregon, which has a salinity of about 30 g/l, has about twice as many benthic macroinvertebrate species as Mono Lake (Herbst 1986). During 1983-1984, when salt concentrations were reduced 5-10 g/l by large freshwater inflows in both Mono Lake and Abert Lake, species diversity increased in both lakes (Herbst 1986). Despite the increase in species diversity at lower salinities, however, prediversion salinities at Mono Lake were probably too high for potential predators and competitors to survive well enough to affect productivity of the alkali fly (Herbst pers. comm.).

The surface area of Mono Lake was greater during the prediversion period because of the higher lake levels, but suitable habitat for the alkali fly was not necessarily more prevalent. Stine (1987, 1992) estimates most of the hard substrates were well below depths inhabited by the alkali fly during the prediversion period (Table 3E-2, Figures 3E-7 and 3E-8). However, the relative value to alkali fly productivity of hard substrate versus soft substrate may have been less under prediversion conditions than under current conditions. Furthermore, a leafy algae may have been present (McPherson pers. comm.), or submerged vegetation that was drowned during a rise in lake level in the late 19th century or in 1938 after a short lowstand period may have persisted until 1941 to provide additional suitable substrate during the prediversion period.

Pelagic Zone Productivity

Early accounts of Mono Lake suggest that brine shrimp were abundant in the lake long before LADWP began diverting water from the basin, but quantitative information is lacking (Mason 1967, Winkler 1977). As described in Appendix J, increasing salinity has negative effects on survival, growth, and reproduction of brine shrimp, which would tend to reduce brine shrimp productivity. Therefore, brine shrimp productivity was probably higher under prediversion conditions than under current conditions. However, as noted above for the alkali fly, the postdiversion increases in salinity may have reduced levels of predation and competition.

Nothing is known about what species other than brine shrimp inhabited the pelagic zone in prediversion Mono Lake. Though brine shrimp are the only zooplankton in the lake at present, Mason (1967) found two planktonic rotifers (*Brachionus plicatilus* and *Hexarthra jenkinae*) between 1959 and 1963, when salinity was 70 g/l or lower. The rotifers were abundant only in December 1959, when few brine shrimp were present; however, at the lower salinities of the prediversion period, rotifers, as well as other potential competitors, also may have been abundant in summer.

Pelagic zone predators also may have been present in prediversion Mono Lake. Wurtsbaugh and Berry (1990) attributed a decline in abundance of *A. franciscana* in the south arm of the Great Salt Lake to predation by the insect *Trichocorixa verticalis* that invaded the lake between 1963 and 1987 when salinity dropped from 250 g/l to 50 g/l. Potential competitors of the zooplankton also invaded the lake when the salinity dropped. *T. verticalis* cannot live in highly alkaline water and thus would not have been present in Mono Lake, but other predators would be able to live under prediversion conditions (Dana et al. 1992).

The volume and surface area of Mono Lake were greater under prediversion conditions than at present, so more brine shrimp habitat would have been available (NAS 1987). However, lake level changes could affect habitat quality and thus brine shrimp production. Hurlbert (1991), for instance, observing that shallow lakes tend to be more productive than deep lakes (because more of the water receives sunlight and is close to sediments), showed that, for a period after water diversions began, total production may have increased in Mono Lake as lake elevation dropped. Total production would have increased if gains in productivity caused by reduced depth outweighed losses resulting from smaller habitat area.

ENVIRONMENTAL SETTING

Sources of Information

Conditions in the pelagic zone of Mono Lake in 1989 are described in Jellison et al. (1990). Little information is available on the littoral zone in 1989, but descriptions are given in Little et al. (1989) and Herbst (1992) of the littoral zone in 1988 and 1991, respectively.

Estimates of productivity of the Mono Lake brine shrimp population in 1989 are not available, but Jellison et al. (1990) provided graphs of numerical densities in 1989. The graphs show density of brine shrimp adults, juveniles, and nauplii in each month of 1989. Similar graphs for 1988 and 1990 are presented in Jellison et al. (1989b) and Jellison, Dana, Romero, and Melack (1991).

No estimates of productivity or abundance of the Mono Lake alkali fly population in 1989 are available. However, Little et al. (1989) and Herbst (1992) provided information on mean densities of alkali fly larvae and pupae on different substrate types in 1988 and 1991.

Little et al. (1989) sampled the substrates in April, June, and August 1988 at 15 near-shore stations spaced 3 km apart. All stations were in water 30 cm deep. In June and August, the authors also measured surface areas of the different substrate types at each station along 50-m transects. The transects included areas between water depths of 20 and 40 cm. Little et al. (1989) presented tables of mean density of the three larval instars and pupae on each substrate type in June and August. Estimates of mean densities on all hard substrates and all soft substrates can be derived from estimates of the mean densities and relative surface areas of the individual substrate types.

Herbst (1992) sampled the hard and soft substrates every 2-3 weeks from late April to mid-October 1991 at six stations. The stations were widely distributed around Mono Lake, but were located in areas where tufa was abundant. Sampling depths were between 25 and 50 cm. Herbst (1992) provided graphs of mean densities of the three larval instars and pupae on each sampling date.

Lake Condition

The large range in annual precipitation and changes in water diversion schedules during recent years at Mono Lake has resulted in highly variable habitat conditions in the lake. Most important of all, high freshwater inflows in 1982 and 1983 resulted in chemical stratification, which was sustained, with the help of additional inflows in 1986, until November 1988 (Figure 3E-1) (Jellison and Melack 1991). Before and after this period of meromixis, the lake was monomictic, mixing completely during the winter. Salinity in August 1989 was about 89 g/l (Figure 3B-1), and total alkalinity was about 34 g/l.

The breakdown of chemical stratification in November 1988 produced highly unusual conditions in Mono Lake in 1989, the point of reference, which may have affected productivity of the brine shrimp and alkali fly populations. The hatching brine shrimp suffered total mortality in early 1989 as a result of the low water temperatures and low oxygen concentrations caused by upwelling monimolimnetic water (Jellison, Dana, Romero, and Melack 1991). On the other hand, the upwelling water was rich in ammonium, so nutrient and algae concentrations in 1989 were high (Figures 3E-10 and 3E-11). There is no evidence that the alkali fly population experienced unusually high mortality in 1989, but mortality of the alkali fly may have escaped detection because the population was not sampled in early 1989.

Littoral Zone Productivity

The surface area of the benthic-littoral zone of Mono Lake has declined with the reduction in lake surface area, but the amount of high-quality hard substrate habitat for the alkali fly has probably increased because the fall in lake level has brought more tufa and pumice into the near-surface water layer (Figure 3E-8). In 1989, when the lake level was about 6,376 feet, there was about 523 acres of hard substrate in the top 10 feet of lake (Table 3E-2). Although this area is large compared to that at most other lake levels, the hard substrate area would be even larger if the lake level were 5 or 10 feet higher. As has been described, however, available substrate is only one of a number of factors potentially affecting alkali fly production that may be affected by lake level changes. A complete analysis of the effect of lake surface elevation on amount of usable substrate is presented in Appendix L, "Alkali Fly Productivity Model", and in the impact section of this chapter.

Estimates of alkali fly productivity are not available for the August 1989 point of reference, but densities can be estimated for August 1988 and August 1991 from information provided in Little et al. (1989) and Herbst (1992) (Table 3E-3). Mono Lake was meromictic in 1988 and was monomictic in 1991. Estimates of densities of pupae in August were similar in the two studies. In both years, the pupae occupied hard substrates almost exclusively.

Estimates of larval density were consistently higher in the 1991 study than in the 1988 study (Table 3E-3). The differences in estimates between the studies may reflect real differences in densities of alkali fly between 1988 and 1991 or may reflect differences in how the two studies were conducted. For instance, the density estimates for soft substrates, which were higher by an order of magnitude or more in the 1991 study, in part reflect differences in sampling. As noted above, Herbst (1992) sampled soft substrates only in areas where tufa was abundant, whereas Little et al. (1989) sampled soft substrates without regard to the distribution of tufa. Little et al. (1989) found that densities on soft substrates were significantly higher at stations in tufa-rich areas than at stations far removed from tufa.

Pelagic Zone Productivity

Density of Mono Lake brine shrimp adults was about 70,000 individuals per square meter in August 1989 and reached more than 90,000 per square meter in September 1989 (Figure 3E-13). These densities were the highest that the population had achieved since 1982 (Figure 3E-12). On the other hand, densities in the spring of 1989 were unusually low (Figure 3E-12). Densities of nauplii and juveniles also were very low in the spring (Figure 3E-13). Mixing of monimolimnetic water produced unusually low water temperatures and low oxygen concentrations in spring 1989 that caused high mortality of brine shrimp nauplii (Jellison et al. 1990).

The low abundances of brine shrimp in spring and the high abundances in autumn resulted from the breakdown of meromixis at the end of 1988 (Jellison, Dana, Romero, and Melack 1991). High autumn abundances resulted from good feeding conditions because the deep mixing replenished ammonium in the epilimnion (Figure 3E-10), stimulating growth of algae, and because grazing pressure on the algae was low during spring and early summer.

Because conditions in 1989 were so unusual, abundances of brine shrimp in 1989 were compared with abundances in 1988, a meromictic year, and 1990, a monomictic year (Figures 3E-13, 3E-14, and 3E-15). In August 1988, density of adults was about 35,000 individuals per square meter, but in June 1988 the density reached over 70,000 per square meter. In August 1990, density was between 30,000 and 35,000 per square meter, which was the peak abundance for the year.

The breakdown of meromixis in Mono Lake in the autumn of 1988 produced unusual conditions in 1989, leading to very low abundances of brine shrimp in spring and very high abundances in autumn. For the year as a whole, however, abundance of the brine shrimp population in 1989 appears not to have differed greatly from abundances in other recent years (Figure 3E-12).

IMPACT ASSESSMENT METHODOLOGY

Impact Prediction Methodology

Alkali Fly Productivity Model

Introduction. The effects of the alternatives on alkali fly production in Mono Lake were assessed based on results of the field and laboratory studies described above under "Environmental Setting" and in Appendix I. These studies suggest that the most important effects of different lake levels are changes in salinity and area of high-quality habitat (effective habitat area); therefore, this assessment focused on these impacts. Temperature, which controls seasonal patterns of alkali fly biomass and production, also was considered.

The alkali fly productivity model, described in detail in Appendix L, predicts the effects of various lake surface elevations on the alkali fly population at Mono Lake. Using available lake bathymetry and alkali fly field and experimental data for model input and calibration, this population model estimates the relative seasonal abundance of alkali fly aquatic lifestages for various lake levels. The model estimates monthly alkali fly average biomass and cumulative production at environmental conditions corresponding to lake elevations from 6,350 to 6,420 feet. The model also simulates effects of salinity and effective habitat surface area of different lake levels on the alkali fly population. Salinity influences mean density, biomass, and production per unit area of substrate; effective habitat surface area affects lakewide total biomass and production.

Figure 3E-16 presents a diagram of the alkali fly assessment model calculations and indicates the necessary input data and assumptions. Figure 3E-17 shows the locations of sampling stations that provided density data used in the model. The model computes daily mean density of individuals per unit area of available high-quality hard substrate for each alkali fly lifestage. These densities are then applied for each lake elevation to the effective habitat area that reflects the relative value of hard and soft substrates and the decrease in habitat usability with depth. Depth-weighting for both hard and soft substrates is based on empirical equations developed from sample counts at various depths. Soft substrate areas are weighted at 5% or 10% (depending on distance from hard substrate) of their actual areas because mean fly densities observed on soft substrates are much lower than on hard substrates. No allowance is made for the effects of submerged vegetation. An important assumption of the model is that the relative densities of alkali fly on hard and soft substrates do not change with changes in lake level. The validity of this assumption is unknown.

The model calculates mean daily density, biomass, and production for the May 1 and October 31 growing season. The 1991 field data were collected during this period; temperatures are too cold for significant growth in other months.

Egg Pattern. The model estimates of egg density on high-quality hard substrates use an empirically derived relationship with temperature that closely matches the observed average hard substrate egg density pattern during 1991. The number of eggs hatching each day to become first instars is determined from the egg density divided by the egg development time multiplied by percent hatching success. Egg hatching success is assumed to decrease linearly with increasing salinity. The model assumes that adult densities and fecundity are not affected by salinity; thus, the same empirical egg pattern is used for all lake levels.

Development Time. Development times of alkali fly in the model depend on temperature and salinity (Appendix L). Daily temperatures are used to estimate development times for each lifestage, and development is considered to halt at temperatures below 10°C. Above 10°C, development time decreases with temperatures. At 20°C, development times are assumed to be 3 days for eggs, 4 days for first instars, 7 days for second instars, 15 days for third instars, and 15 days for pupae. Development times for larval instars are assumed to lengthen with increasing salinity, whereas development times for eggs and pupae are assumed to be unaffected by salinity.

Density Estimates. Daily first instar density is calculated as the previous day's density, plus the eggs that hatch, minus the first instars that develop into second instars, and minus the first instars lost to mortality. An initial first instar density was obtained from selected field data on April 31. Second, third, and pupal densities are calculated similarly. Actual data are unavailable, but mortality is assumed to increase from 1% per day at 50 g/l salinity to 10% per day at 150 g/l salinity for the larval lifestages. Pupal mortality is not affected by salinity and for modeling purposes is assumed to be 0% for all salinities. Temperature does not affect mortality rates in the model.

Biomass Estimates. Daily biomass for each lifestage is estimated as the product of population density (individuals per square meter) and the estimated mean dry weight of that lifestage. The mean weight of larvae was assumed to be 50% of the weight of the fully developed life stage. Pupal weight was assumed constant. No direct measurements of biomass from the 1991 field data exist for calibration of daily modeled biomass.

Production Estimates. Production at each life stage is estimated as the product of the mean weight of the fully developed life stage and the development rate of that life stage. The production usable by foraging birds is estimated from third instar production. The model calculates the seasonal total production for each lake level by summing daily production values.

The model estimates the proportion of third instar population that remains attached to the substrate as pupae and the fraction that is lost from the substrate to become open water drift or is windrowed ashore. The model specifies separate loss fractions for hard substrate (10%) and soft substrate (90%). The great majority of dislodged third instars and pupae are blown ashore as windrows; an unknown fraction becomes drift available to water birds.

Brine Shrimp Productivity Model

Introduction. Assessing effects of the alternatives on production of Mono Lake brine shrimp is based on results of the field and laboratory studies described above under "Environmental Setting" and in Appendix J. These studies suggest that the most important effects of different lake levels are changes in food production (planktonic algae), salinity, and total habitat area (lake surface area); therefore, this assessment focused on these impacts. Temperature and dissolved oxygen concentration, factors important in brine shrimp population dynamics, also were considered.

The brine shrimp productivity model predicts the effects of various lake surface elevations on the brine shrimp population at Mono Lake. The model includes separate physical and biological limnology models to simulate temperature, light level, vertical mixing, and salinity changes and their effects on algae and brine shrimp production. A complete description of the brine shrimp productivity model is presented in Appendix M, supported by reports from the UC Santa Barbara research group (especially Jellison, Dana, Romero, and Melack [1991]). The UC Santa Barbara research and assessment models are largely directed toward understanding possible effects of increasing salinity; lower salinity conditions have not been as intensively studied.

Physical Limnology Model. Vertical temperature, salinity, and mixing patterns in Mono Lake were simulated with a computer model, Dynamic Reservoir Simulation Model (DYRESM) (Jellison, Dana, Romero, Melack 1991). DYRESM models the lake as a vertical stack of horizontal layers of uniform temperature and salinity (as conductivity). The model uses mass balance equations to calculate changes in the volume, temperature, and salinity of each layer. The layers fluctuate vertically with changes in volume caused by inflows, rainfall, and evaporation.

DYRESM simulations for each lake level alternative were run for a 50-year period beginning with the point-of-reference elevation of 6,376.3 feet. Inflows and lake level fluctuations simulated with LAAMP (Jones & Stokes Associates 1993) were used as input for the DYRESM model. Daily meteorological data for 1990 were used for all 50 years of simulation.

Simulated years with vertical salinity differences that persisted through the mixing season were considered meromictic years. The frequency of meromictic years during the 50-year simulations estimates the probability of producing meromictic conditions in the lake under each alternative. Conditions during the period of transition from the point of reference to the final equilibrium conditions for each lake level alternative were simulated; thus, the simulations estimate the probability of meromixis (meromictic conditions) under a combination of transition and final conditions. The probability of meromixis under final conditions was estimated as the frequency of meromictic years during the final decade of the DYRESM simulations. Use of the final decade overestimates the probability of meromixis because the hydrologic inputs used for the final decade are the actual hydrologic conditions that produced the long meromictic period of the 1980s.

The DYRESM model algorithms are described in the model documentation (Imberger and Patterson 1981), the UC Santa Barbara application to Mono Lake (Jellison et al. 1991; Dana, Jellison, Romero, and Melack 1992), and Appendix M.

Biological Limnology Model. The biological limnology model contains two linked submodels: a nitrogen submodel that simulates the movement of nitrogen in Mono Lake and a brine shrimp submodel that simulates brine shrimp population dynamics (Appendix M). The biological model simulated only 1 year, representing the final condition of each lake level alternative, but the year was simulated for both monomictic and meromictic conditions. The DYRESM final decade results were then consulted to determine whether monomixis or meromixis would be more likely under the final equilibrium conditions for that alternative.

Nitrogen Balance Submodel. The nitrogen balance submodel simulates nitrogen movement among pools representing the sediments, the hypolimnion, the epilimnion, the planktonic algae, and the brine shrimp population (Figure 3E-18). Nitrogen in the hypolimnetic and epilimnetic pools is present almost entirely as ammonium (NH_4^+), while that in the algae and brine shrimp is bound up in tissues, feces, or other particulate forms. Only the ammonium nitrogen, which is dissolved, is immediately available to algae (see Appendix M, Table M-2, for nitrogen [N] equivalence formulas).

The submodel assumes a constant areal rate of ammonium release from the sediments. When Mono Lake is holomictic (not stratified), the released ammonium moves directly into the combined epilimnetic and hypolimnetic pool. When the lake is stratified, the ammonium is added to the hypolimnetic and epilimnetic pools separately, based on the area of sediments within each layer. Vertical movement of ammonium between the hypolimnion and epilimnion is modeled by moving slabs of water with the ammonium they contain back and forth between the water layers as the epilimnetic depth changes. Movement of nitrogen from ammonium to the algae (nitrogen assimilation) is modeled as a photosynthetic growth process. The submodel assumes algal growth rate is regulated by temperature, light, ammonium concentration, and salinity in the epilimnion.

Nitrogen is removed from the algal pool through grazing by brine shrimp and by sedimentation (the settling of algae out of the epilimnion). The maximum grazing rate of a brine shrimp is dependent on its weight and the water temperature. When the grazing rate is below maximum (because algal biomass is below the upper limit), the rate is dependent on algal biomass, as well as the weight class and temperature. Total daily transfer of nitrogen from the algal pool to the brine shrimp pool is the sum over all weight classes of the weight class grazing rate times the number of brine shrimp in the weight class.

Nitrogen leaves the brine shrimp pool by excretion, defecation, cyst production, and mortality. Excreted nitrogen (ammonium) is immediately available for reuse by the algae, but the other processes result in particulate nitrogen that settles to the lake bottom. Nitrogen excretion and defecation rates are assumed equal to that portion of nitrogen from ingested algae not used for growth or production of cysts or nauplii (i.e., grazing minus production).

Brine Shrimp Submodel. The brine shrimp submodel simulates hatching of cysts, grazing, growth, development, naupliar production, cyst production, excretion, defecation, and mortality of a population of brine shrimp (Jellison, Melack, Dana 1992). Growth of the brine shrimp is modeled by incrementing their weight by a fixed proportion (growth efficiency) of the weight of the grazed algae (i.e., that not lost to feces and excretion). Grazing and growth are computed in terms of nitrogen content (i.e., weight of nitrogen consumed and nitrogen weight added to body tissue). The model assumes no growth occurs in the adult stage and that, for ovigerous females, a fixed proportion (reproductive efficiency) of grazed algae is devoted to production of nauplii (ovoviviparity) or cysts (oviparity). Division of the total number of nauplii and cysts produced depends on the time of year, water temperature, algal biomass, and the number of broods previously produced.

The initial size of the brine shrimp population is held constant to simplify comparisons of the different lake levels.

Brine shrimp mortality was modeled by removing from the population each day a proportion (mortality rate) of the individuals in each age class. Separate mortality rates were estimated for nauplii, juveniles, and adults.

The effect of salinity on the brine shrimp population is incorporated into the submodel by adjusting model parameters. Growth efficiency, reproductive efficiency, percent ovigerity (i.e., percent ovigerous females), cyst hatching success, and maximum rate of algal growth increase in the model as salinity declines, whereas mortality of juveniles and adults, the peak day of cysts hatching, and percent ovoviviparity (i.e., percent of broods containing nauplii rather than cysts) decrease. All the changes in model parameters, except percent ovoviviparity, cause higher brine shrimp production at lower salinities. However, the ovoviviparity results are suspect because percent ovoviviparity in the bioassays was consistently much lower than from field observations (Jellison, Melack, Dana 1992).

Because of trophic interactions, brine shrimp productivity would probably be much less affected by salinity increases than the direct effects of salinity on the brine shrimp suggest. For instance, because brine shrimp are food limited much of the year, reductions in brine shrimp growth efficiency because of higher salinity would mean more ammonium excretion and algal growth, thereby allowing higher brine shrimp grazing and growth rates. The effects of salinity cannot be properly understood in isolation from the other factors that affect brine shrimp production.

Factors Not Included in the Models

Competition and Predation. One possible impact on the alkali fly and brine shrimp that could not be simulated is competition or predation from new species invading Mono Lake at lower salinities. David Mason (1967) found rotifers in Mono Lake between 1959 and 1963 when the salinity was about 62 to 70 g/l, but numbers were generally too low to affect the brine shrimp population. Dana et al. 1992 speculate that the brine shrimp population could experience competition and predation in Mono Lake only at salinities below about 50 g/l. At prediversion salinities, which were about 50 g/l, predation and competition would probably not have had much effect on alkali fly productivity (Herbst pers. comm.).

Submerged Vegetation. Lakeshore submerged vegetation may be important habitat for the alkali fly. Normal fluctuations in lake level cause periodic flooding of shoreline vegetation and may persist under water for up to 10 years and support high densities of alkali larvae and pupae (Herbst 1990a, 1990b). Submerged vegetation is likely to be a less important habitat at low lake levels than at high lake levels because alkalinity of most near-lake soils at low lake levels is too high to sustain plants, while salt grasses and other plants are relatively abundant at higher elevations. The alkali fly productivity model does not incorporate submerged vegetation into effective habitat area because too little is known about its importance; consequently the existing model may underestimate productivity at the higher lake level alternatives.

Changes in Relative Value of Substrate Types with Lake Level. As noted earlier, the alkali fly model assumes that densities of alkali fly on soft substrates are 5% or 10% (depending on distance from hard substrate) of estimated densities on hard substrates. Although processes may exist that would lead to changes in relative densities of alkali fly on hard and soft substrates with changes in lake level, the overall effect of these processes cannot be quantified. Therefore, the model assumes that the relative densities remain constant for all alternative lake levels. If, however, relative density on soft substrate increases at higher lake levels, then the model underestimates alkali fly productivity at higher lake levels.

Vertical Mixing Regime. The alkali fly model does not consider the vertical mixing regime of Mono Lake (monomixis versus meromixis), but the mixing regime probably has much less influence on the littoral zone than on the pelagic zone and therefore is unlikely to significantly affect alkali fly productivity.

Determination of Point-of-Reference and Prediversion Conditions

Point-of-Reference Condition. Model simulations of the point-of-reference scenario were used to describe point-of-reference conditions for the alkali fly and the brine shrimp populations. The simulated point-of-reference values were derived in the same way that predictions for the alternatives were derived and therefore provide relatively consistent comparisons. Recent field data are presumably more accurate, but were unavailable for 1989 and would provide less consistency if used as point-of-reference conditions and compared to model simulation results.

The simulations of the alkali fly productivity model, the physical limnology model (DYRESM), and biological limnology model for brine shrimp productivity used different elements of the point of reference. DYRESM used streamflows at the point of reference, while the alkali fly model and the biological limnology model used the lake level at the point of reference (6,376 feet).

DYRESM simulations of the first 50 years follow the LAAMP simulated surface elevations and releases to Mono Lake shown in Chapter 2 for the point of reference. These DYRESM simulations of the point-of-reference streamflows indicate that about 20 of the next 50 years would be meromictic, including all years of the final decade. However, the DYRESM simulation for the 6,377-Ft Alternative, which has a target lake level only 1 foot higher than the point-of-reference lake level, indicates that only 1 year of the final decade is meromictic (Figure 3E-19). The final equilibrium conditions simulated by DYRESM for the 6,377-Ft Alternative were considered more representative of the point-of-reference lake level conditions than the final equilibrium conditions of the point-of-reference simulations, and the probability of meromixis at the point-of-reference lake level was considered low. Therefore, predictions for the brine shrimp impact assessment variables under the different lake level alternatives were compared with point-of-reference values that assumed monomictic conditions. The alkali fly impact assessment variables were not affected by the mixing regime (i.e., monomixis versus meromixis).

Alkali Fly. The alkali fly model simulation of point-of-reference conditions generally matches observed conditions fairly closely. Simulated and observed values are close for density of eggs, first and third instar larvae, and pupae (Appendix L, Figures L-23, L-24, L-26, and L-27). The match is not as good for second instar larvae and drift (Appendix L, Figures L-25 and L-28).

Brine Shrimp. Simulations of the brine shrimp model for a lake surface elevation of 6,375 feet, just 1 foot less than the point-of-reference lake elevation, were also used to describe point-of-reference conditions in the brine shrimp impact analyses. The simulated point-of-reference values were determined for both monomictic and meromictic conditions; each variable thus has two point-of-reference values. However, as noted earlier, monomictic conditions were considered to be more representative of typical point-of-reference conditions than meromictic conditions, and predictions for the different alternatives were compared only with the point-of-reference values for monomictic conditions. Comparisons with the point-of-reference values for meromictic conditions can be made by consulting Table 3E-4 and Figures 3E-20 through 3E-22. The match between the simulated point-of-reference values and means of estimates derived from field data for meromictic (1983-1988) and monomictic (1989-1990) years is poor in some cases (see Appendix M).

Prediversion Condition. Prediversion conditions in Mono Lake are largely unknown, so cumulative impact assessments are necessarily speculative. Simulation results for the No-Diversion Alternative should most closely match prediversion conditions. The DYRESM simulations indicated that the probability of meromixis is very low under final equilibrium conditions above 6,390 feet (Figure 3E-19), and monomictic conditions were assumed at the prediversion lake level for the cumulative impact assessment. DYRESM simulations were not actually made for the prediversion conditions.

Alkali Fly. The alkali fly model results for the No-Diversion Alternative (6,420 feet lake level) should most closely match prediversion conditions. These results, however, show a substantial decrease in productivity from the point-of-reference level, contradicting many historical accounts of very high prediversion abundances of alkali flies (see "Prediversion Conditions" section). This difference could not be resolved, but the simulation results should be interpreted cautiously, particularly when projecting well beyond observed conditions, because potentially important factors (e.g., submerged vegetation habitat area) that may be missing from the model could lead to substantial prediction errors.

Brine Shrimp. The No-Diversion and 6,410-Ft Alternatives, which presumably would most closely match prediversion conditions, were not simulated with the biological model. Therefore, simulation results for the 6,390-Ft Alternative, the highest lake level simulated, were used as a proxy for the prediversion conditions. Representing prediversion conditions with the 6,390-Ft Alternative probably underestimates the cumulative impacts of most alternatives because brine shrimp and cyst production are presumed to increase at lake levels above 6,390 feet (see impacts and mitigation measures for 6,410-Ft and No-Diversion Alternatives). Furthermore, cumulative impacts of the 6,390-Ft, 6,410-Ft, and No-Diversion Alternatives cannot be estimated, but it is assumed that they would be less than significant.

Criteria for Determining Impact Significance

Several impact assessment variables were selected to evaluate the impact of lake levels changes on the alkali fly and brine shrimp populations, particularly as they affect feeding conditions for birds. Criteria for determining impact significance for each variable are discussed below.

Project Impacts

Alkali Fly. Variables selected to evaluate predicted changes in the overall abundance of alkali flies and their availability to birds were lakewide total annual (May-October) production of pupating third instar larvae (MT/lake), areal mean drift (dislodged third instar larvae) density (ind/m^2), and lakewide total annual production of drift (MT/lake). Actual drift densities are expected to be about 10 times smaller than predicted drift estimates. Alternatives were considered to have significant effects if third instar larvae, drift production, or drift density is predicted to differ by more than 10% from point-of-reference estimates. This was considered to be the threshold for measurement of differences in these alkali fly productivity variables.

Brine Shrimp. Brine shrimp biomass density (mg N/m^3), areal mean (g N/m^2) and lakewide total annual brine shrimp production (MT N/lake), and areal mean and lakewide total cyst production (numbers of cysts) were used to evaluate effects of alternatives on brine shrimp availability to birds. Brine shrimp biomass and production directly estimate feeding conditions for birds, whereas cyst production affects the long-term survival potential of the brine shrimp population. The biomass density of brine shrimp is useful for analyzing bird food availability because food density, not simply total amount of food, may be important for birds feeding on small prey such as brine shrimp. Birds must expend more energy feeding on small prey that are widely dispersed.

Annual brine shrimp production determines the capacity of the pelagic zone to support bird populations because production represents not simply the amount (biomass) of food present, but also the rate at which the food is produced. Areal mean production estimates indicate how much food is produced each year in a given area, and the lakewide totals indicate how much food is produced each year in the entire lake. The lakewide totals reflect effects of alternatives on the total surface area of habitat available and the effects on food density, salinity, nitrogen cycling, and other factors, while the areal means reflect the effects on food density, salinity, nitrogen cycling, and other factors only. Annual production estimates are expressed in terms of nitrogen to facilitate comparisons with ammonium concentrations and primary production. Annual cyst production represents the maximum potential size of the following year's population. Conversion to dry weight of biomass can be made by assuming nitrogen is about 7% of biomass (Appendix M).

Determining impact significance for brine shrimp is difficult because almost nothing is known about how declines in the brine shrimp population might threaten the population's survival or how changes in brine shrimp density, biomass, or production may affect bird populations using shrimp as food. For determining significance, the range of values in the 1983-1988 biological model simulation (Table 3E-5) was used to represent natural variability of the variables during meromictic point-of-reference conditions and the range of values in the 1989-1990 simulation was used to represent natural variability during monomictic point-of-reference conditions. However, 1989-1990 is too short a period to estimate variability reliably, so natural variability for monomictic conditions was estimated as the range of values during meromictic conditions scaled to the value of the monomictic point of reference (i.e., monomictic range = meromictic range times [monomictic point of reference divided by meromictic point of reference]). Natural variability for lakewide totals (monomictic and meromictic) was estimated as the range of the areal means scaled to the point-of-reference values for lakewide totals.

For the impact analyses, predicted values of the impact assessment variables for lake level alternatives that exceeded point-of-reference values by more than 25% of the estimated range of natural variability were considered to represent significant beneficial effects; those that fell below point-of-reference values by more than 25% of the range were considered to represent significant adverse impacts. Predicted values that were within 25% of the estimated range were determined to have no significant effect (termed "point-of-reference range for no impacts"). Point-of-reference ranges for no impact for the impact assessment variables were used to evaluate impacts of the alternatives (Table 3E-4). Point-of-reference estimates for monomictic conditions were used for impact assessments, but estimates for meromictic conditions are also presented (Table 3E-4, Figures 3E-20 through 3E-22) because, as noted earlier, the point-of-reference equilibrium lake level condition has an estimated 10% probability of meromictic conditions.

Significant impacts on alkali fly are judged based on 10% change from the point-of-reference mean estimate, while impacts on brine shrimp are judged based on 25% of the estimated natural variation.

Cumulative Impacts

Alkali Fly. An alternative lake level was considered to have a significant adverse impact on alkali fly if the value of any of the alkali fly impact assessment variables (lakewide total third instar annual production, areal mean drift density, and lakewide total annual drift production) was more than 10% below the projected No-Diversion Alternative value.

Brine Shrimp. The impact assessment criteria used for determining significance of cumulative impacts are the same as those used for the point-of-reference impacts (brine shrimp biomass, mean areal annual production, total lakewide annual production, mean areal annual cyst production, and lakewide total annual cyst production), but the no-impact ranges of natural variation between years were scaled to the estimated prediversion values (6,390-Ft Alternative) (Table 3E-4).

SUMMARY COMPARISON OF THE IMPACTS AND BENEFITS OF THE ALTERNATIVE

Effects of the alternatives on the alkali fly and brine shrimp populations are listed below and in Tables 3E-6 and 3E-7. Impacts on and benefits to alkali fly are based on predicted changes in annual production of third instar larvae, and annual production and density of drift (dislodged third instar larvae), while impacts on and benefits to brine shrimp are based on predicted changes in brine shrimp biomass and annual production of brine shrimp and cysts.

OVERVIEW OF MODEL PREDICTIONS

Alkali Fly Effects

Alkali fly impact assessment results are summarized in Table 3E-8. Predicted monthly and annual (May-October) lakewide alkali fly production estimates for third instar larvae and drift over a range of lake levels (6,350-6,420 feet) are shown in Figures 3E-23 and 3E-24. Production is minimized at the lowest evaluated lake level because of high salinity and reduced habitat area. Maximum values occur at intermediate lake elevations of 6,380-6,390 feet where the effective habitat area is greatest and salinity is decreased. At higher elevations, salinity impacts are further reduced, but the effective habitat also is smaller and drift density and productivity decline. As noted earlier, effective habitat may be underestimated at the higher elevations because submerged vegetation is not modeled and because relative densities of alkali fly on hard and soft substrates may change with changes in lake elevation.

The effects of changing salinity within the evaluated elevation range of 6,350 feet (147 g/l salinity) to 6,420 feet (46.5 g/l salinity) without the influence of effective habitat area are indicated by changes in areal mean density and production estimates. Third instar densities increased from 8,000 to 60,000 ind/m^2 as salinity decreased from 147 to 46.5 g/l, primarily due to reduced mortalities. Pupating third instar productivity increased from 1.6 to 9 g/m^2/day within the identical range of salinities, due to increased densities, decreased development times, and higher mean weights.

To evaluate the effects of changing effective habitat area without simultaneously affecting salinity, the assessment model was run for the evaluated elevation range with salinity fixed at 46.5 g/l (the lowest salinity within the range of evaluated elevations). Total production of pupating third instars reached a maximum of 2,700 MT/lake in the elevation range of 6,375-6,395 feet, which is twice that produced when salinity effects are incorporated (Figure 3E-23). At higher lake elevations, habitat-influenced production approaches levels shown in Figure 3E-23 (700 MT/lake at 6,420 feet elevation) because the actual salinity approaches the modeled constant salinity of 46.5 g/l. At lower elevations when salinity is highest at 147 g/l, habitat-influenced production (900 MT/lake at 6,350 feet elevation) is more than six times the production anticipated when salinity impacts are included. Drift production follows a similar pattern to production of pupating third instars, with 90% on soft substrate and 10% on hard substrate assumed to become drift.

Brine Shrimp Effects

Table 3E-9 summarizes predicted values for several brine shrimp variables at different Mono Lake surface elevations. The lowest lake level, 6,360 feet, corresponds approximately to the lake level under the No-Restriction Alternative, and the highest lake level, 6,390 feet, is lower than the 6,410-Ft and No-Diversion Alternatives. The predictions are derived from 1-year simulations of the biological limnology model using 1984 and 1990 observed daily temperature and salinity profiles as inputs to represent meromictic and monomictic conditions, respectively.

Areal primary production (i.e., primary production per unit area of the lake) would vary little among the different lake levels, regardless of whether monomictic or meromictic conditions are assumed, but total lakewide production would increase 50% from the lowest (6,360 feet) to highest (6,390 feet) simulated lake levels. Total lakewide primary production would probably continue to increase at higher lake levels. These increases of total production largely reflect the increased habitat area available at higher lake levels. Predicted primary production was much lower for meromictic conditions than for monomictic conditions. This difference may result more from the particular years 1984 and 1990 having been selected for input data than from any consistent difference in primary production attributable to the mixing regime.

Predicted brine shrimp production differed greatly among lake levels on both an areal and total lakewide basis (Table 3E-9). The predictions for monomictic and meromictic conditions differed much less than did the primary production predictions.

Three major factors would affect brine shrimp production at the alternative lake levels: nitrogen availability for growth of algae, salinity, and lake surface area. Lake surface area and salinity are relatively constant at a given lake level, while nitrogen availability is highly variable. Therefore, at a given lake level, salinity and lake surface area limit maximum rates of algae and brine shrimp production, but nitrogen availability determines the realized rates within these limits.

Nitrogen Availability and Mixing Regime Impacts

Model simulations of annual growth patterns of algae in a meromictic year (1984) and a monomictic year (1990) demonstrate the importance of nitrogen availability (Figure 3E-25). The simulations show potential growth rates of algae as controlled by temperature alone, light level alone, and epilimnetic dissolved nitrogen (ammonium) concentration alone. Temperature variations alone would produce a threefold to fivefold increase in algal growth rate from winter to summer. However, the growth rates based on temperature were never realized because, at all times, light level or ammonium concentration held growth rates below those determined by temperature alone. In 1984, ammonium concentrations limited growth at all times except during summer, when the brine shrimp excrete large amounts of ammonium. In 1990, light conditions limited growth in winter, early spring, and perhaps in late summer, but ammonium concentrations limited growth most of the year. These patterns of growth limitation are consistent with findings of other research conducted at Mono Lake (Jellison, Dana, Romero, Melack 1991; Jellison and Melack 1992).

The UC Santa Barbara field studies found that year-to-year variations in epilimnetic ammonium concentrations in Mono Lake were strongly influenced by the vertical mixing regime (i.e., whether the lake was monomictic or meromictic) (Jellison, Dana, Romero, and Melack 1991; Jellison, Dana, and Melack 1991). Much less of the ammonium released from the sediments reached the mixed layer early in the 1983-1988 meromictic period than during monomictic years because the chemocline limits ammonium transport. However, as ammonium concentrations in the monimolimnion increased and the chemocline deepened later in the meromictic period, mixed layer ammonium concentrations increased (Figure 3E-10), leading to increases in algal biomass (Figure 3E-11). The most dramatic increase in epilimnetic ammonium concentration occurred in 1989, following breakdown of meromixis.

Although ammonium availability and algal production were clearly suppressed immediately after meromixis became established in 1982-1983, elevated levels later in the meromictic period and immediately after meromixis broke down may have produced long-term averages that are no lower than those occurring under equilibrium monomictic conditions. The field studies provided no multiyear record of monomictic conditions with which to test this possibility. Nonetheless, meromixis does change the nitrogen balance of Mono Lake, but it may not affect long-term productivity because reduced production early in the meromictic period may be balanced by elevated production late in the period and immediately after meromixis breaks down.

Meromixis in Mono Lake clearly influenced algal biomass, which was relatively low in 1983 through 1987 and high in 1988 through 1990 (Figure 3E-11), but had little effect on brine shrimp production. Peak abundances of brine shrimp showed no consistent relationship to presence or absence of meromixis (Figure 3E-12). In most years, algal biomass peaked in early spring before brine shrimp were present in sufficient numbers to exploit it effectively, so only a portion of annual primary production influenced brine shrimp production. Therefore, effects of meromixis on algae were not necessarily propagated up the food chain to the brine shrimp population.

Meromixis reduces the proportion of Mono Lake sediments that receive dissolved oxygen during the winter mixing period and this factor, too, could be expected to inhibit brine shrimp production because brine shrimp cysts do not hatch in anoxic sediments. However, even under meromictic conditions, the number of cysts in oxygenated sediments is more than sufficient to replenish the population.

Many, but not all, of the effects of meromixis observed in the field were successfully simulated by the computer models. The 1983-1990 simulations (Table 3E-5) successfully simulated year-to-year increases in summer epilimnetic ammonium concentrations during meromixis, but failed to simulate the large increase observed in 1989 (Figure 3E-10). As noted earlier, the model simulations for 1984 representing early meromictic conditions overestimated summer epilimnetic ammonium concentrations. Despite these problems, the model accurately simulated brine shrimp biomass for both 1984 and 1990 and was consistent with field observations in indicating that mixing regime (i.e., meromixis versus monomixis) had little influence on brine shrimp production.

Salinity Impacts

Salinity in Mono Lake would decrease from about 120 g/l at a lake level of 6,360 feet to 71 g/l at 6,390 feet. Most of the difference in predicted brine shrimp areal production among the simulated lake levels (Table 3E-9) results from salinity effects. Salinity would cause even greater differences if not for interactions of brine shrimp with the other nitrogen pools (i.e., algae and ammonium). Predicted areal brine shrimp production varied more than 1,000% between lake levels of 6,360 and 6,390 feet when simulations did not include nitrogen exchanges among the brine shrimp, algae, and ammonium (Table 3E-10). When these interactions were included, predicted production increased less than 100% between 6,360 and 6,390 feet (Table 3E-9).

The nitrogen interactions ameliorate the influence of salinity on brine shrimp production by improving growth conditions for the shrimp as production decreases. For example, the reduction in shrimp production at higher salinities results partly from reduced growth efficiency (Appendix M). Reduced growth efficiency increases ammonium excretion per shrimp (because less of the grazed algae is used for growth and more is directed to excretion and defecation), which increases algal production. Reduced shrimp production reduces grazing, which also increases algal production.

Lake Surface Area Impacts

The effect on total primary and brine shrimp production from changes in Mono Lake surface area was simulated by multiplying the predicted mean areal estimates of production by the projected surface areas. Because differences in surface area between alternatives were considerable (Table 3E-8), the surface area effect was substantial. Total primary production increased about 50% as lake level rose from 6,360 feet to 6,390 feet and, as noted earlier, nearly all this difference was caused by the surface area effect alone (Table 3E-9). Total brine shrimp production increased about 250% between lake levels of 6,360 and 6,390 feet (Table 3E-9), but approximately half of this increase was caused by the surface area effect and half by the salinity effect. At higher lake levels, total brine shrimp production would probably continue to increase considerably.

IMPACTS AND MITIGATION MEASURES FOR THE NO-RESTRICTION ALTERNATIVE

Changes in Resource Condition

Long-Term Changes

LAAMP model results (Jones & Stokes Associates 1993) show that lake levels under the No-Restriction Alternative would eventually stabilize at about 6,350 feet, 26 feet below the lake level point of reference. As a result, lake surface area would drop from 40,724 acres to 29,650 acres, and effective habitat area for the alkali fly would decrease by more than half from 981 acres to 410 acres. Salinity would increase from 90.8 g/l to 147 g/l.

DYRESM simulations of the No-Restriction Alternative were not made because UC Santa Barbara staff determined that the lake salinity would increase beyond the observed range of values so that several assumed "equations of state" and the relationship between salinity and conductivity would exceed the applicable range. However, because of increased lake salinity, it is reasonable to assume that freshwater inflows would have a strong effect on salinity stratification and that meromictic events would occur more frequently and persist for longer periods of time than the point-of-reference simulations indicated. Therefore, predictions for this alternative assuming meromictic conditions were used to assess impacts.

Alkali Fly Effects. The No-Restriction Alternative was simulated with the alkali fly model based on a lake level of 6,350 feet, the dynamic equilibrium lake level predicted for this alternative by LAAMP (Jones & Stokes Associates 1993).

Third instar lakewide productivity would decrease 84% from 919 metric tons (MT) to 146 MT (Table 3E-8, Figure 3E-23). This reduction is greater than 10% and therefore is considered a significant adverse impact on third instar productivity.

Seasonal lakewide drift production would decrease 80% from 409 MT to 82 MT. Drift densities would be reduced 66% to 5.6 ind/m^2 (Table 3E-8, Figure 3E-24). Both reductions are significant adverse impacts.

Brine Shrimp Effects. The No-Restriction Alternative was simulated with the biological submodel by assuming a lake level of 6,360 feet, though the lake would decline to 6,350 feet under this alternative. Therefore, the 6,360 foot simulations may underestimate the impacts of this alternative.

Predicted brine shrimp biomass, areal mean production, and lakewide total production are below point-of-reference values (Table 3E-9) and are below the point-of-reference ranges for no impacts (Figures 3E-20 and 3E-21). Predicted areal mean and lakewide total cyst production for the 6,360-Ft Alternative are also below the point-of-reference ranges for no impacts (Figure 3E-22). The reductions in brine shrimp biomass, production, and cyst production are considered significant adverse impacts because the predicted values are below the point-of-reference ranges for no impacts.

Differences between meromictic and monomictic conditions had little effect on the brine shrimp (Table 3E-9, Figures 3E-20 and 3E-21) and contributed little to the differences between the predicted values and the point-of-reference range for no impact. The principal cause of the adverse impact of the 6,360-Ft Alternative on the brine shrimp population was increased salinity, though decreased surface area also affected the lakewide totals.

Near-Term Changes

The alkali fly and brine shrimp models are designed to evaluate conditions at a fixed lake level and are not well suited for assessing near-term impacts during the period of transition to the alternative. Furthermore, it is difficult to generalize about near-term impacts because the transition to the alternative lake level would be gradual and continuous. Generally, near-term conditions for alkali fly and brine shrimp are expected to be intermediate between point-of-reference conditions and final equilibrium conditions under the No-Restriction Alternative. Frequency of meromictic events might be somewhat reduced early in the transition period because of reduced freshwater inflows but would later increase above point-of-reference values.

Drought Effects

Under the No-Restriction Alternative, a drought would not substantially increase salinity of Mono Lake (Chapter 2) and would therefore not reduce alkali fly and brine shrimp production below the levels predicted for the No-Restriction Alternative. Probability of meromixis would increase following a period of drought, but impacts on alkali fly and brine shrimp production from meromixis are uncertain.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (No-Restriction Alternative)

- Significantly decreases lakewide alkali fly production, lakewide drift production, and drift density by 84%, 80%, and 66%, respectively.

Mitigation Measures. Herbst measured alkali fly density on artificial (concrete) substrates and found densities similar to those on tufa (1992). In theory, therefore, impacts of the No-Restriction Alternative on the alkali fly population could be mitigated by placing many concrete blocks in the littoral zone of the lake. However, this measure would have a substantial adverse visual impact if the lake level decreased and exposed the blocks (as might occur during drought). Also, the measure would probably be incompatible with the Mono Basin National Forest Scenic Area Management Plan and be expensive to implement.

- Significantly decreases brine shrimp biomass, areal mean and lakewide production, and areal mean and lakewide cyst production by 40%, 32%, 44%, 52%, and 60%, respectively.

Mitigation Measures. None are available because there are no practical methods to manage the brine shrimp populations in Mono Lake.

IMPACTS AND MITIGATION MEASURES FOR THE 6,372-FT ALTERNATIVE

Changes in Resource Condition

Long-Term Changes

Lake levels under the 6,372-Ft Alternative would reach a dynamic equilibrium at about 6,375 feet, about 1 foot below the point-of-reference elevation. Lake surface area, effective alkali fly habitat area, and salinity would therefore change only slightly from the point-of-reference condition (Table 3E-8). LAAMP simulations of lake level fluctuations under the 6,372-Ft Alternative indicate that the lake level would vary between 6,372 feet and 6,379 feet.

Meromictic conditions are predicted by DYRESM model for a few years (1956, 1969, and 1982-1986), but the salinity differences between the surface and bottom layers were relatively small (2-8 g/l); the meromictic conditions did not persist for many years. A total of 6 years (out of 50) are predicted to be meromictic under the 6,372-Ft Alternative, but 4 of these years would occur in the final decade (Figure 3E-19). Because both monomictic and meromictic conditions appear to be likely under this alternative, predictions were made for both conditions.

Alkali Fly Effects. The 6,372-Ft Alternative was simulated with the alkali fly model by assuming a lake level of 6,375 feet, the dynamic equilibrium lake level predicted for this alternative by LAAMP.

Third instar lakewide productivity would decrease 9%, from 919 MT to 832 MT (Table 3E-8). This reduction is considered a less-than-significant impact.

Seasonal lakewide drift production would fall 9%, from 409 MT to 373 MT (Table 3E-8). Drift densities would decrease 6%, to 15.5 ind/m^2. Both reductions are less than 10% and therefore are less than significant.

Brine Shrimp Effects. Regardless of whether monomictic or meromictic conditions are assumed for this alternative, the predicted values of brine shrimp biomass, areal mean production, and lakewide total production for the 6,372-Ft Alternative fall within the point-of-reference ranges for no impacts (Figures 3E-20 and 3E-21), and thus impacts on brine shrimp productivity are considered to be less than significant.

Predicted areal mean and lakewide total brine shrimp cyst production for the 6,372-Ft Alternative under monomictic conditions are 86% and 79% of the point-of-reference values (Table 3E-9) and are below the point-of-reference ranges for no impacts. The predicted values for cyst production under meromictic conditions are within the no-impact ranges (Figure 3E-22). Under monomictic conditions, implementation of the 6,372-Ft Alternative would have a significant adverse impact on cyst production; under meromictic conditions, implementation would have a less-than-significant impact on cyst production. However, the point-of-reference ranges for no impacts on cyst production are quite narrow and the monomictic predictions lie close to the range boundaries (Figure 3E-22), so the significant adverse impact predicted under monomictic conditions probably would be relatively minor.

Near-Term Changes

Because the difference in lake level between this alternative and the point of reference is only 4 feet, near-term changes are unlikely to have any significant impacts on the alkali fly and brine shrimp populations.

Drought Effects

Under the 6,372-Ft Alternative, drought would have minor effects on the alkali fly and brine shrimp populations.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,372-Ft Alternative)

- Significantly decreases lakewide and areal mean brine shrimp cyst production by 21% and 14%, respectively, during monomictic conditions that are estimated to occur about 60% of the time.

Mitigation Measures. None are available.

IMPACTS AND MITIGATION MEASURES FOR THE 6,377-FT ALTERNATIVE

Changes in Resource Condition

Long-Term Changes

The lake level dynamic equilibrium for the 6,377-Ft Alternative is about 6,380 feet, 4 feet above the lake level point of reference. Lake surface area would increase slightly from 40,724 acres to 43,670 acres, and effective alkali fly habitat area would increase from 981 acres to 1,173 acres. This alternative has the greatest estimate of effective alkali fly habitat area. Salinity would fall from 90.8 g/l to 84.6 g/l. LAAMP simulations of lake level fluctuations under the 6,377-Ft Alternative indicate that the lake level would vary between 6,377 feet and 6,383 feet.

Very weak meromictic conditions are simulated for a few years, but the salinity differences between the surface and bottom layers are so small (1-2 g/l) that meromictic conditions do not persist for more than a single year. A total of 7 years (out of 50) are simulated as meromictic under the 6,377-Ft Alternative (Figure 3E-19). Only 1 year of the final decade was meromictic, so predictions were examined for monomictic conditions only.

Alkali Fly Effects. The 6,377-Ft Alternative was simulated with the alkali fly model by assuming a lake level of 6,380 feet, the dynamic equilibrium lake level predicted for this alternative by LAAMP.

Third instar productivity would increase 32%, from 919 MT at the point of reference to 1,210 MT (Table 3E-6). These increases are beneficial effects.

Seasonal lakewide drift production would increase 29%, from 409 MT at the point of reference to 526 MT. Drift densities would increase 15%, from 16.5 to 19 ind/m^2. These increases are beneficial effects.

Brine Shrimp Effects. Predicted brine shrimp biomass, areal mean production, and lakewide total production are about 10% higher than point-of-reference values (Table 3E-9) and within point-of-reference ranges for no impacts (Figures 3E-20 and 3E-21). Slight benefits to brine shrimp would occur.

Predicted areal mean and lakewide total brine shrimp cyst production are 10% and 14% higher, respectively, than point-of-reference values (Table 3E-9). Mean cyst production is within the point-of-reference range for no impacts (Figure 3E-21a), but total cyst production is slightly above the range (Figure 3E-21b). Implementation of this alternative would benefit lakewide total cyst production.

Near-Term Changes

Because the difference in lake level between this alternative and the point-of-reference is only 2-3 feet, near-term changes are unlikely to have any measurable benefits or significant impacts on the alkali fly and brine shrimp populations.

Drought Effects

Under the 6,377-Ft Alternative, drought might reduce the lake level to 6,373 feet (Chapter 2). The effects of drought on alkali fly and brine shrimp would therefore probably be slightly adverse under the 6,377-Ft Alternative.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,377-Ft Alternative)

- Causes beneficial increases in lakewide alkali fly production, lakewide drift production, and areal mean drift density of 32%, 29%, and 15%, respectively.
- Causes beneficial increases in lakewide brine shrimp cyst production of 14%.

IMPACTS AND MITIGATION MEASURES FOR THE 6,383.5-FT ALTERNATIVE

Changes in Resource Condition

Long-Term Changes

The lake level dynamic equilibrium for the 6,383.5-Ft Alternative is about 6,385 feet, 9 feet above the lake level point of reference. Lake surface area would increase slightly from 40,724 acres to 46,310 acres, and effective alkali fly habitat area would increase from 981 acres to 1,163 acres. Salinity would decrease from 90.8 g/l to 77.5 g/l. LAAMP simulations of lake level fluctuations under the 6,383.5-Ft Alternative indicate that the lake level would rise from the initial elevation of 6,376 to 6,383 feet during the first 6 years, then vary between 6,383 and 6,389 feet.

Weak meromictic conditions are predicted by DYRESM for a few years with higher than average runoff, but the salinity differences between the surface and bottom layers are so small (2-4 g/l) that meromictic conditions would not persist for more than a single year, except during the initial rise from 6,376 to 6,383 feet. A total of 9 years (out of 50) are predicted to be meromictic under the 6,383.5-Ft Alternative (Figure 3E-19). Because only 1 year of the final decade was meromictic, predictions were examined only for monomictic conditions.

Alkali Fly Effects. The 6,383.5-Ft Alternative was simulated with the alkali fly model by assuming a lake level of 6,385 feet, the dynamic equilibrium lake level predicted for this alternative by LAAMP.

Third instar productivity would increase 47%, from 919 MT to 1,353 MT (Table 3E-8). This alternative would have a very high lakewide alkali fly productivity due to a large effective alkali fly habitat area combined with a low salinity.

Seasonal lakewide drift production would increase 47%, from 409 MT to 601 MT. Drift densities would increase 19%, from 16.5 to 19.6 ind/m^2. This alternative has the highest drift densities because drift production is high relative to the lake surface area.

Brine Shrimp Effects. Predicted brine shrimp biomass, areal mean production, and lakewide total production lie 26%, 12%, and 25%, respectively, above point-of-reference values (Table 3E-7). Mean production is within the point-of-reference ranges for no impacts (Figure 3E-21a), but biomass and total production exceed these ranges for no impacts (Figures 3E-20 and 3E-21b). Lakewide total production is only slightly above the range. The 6,383.5-Ft Alternative would have substantial benefits to total brine shrimp production and brine shrimp biomass and would have minor benefits to mean brine shrimp production. The benefits to total brine shrimp production are greater than those for mean production because total production is affected by both reduced salinity and increased surface area, whereas mean production is affected by reduced salinity only.

Predicted areal mean and lakewide total brine shrimp cyst production are 40% and 58% higher, respectively, than point-of-reference values (Table 3E-9), and both values exceed point-of-reference ranges for no impacts (Figure 3E-22). The 6,383.5-Ft Alternative would have significant benefits on cyst production.

Near-Term Changes

Flooding of grasses and other shoreline vegetation during lake filling would temporarily increase suitable substrate for alkali fly larvae and pupae and therefore would probably be a substantial near-term benefit.

DYRESM simulations for this alternative predict an early period of meromixis caused by the high volume of fresh water entering the lake. Meromixis may be an important near-term impact of this alternative, but its effects are difficult to assess because the effects of meromixis on productivity are uncertain. Any impacts of meromixis during the early filling phase for this alternative could be monitored, and mitigated if necessary, by filling the lake more slowly than presently assumed by LAAMP for this alternative.

Drought Effects

Under the 6,383.5-Ft Alternative, drought might reduce the lake level to about 6,378 feet (Chapter 2). The effects on alkali fly and brine shrimp would therefore probably be similar to the impacts predicted for the 6,377-Ft Alternative. Substantial benefits to alkali fly and drift production and to brine shrimp cyst production were predicted for the 6,377-Ft Alternative, but the effects were less than predicted for the 6,383.5-Ft Alternative. Therefore, alkali fly and brine shrimp would still benefit under drought conditions with the 6,383.5-Ft Alternative, compared to the point-of-reference, but would not benefit as substantially under drought conditions as under normal conditions for the 6,383.5-Ft Alternative.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,383.5-Ft Alternative)

- Causes beneficial increases in lakewide alkali fly production, lakewide drift production, and areal mean drift density of 47%, 47%, and 19%, respectively.
- Causes beneficial increases in brine shrimp biomass, lakewide production, and mean and lakewide cyst production of 26%, 25%, 40%, and 58%, respectively.

IMPACTS AND MITIGATION MEASURES FOR THE 6,390-FT ALTERNATIVE

Changes in Resource Condition

Long-Term Changes

Under the 6,390-Ft Alternative, lake levels stabilize at approximately 6,390 feet, 14 feet above the point of reference. Lake surface area would increase from 40,724 acres to 48,245 acres, and effective habitat area would increase very slightly from 981 acres to 993 acres. Salinity would decrease from 90.8 g/l to 71.3 g/l. LAAMP simulations of lake level fluctuations under the 6,390-Ft Alternative indicate that 30 years will be required for the lake level to rise from the initial elevation of 6,376 to 6,390 feet. The lake level will then fluctuate between 6,389 and 6,385 feet.

Weak meromictic conditions are simulated by DYRESM only for the first few years during the initial rise from 6,376 feet. The salinity drops from an initial value of about 90 g/l to about 70 g/l, and the differences between the surface and bottom layers are relatively small (2-5 g/l). Only the first 6 years (out of 50) are simulated as meromictic under the 6,390-Ft Alternative (Figure 3E-19). Because all years in the final decade were monomictic, predictions were examined for monomictic conditions only.

Alkali Fly Effects. Third instar lakewide production would increase 46%, from 919 MT to 1,341 MT (Table 3E-8).

Seasonal lakewide production of drift would increase 55%, from 409 MT to 635 MT. The 6,390-Ft Alternative has a greater total drift production than other alternatives because of a high third instar production in combination with high dislodgement rates. Drift densities would increase 15%, from 16.5 to 19 ind/m^2.

Brine Shrimp Effects. Predicted brine shrimp biomass, areal mean production, and lakewide total production lie 45%, 34%, and 49%, respectively, above point-of-reference values (Table 3E-9). Mean production is within the point-of-reference range for no impacts (Figure 3E-21a), but biomass and total production well exceed their ranges (Figures 3E-20 and 3E-21b). Mean production is only slightly below the upper boundary of the range for no impacts (Figure 3E-21a). Predicted areal mean and lakewide total brine shrimp cyst production are about twice the point-of-reference values (Table 3E-8) and greatly exceed point-of-reference ranges for no impacts (Figure 3E-22). Substantial benefits to brine shrimp for this alternative are similar to those previously described for the 6,383.5-Ft Alternative.

Near-Term Changes

Predicted near-term impacts and mitigation for this alternative are the same as those previously described for the 6,383.5-Ft Alternative. Flooding of shoreline vegetation would benefit alkali fly production. Meromixis during lake filling might affect brine shrimp production.

Drought Effects

Under the 6,390-Ft Alternative, drought might reduce the lake level to about 6,383 feet (Chapter 2). Substantial benefits to alkali fly and drift production and to brine shrimp cyst production were predicted for the 6,385.5-Ft Alternative. Therefore, alkali fly and brine shrimp would still benefit substantially under drought conditions with the 6,390-Ft Alternative compared to the point of reference.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,390-Ft Alternative)

- Causes beneficial increases in lakewide alkali fly production, lakewide drift production, and areal mean drift density of 46%, 55%, and 15%, respectively.
- Causes beneficial increases in brine shrimp biomass, lakewide production, and mean and lakewide cyst production of 45%, 49%, 82%, and 118%, respectively.

IMPACTS AND MITIGATION MEASURES FOR THE 6,410-FT ALTERNATIVE

Changes in Resource Condition

Long-Term Changes

Lake levels under the 6,410-Ft Alternative would eventually stabilize at about 6,410 feet, 34 feet above the lake level point of reference. Lake surface area would increase from 40,724 acres to 53,534 acres. Effective alkali fly habitat area would be reduced by more than half, from 981 acres to 427 acres, and salinity would decrease from 90.8 g/l to 52.9 g/l. LAAMP simulations of lake level fluctuations under the 6,410-Ft Alternative indicate that 80 years will be required for the lake level to rise from the initial elevation of 6,376 to 6,410 feet.

Meromictic conditions are simulated by DYRESM for the first 10 years during the initial rise from 6,376 feet. The salinity drops from an initial value of about 90 g/l to about 80 g/l, and the differences between the surface and bottom layers are moderate (5-10 g/l), similar to that actually observed during the 1982-1988 period. Based on the DYRESM simulations of the 6,390-Ft Alternative, additional meromictic events would be expected for annual inflows of greater than 150 thousand acre-feet (TAF), which occurred in 5 years during the second 25 years of the historical 1940-1989 sequence (not simulated with DYRESM). A total of perhaps 15 years might be meromictic for the 6,410-Ft Alternative because of the large and prolonged inflows required to raise the surface elevation of the lake (Figure 3E-19). Meromixis would be unlikely after final equilibrium conditions were attained.

Alkali Fly Effects. Third instar production would decrease 7%, from 919 MT/lake to 855 MT/lake, because of a reduced effective alkali fly habitat area (Table 3E-8). The decrease is considered to be less than significant.

Lakewide total production of drift would increase 15%, from 409 MT to 470 MT. Drift densities would decrease by a third, from 16.5 to 11 ind/m^2. The increase in total drift production is considered a substantial benefit, but the decrease in drift density, which is greater than 10%, would be considered a significant adverse impact, except that model estimates for the highest lake levels may underestimate productivity.

Brine Shrimp Effects. No biological model simulations were made for this alternative, but benefits are assumed to be somewhat greater than those previously described for the 6,390-Ft Alternative. Because predicted areal mean brine shrimp production for the 6,390-Ft Alternative falls very near the boundary of the no-impact range (Figure 3E-21a) and would likely be greater at 6,410 feet than at 6,390 feet, it is concluded that the 6,410-Ft Alternative would have a substantial benefit to areal mean brine shrimp production.

Near-Term Changes

The predicted near-term impacts (flooding shoreline vegetation and meromixis) and mitigation for this alternative are the same as those previously described for the 6,383.5-Ft Alternative.

Drought Effects

Under the 6,410-Ft Alternative, drought might reduce the lake level to about 6,400 feet (Chapter 2). Effects of drought under the 6,410-Ft Alternative would generally be beneficial in comparison to the point of reference, but probably would be reduced in comparison to normal conditions for the 6,410-Ft Alternative.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (6,410-Ft Alternative)

- Causes unknown changes in alkali fly drift production and drift density.
- Causes beneficial increases in brine shrimp biomass, lakewide production, and mean and lakewide cyst production.

IMPACTS AND MITIGATION MEASURES FOR THE NO-DIVERSION ALTERNATIVE

Changes in Resource Condition

Long-Term Changes

Lake levels under the No-Diversion Alternative would eventually reach a dynamic equilibrium at about 6,420 feet, 44 feet above point-of-reference elevations. Lake surface area is the most extensive under this alternative, increasing 36% from 40,724 acres to 55,534 acres. Effective alkali fly habitat area, however, is smallest, decreasing from 981 acres to 307 acres under this alternative, because of the presence of steep rims with unsuitable habitat. Salinity would decrease from 90.8 g/l to 46.5 g/l, the lowest salinity estimated for any alternative. DYRESM simulations were not made for the No-Diversion Alternative. Meromictic conditions would be expected during the initial lake rise, which would require 50 years with no diversions to reach elevation 6,410 feet. Meromixis would be unlikely after final equilibrium conditions were attained.

Alkali Fly Effects. The No-Diversion Alternative was simulated with the alkali fly model by assuming a lake level of 6,420 feet, the dynamic equilibrium lake level predicted for this alternative by LAAMP.

Lakewide total third instar productivity would decrease 33%, from 919 MT to 708 MT, due to a reduced effective habitat area (Table 3E-8). This decrease is considered a significant adverse impact.

Lakewide total production of drift would increase only 2%, from 409 MT to 419 MT. Drift density would decrease 46%, from 16.5 to 8.9 ind/m^2, and would be a significant adverse impact except that model estimates for the highest lake levels may underestimate productivity.

Brine Shrimp Effects. No biological model simulations were made for the No-Diversion Alternative, but benefits are assumed to be greater than those predicted for the 6,390-Ft Alternative.

Near-Term Changes

The predicted near-term impacts (flooded vegetation and meromixis) and mitigation for this alternative are the same as those previously described for the 6,385.5-Ft Alternative.

Drought Effects

Under the No-Diversion Alternative, drought would reduce the lake level to about 6,416 feet (Chapter 2). Effects of drought under the No-Diversion Alternative would be beneficial for brine shrimp but uncertain for alkali fly in comparison to the point of reference.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures (No-Diversion Alternative)

- Causes unknown changes in alkali fly drift production and drift density.
- Causes beneficial increases in brine shrimp biomass, lakewide production, and mean and lakewide cyst production.

CUMULATIVE IMPACTS OF THE ALTERNATIVES

Related Impacts of Earlier Stream Diversions by LADWP

Alkali Fly

Effective Habitat Area and Salinity. Effective habitat surface area and salinity of Mono Lake strongly affect alkali fly production. At the prediversion lake level, effective alkali fly habitat area was only about 307 acres because inshore areas are steeply sloping and include little hard substrate habitat. However, as noted previously, effective habitat area estimates of the alkali fly productivity model do not include submerged vegetation, assume constant relative densities of alkali fly on hard and soft substrates, and may therefore underestimate suitable habitat area for alkali fly at higher lake elevations. Prediversion salinity was about 46.5 g/l.

Third Instar Productivity. Monthly and seasonal third instar lakewide production estimates for the 6,350-6,420 feet range of lake elevations are shown in Figure 3E-23, which allows direct comparison between the EIR alternatives and the No-Diversion Alternative. As discussed, the prediversion condition is unknown.

Drift. Monthly and seasonal lakewide drift production estimates for the 6,350-6,420 feet range of lake elevations are shown in Figure 3E-24, which allows direct comparison between the EIR alternatives and the No-Diversion Alternative. As discussed, the prediversion condition is unknown.

Brine Shrimp

Lake Surface Area, Salinity, and Probability of Meromixis. Surface area and salinity of Mono Lake strongly affect brine shrimp production. Based on estimates for the No-Diversion Alternative, the prediversion lake level was about 6,420 feet, the lake surface area was about 55,534 acres, and salinity was about 46.5 g/l. Surface area decreased about 27% and salinity increased about twofold as the lake level dropped to the point-of-reference elevation (Table 3E-8). Under the No-Restriction Alternative, the lake surface area would be just over half of the prediversion surface area and salinity would be more than three times as high.

Brine Shrimp Biomass and Production. Simulated cumulative impacts on the brine shrimp population were generally large because the population was affected by both the increased salinity and the decreased lake surface area accompanying the decrease in lake level from the prediversion level. However, as noted in the section, "Criteria for Determining Impact Significance", little is known about how changes in brine shrimp biomass or production affect bird populations that feed on shrimp. The cumulative impacts were not generally affected by whether the lake was monomictic or meromictic (Table 3E-9).

As noted in the section, "Determination of Point-of-Reference and Prediversion Conditions", brine shrimp model simulations were not run for lake levels above 6,390 feet, so results for the 6,390-Ft Alternative simulation were used as a proxy for prediversion conditions. Results of simulations for lake levels below 6,390 feet (Table 3E-9) were considered to indicate significant impacts if the values fell below the lower bound of the no-impact range for prediversion conditions (i.e., 6,390 feet) (Table 3E-4). Thus, for example, brine shrimp biomass for all alternatives except the 6,383.5-Ft Alternative were considered to represent significant impacts because the simulated values (Table 3E-9) were below the lower bound of the prediversion no-impact range for brine shrimp biomass (i.e., 58 mg N/m^3) (Table 3E-4). Estimated areal and lakewide cyst production of the brine shrimp under all the alternatives were below prediversion no-impact ranges and therefore all the alternatives were considered to have a significant impact on cyst production.

Results for total lakewide production and areal mean production, probably the two brine shrimp impact variables most directly related to bird production, lead to somewhat inconsistent conclusions regarding impacts. Total lakewide production for all alternatives except the 6,383.5-Ft Alternative were below the prediversion no-impact range, while areal mean production was below the prediversion range under the No-Restriction Alternative only (compare Tables 3E-4 and 3E-9). This inconsistency complicates efforts to determine how changes in brine shrimp production affect the bird populations. Given that the impact assessment variables other than areal mean brine shrimp production were below prediversion no-impact ranges at most alternatives, and given that cumulative impacts were probably underestimated because estimates for the 6,390-Ft Alternative were used to represent prediversion conditions, all lake level alternatives below the 6,390-Ft Alternative had a significant cumulative impact on brine shrimp productivity.

Cumulative Adverse Impacts

No-Restriction Alternative

Predicted values of the alkali fly impact assessment variables for the No-Restriction Alternative (lakewide total third instar annual production, areal mean drift density, and lakewide total annual drift production) ranged from 37% to 80% below estimated values for the No-Diversion Alternative (Table 3E-8). The relationship to prediverison conditions, however, is unknown.

Predicted values of the brine shrimp impact assessment variables for the No-Restriction Alternative (brine shrimp biomass, areal mean and lakewide total brine shrimp production and cysts production) ranged from 46% to 82% below estimated prediversion values. All these predicted values were below the prediversion ranges for no impacts (compare Tables 3E-9 and 3E-4). This alternative is considered to have a significant cumulative adverse impact on the brine shrimp population.

6,372-Ft Alternative

Predicted values of the alkali fly impact assessment variables for the 6,372-Ft Alternative ranged from 11% below to 74% above estimated values for the No-Diversion Alternative (Table 3E-8), but the relationship to prediversion conditions is unknown.

Predicted values of the brine shrimp impact assessment variables for the 6,372-Ft Alternative ranged from 22% to 64% below estimated prediversion values, assuming monomictic conditions for the alternative, and from 30% to 57% below the prediversion values, assuming meromictic conditions. Predicted brine shrimp biomass, brine shrimp lakewide production, cyst areal production, and cyst lakewide production were below the prediversion ranges for no impacts. Predicted brine shrimp areal production was below the no-impact range for simulations assuming meromictic conditions, but was within the no-impact range for simulations assuming monomictic conditions (compare Tables 3E-9 and 3E-4). The

6,372-Ft Alternative is considered to have a significant cumulative adverse impact on the brine shrimp population.

6,377-Ft Alternative

Predicted values of the alkali fly impact assessment variables for the 6,377-Ft Alternative ranged from 26% above to more than twice estimated values for the No-Diversion Alternative (Table 3E-8), but the relationship to the prediversion condition is unknown.

Predicted values of the brine shrimp impact assessment variables for the 6,377-Ft Alternative ranged from 15% to 48% below estimated prediversion values. Predicted brine shrimp biomass, brine shrimp lakewide production, cyst areal production, and cyst lakewide production were below the prediversion ranges for no impacts, but predicted brine shrimp areal production was within the no-impact range (compare Tables 3E-9 and 3E-4). The 6,377-Ft Alternative is considered to have a significant cumulative adverse impact on the brine shrimp population.

6,383.5-Ft Alternative

Predicted values of the alkali fly impact assessment variables for the 6,383.5-Ft Alternative ranged from 43% above to more than twice estimated values for the No-Diversion Alternative (Table 3E-8), but the relationship to the prediversion condition is unknown.

Predicted values of the brine shrimp impact assessment variables for the 6,383.5-Ft Alternative ranged from 10% to 28% below estimated prediversion values. Predicted brine shrimp lakewide production, cyst areal production, and cyst lakewide production were below the prediversion ranges for no impacts, but predicted brine shrimp biomass and areal production were within the no-impact range (compare Tables 3E-9 and 3E-4). The 6,383.5-Ft Alternative is considered to have a significant cumulative adverse impact on the brine shrimp population.

6,390-Ft Alternative

Predicted values of the alkali fly impact assessment variables for the 6,390-Ft Alternative ranged from 52% above to more than twice estimated values for the No-Diversion Alternative (Table 3E-8), but the relationship to the prediversion condition is unknown.

Cumulative impacts of the 6,390-Ft Alternative were not simulated with the biological model for brine shrimp. It is assumed that cumulative impacts of the 6,390-Ft Alternative would be less than significant.

6,410-Ft Alternative

Predicted values of the alkali fly impact assessment variables for the 6,410-Ft Alternative ranged from 12% to 24% above estimated values for the No-Diversion Alternative (Table 3E-8), but the relationship to the prediversion condition is unknown.

Cumulative impacts of the 6,410-Ft Alternative were not simulated with the biological model for brine shrimp. It is assumed that cumulative impacts of the 6,410-Ft Alternative would be less than significant.

No-Diversion Alternative

Conditions under the No-Diversion Alternative would probably be similar to prediversion conditions. The cumulative impact of the No-Diversion Alternative on alkali fly and brine shrimp populations would therefore be practically nonexistent.

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Table 3E-1. Glossary of Technical Terminology

anoxic - lacking oxygen

benthic zone - area of lake bottom

bioenergetic - of or related to the energy flow of a population of organisms

chemocline - chemical gradient separating the two layers of lake water

chlorophytes - the green algae (division Chlorophyta)

coccoid - spherical

consumer - organism that obtains energy and nutrients from biological sources (i.e., eats plants and/or animals)

cyanobacteria - the blue-green algae (division Cyanophyta)

cyst - egg with a resistant outer covering to withstand freezing or drying

diapause - temporary interruption in the growth of invertebrates, usually associated with a dormant period

diatoms - type of algae (class Bacillariophyceae)

detritus - freshly dead or partially decomposed organic matter

dominant - ecologically most important

epilimnion - upper layer of lake water (above the *thermocline*), which is well mixed and generally well illuminated by sunlight

euphotic zone - layer of lake water receiving sufficient sunlight for photosynthesis (layer with light intensity more than 1% of surface light intensity)

fecundity - reproductive capacity

food web - a group of interrelated food chains (a food chain is a sequence of organisms in which each is food for a higher member of the sequence)

holomixis - complete mixing of lake water

hypolimnion - lower layer of lake water (beneath the *thermocline*)

instar - a development stage of an arthropod between molts

lime gland - alkali fly larvae's special gland for removing carbonate ions from the bloodstream

limnology - study of inland waters

littoral zone - the shallow nearshore region of the lake

meromictic lake - a permanently stratified lake, most commonly as a result of chemical difference between the *hypolimnion* and *epilimnion*

Table 3E-1. Continued

meromixis - periods of chemical stratification in lake water

mixolimnion - less saline, upper water layer of lake

monimolimnion - more saline, lower water layer of lake

monomictic lake - a lake with only one period of complete mixing and one period of temperature stratification per year

monomixis - lake water circulation pattern with one period of complete mixing and one period of temperature stratification each year

nauplii - type of larvae characteristic of many crustaceans, including brine shrimp

osmotic stress - physiological stress caused by salinity imbalance

oviparous birth - reproduction by eggs or cysts that hatch outside the body

ovoviviparously - live birth by eggs hatched within the body

pelagic zone - area of open water

phytoplankton - free-floating algae that inhabit the pelagic zone

plankton - community of free-floating algae and microscopic or very small animals that inhabit the pelagic zone

primary producer - organism that converts nonbiological sources of energy (usually sunlight) and nutrients into living matter (autotrophs)

puparium - the outer shell of a pupa, formed from the larval skin

thermocline - a temperature gradient in lake water separating the epilimnion and hypolimnion

zooplankton - microscopic or very small animals that inhabit the pelagic zone

Table 3E-2. Vertical Distribution of Hard Substrates in Mono Lake below 6,440 Feet

Mono Lake Elevation (feet)	Incremental Lake Area (acres)	Horizontal Surface Area (Acres)					Vertical Distribution (%)	Coverage (%)
		Tufa-Covered Pumice Blocks	Free-Standing Tufa	Bedrock	Beachrock	Total		
6,300-6,310	3,487.7	7.7	0.0	5.8	0.0	13.5	0.6	0.4
6,310-6,320	3,055.4	16.4	14.9	13.4	0.0	44.7	1.9	1.5
6,320-6,330	2,709.7	20.3	29.1	26.3	0.0	75.7	3.2	2.8
6,330-6,340	2,776.2	22.8	44.2	43.9	0.0	110.9	4.7	4.0
6,340-6,350	2,844.6	63.3	53.1	49.3	0.0	165.7	7.1	5.8
6,350-6,355	1,270.5	35.0	22.0	30.2	0.0	87.3	3.7	6.9
6,355-6,360	1,363.0	44.6	19.2	39.0	0.0	102.8	4.4	7.5
6,360-6,365	1,585.7	49.2	19.9	32.3	0.0	101.4	4.3	6.4
6,365-6,370	2,396.9	82.8	13.0	30.3	3.7	129.8	5.5	5.4
6,370-6,375	3,649.5	336.9	20.0	23.9	12.0	392.8	16.8	10.8
6,375-6,380	3,754.9	339.1	7.9	23.9	11.6	382.6	16.3	10.2
6,380-6,385	2,639.6	176.6	10.9	23.9	18.2	229.7	9.8	8.7
6,385-6,390	1,934.7	47.2	12.4	23.9	10.3	93.9	4.0	4.9
6,390-6,395	1,550.9	0.0	9.6	24.5	18.9	53.0	2.3	3.4
6,395-6,400	1,408.3	0.0	18.9	24.5	21.0	64.4	2.8	4.6
6,400-6,405	1,246.8	0.0	12.7	28.2	18.3	59.2	2.5	4.7
6,405-6,410	1,083.5	0.0	2.3	28.2	15.0	45.5	1.9	4.2
6,410-6,415	992.7	0.0	0.4	29.8	15.2	45.3	1.9	4.6
6,415-6,420	1,006.6	0.0	0.0	29.8	6.3	36.1	1.5	3.6
6,420-6,430	3,102.3	0.0	0.0	50.8	6.6	57.4	2.4	1.8
6,430-6,440	2,020.0	0.0	0.0	50.8	0.0	50.8	2.2	2.5
Total area	45,879.5	1,241.9	310.5	632.7	157.1	2,342.5	99.8	104.7

Notes: Hard substrate areas were planimetered from Stine 1992, using Jones & Stokes Associates' and Pelagos' bathymetry.

Mudstone was not included because it provides poor habitat.

Table 3E-3. Densities of Mono Lake Alkali Fly on Hard and Soft Substrates (Number per Square Meter)

	Instar Phase			
	Pupal	Third	Second	First
1988				
Hard substrate	20,896	4,909	3,426	152
Soft substrate	4	647	189	28
1991				
Hard substrate	25,109	16,972	14,781	5,613
Soft substrate	1	5,878	5,002	1,985

Note: Based on observations in August 1988 and August 1991 by Little et al. (1989) and Herbst (1992).

Table 3E-4. Point-of-Reference and Prediversion Values and No-Impact Ranges for Impact Analysis Variables

Variable	Point of Reference					
	Monomictic[a]		Meromictic		Prediversion[b]	
	Annual Mean Value	No-Impact Range	Annual Mean Value	No-Impact Range	Annual Mean Value	No-Impact Range
Brine shrimp biomass						
Volumetric (mg N/m^3)	47	40-54	46	39-5	68	58-78
Annual brine shrimp production						
Areal (g N/m^2)	3.62	2.72-4.52	3.22	2.42-4.02	4.50	3.38-5.63
Total (thousands of metric tons N)	0.59	0.44-0.73	0.57	0.42-0.71	0.88	0.66-1.09
Annual cyst production						
Areal (millions of cysts/m^2)	1.41	1.26-1.56	1.46	1.31-1.61	2.57	2.30-2.84
Total (trillions of cysts)	231	207-255	261	234-288	503	451-555

[a] Monomictic estimates used for impact assessment comparisons to point-of-reference conditions.

[b] Prediversion conditions assumed to be the same as monomictic conditions under the 6,390-Ft Alternative.

Table 3E-5. Results of Brine Shrimp Productivity Model 8-Year Simulation

Year	Lake Level Range[a]	Brine Shrimp Biomass (mg N M^{-3})	Areal Production: Brine Shrimp (g N M^{-2})	Areal Production: Cyst (millions/m^2)	Lakewide Total Production: Brine Shrimp (thousands of MT N)	Lakewide Total Production: Cyst (hundreds of trillions)
1983	6,374-6,380	29	1.64	1.11	0.28	1.85
1984	6,380-6,381	46	3.59	1.48	0.63	2.63
1985	6,379-6,380	52	4.30	1.31	0.74	2.29
1986	6,379-6,381	51	3.21	1.05	0.57	1.85
1987	6,379-6,380	51	4.19	1.67	0.73	2.94
1988	6,377-6,379	58	4.84	1.72	0.82	2.93
1989	6,375-6,377	33	2.15	1.40	0.35	2.35
1990	6,375-6,376	33	2.76	1.40	0.45	2.29

[a] See Figure 3E-1 for monthly lake elevations.

Table 3E-6. Summary Comparison of Alkali Fly Effects under the Alternatives

Alternative or Condition	Third Instar Production (MT/Lake)	Drift Production (MT/Lake)	Drift Density (number/m^2)	Net Effect	
				Project Effect	Cumulative Effect
Point of reference	919	409	16.5	N/A	N/A
No restriction	146*	82*	5.6*	Significant adverse	Significant adverse
6,372 Ft	832	373	15.5	Less-than-significant adverse	Unknown
6,377 Ft	1,210	526	19.0	Substantial benefit	Unknown
6,383.5 Ft	1,353	601	19.6	Substantial benefit	Unknown
6,390 Ft	1,341	635	19.0	Substantial benefit	Unknown
6,410 Ft	(855)	(470)	(11.0)	Unknown	Unknown
No diversion	(708)	(419)	(8.9)	Unknown	None
Prediversion	Unknown	Unknown	Unknown	N/A	N/A

* = value representing significant adverse impact.

( ) = reliability unknown.

N/A = not applicable.

Table 3E-7. Summary Comparison of Brine Shrimp Effects under the Alternatives

Alternative or Condition	Biomass (Mg N/m³)	Brine Shrimp Production: Areal (g N/m²)	Brine Shrimp Production: Total (Thousands of MT N/lake)	Cyst Prediction: Areal (millions of Cysts/m²)	Project Effect	Cumulative Effect
Point of reference	47	3.62	0.59	1.41	N/A	N/A
No restriction	28*	2.45*	0.33*√	0.68*√	Significant adverse	Significant adverse
6,372 Ft[a]	42	3.53	0.52√	1.21*√	Significant adverse	Significant adverse
6,377 Ft	50	3.84	0.64√	1.55√	Slight benefit	Significant adverse
6,383.5 Ft	59	4.04	0.74√	1.98√	Substantial benefit	Significant adverse
6,390 Ft	68	4.50	0.88	2.57	Substantial benefit	Less than significant adverse
6,410 Ft	Assumed similar to or greater than 6,390-Ft Alternative[b]				Substantial benefit	Less than significant adverse
No diversion	Assumed similar to or greater than 6,390-Ft Alternative[b]				Substantial benefit	Less than significant adverse
Prediversion	Similar to or greater than No-Diversion Alternative				N/A	N/A

* = value representing significant adverse impact.
√ = value representing significant cumulative impact.
N/A = not applicable.

[a] Predicted values for monomictic conditions.
[b] Not simulated with UC Santa Barbara assessment model.

Table 3E-8. Alkali Fly Impact Assessment Results

Alternative or Condition	Evaluated Elevation (feet)	Lake Surface Area (acres)	Effective Habitat Area (acres)	Salinity (g/l)	Seasonal 3rd Instar Production (g/m^2)	Seasonal 3rd Instar Production (M/lake)	Seasonal Drift Production (MT/Lake)	Maximum Drift Density (ind/m^2)
Point of reference - lake level	6,376	40,724	981	90.8	231	919	409	16.5
Point of reference - streamflows	6,365	33,869	478	110	164	317	161	8.6
No restriction	6,350	29,650	410	147	88	146	82	5.6
6,372 Ft	6,375	39,915	921	92.4	223	832	373	15.5
6,377 Ft	6,380	43,670	1,173	84.6	255	1,210	526	19.0
6,383.5 Ft	6,385	46,310	1,163	77.5	287	1,353	601	19.6
6,390 Ft	6,390	48,245	993	71.3	334	1,341	635	19.0
6,410 Ft	6,410	53,534	427	52.9	494	855	470	11.0
No diversion	6,420	55,534	307	46.5	570	708	419	8.9

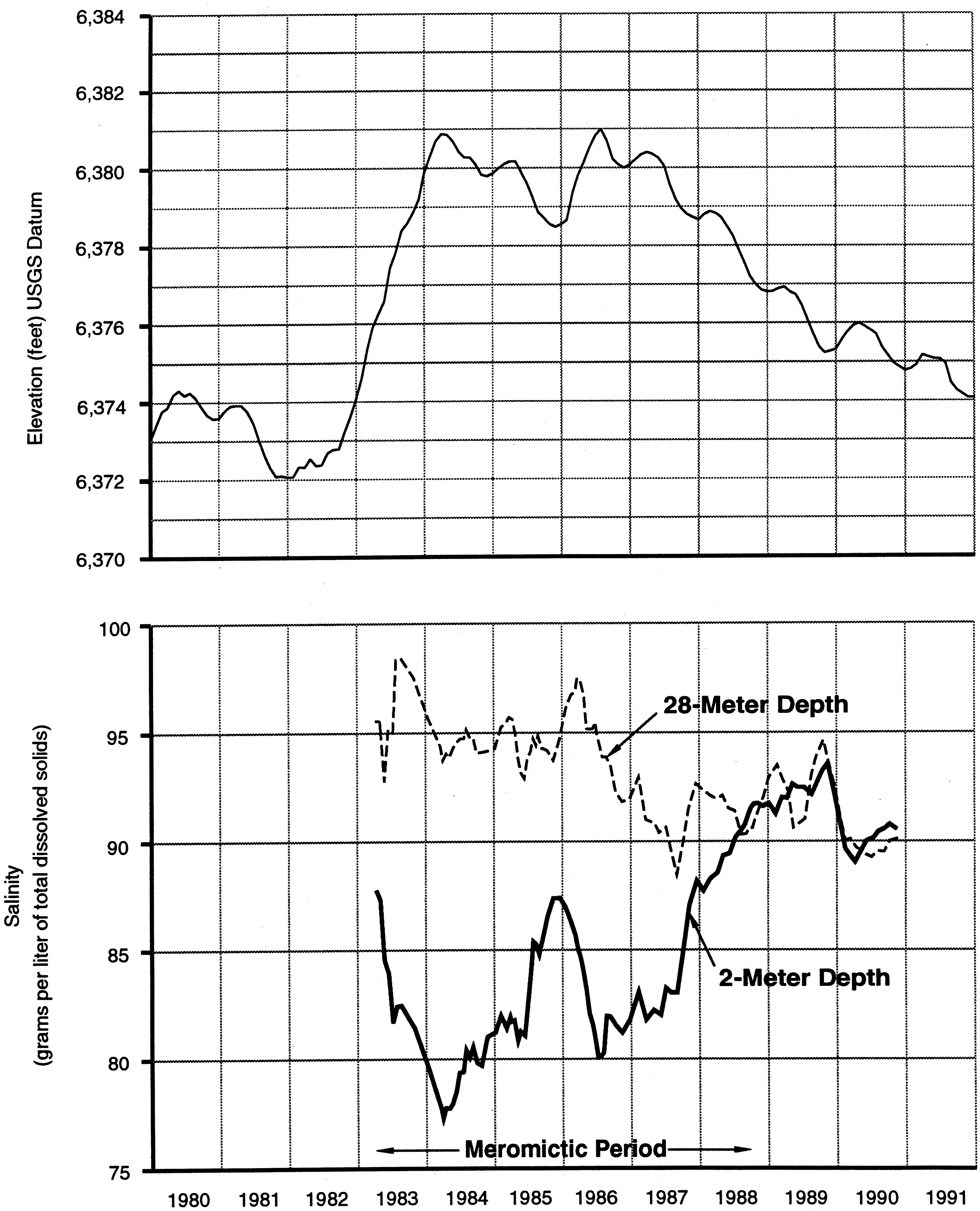
Table 3E-9. Brine Shrimp Impact Assessment Results

Alternative or Condition	Salinity (gl^{-1})	Volumetric: Ammonium Concentration ($mg\ N/m^3$)		Volumetric: Biomass ($mg\ N/m^3$)		Production (Areal Mean): Grams of Nitrogen per Square Meter per Year		Production (Areal Mean)	Production (Lakewide Total): Thousands of Metric Tons of Nitrogen per Lake per Year		Production (Lakewide Total)
		Epilimnetic	Hypolimnetic	Algae	Brine Shrimp	Algae	Brine Shrimp	Millions of Cysts per Square Meter per Year	Algae	Brine Shrimp	Trillions of Cysts per Lake per Year
Monomictic Conditions											
6,390 Ft[a]	71	249	34	460	68	31.38	4.5	2.57	6.14	0.88	503
6,383.5 Ft	80	260	38	467	59	30.9	4.04	1.98	5.69	0.74	364
6,377 Ft	89	273	41	475	50	30.96	3.84	1.55	5.23	0.64	263
Point of reference	92	278	42	477	47	30.8	3.62	1.41	5.03	0.59	231
6,372 Ft	97	286	43	480	42	31.12	3.53	1.21	4.67	0.52	182
No restriction	120	327	50	500	26	30.73	2.56	0.57	4	0.33	75
Meromictic Conditions											
6,390 Ft	71	891	15	127	61	17.22	3.93	2.75	3.47	0.79	555
6,383.5 Ft	80	906	22	146	55	17.37	3.59	2.12	3.35	0.69	408
6,377 Ft	89	926	28	160	49	17.38	3.28	1.58	3.17	0.6	289
Point of reference	92	932	30	161	46	17.41	3.22	1.46	3.08	0.57	261
6,372 Ft	97	948	28	160	43	17.42	3.13	1.29	2.93	0.53	218
No restriction	120	1,008	28	169	28	17.43	2.45	0.68	2.37	0.33	92

[a] Prediversion conditions assumed to be the same as monomictic conditions under the 6,390-Ft Alternative.

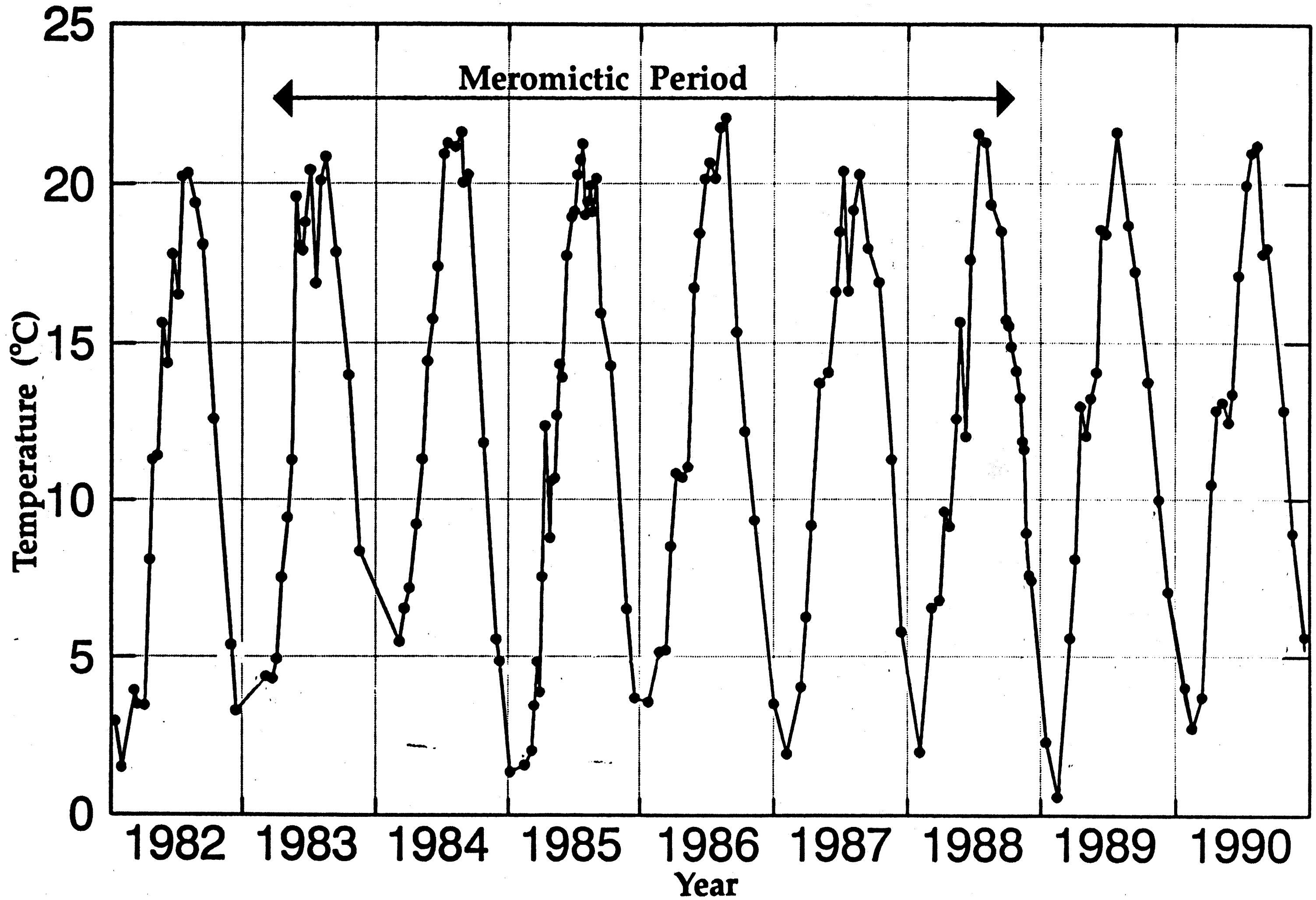
Table 3E-10. Simulated Biomass, Production, and Cyst Production of Brine Shrimp as Affected by Salinity and Habitat Area Only (i.e., No Nitrogen Pool Interaction)

		Volumetric	Production (Areal Mean)		Production (Lakewide Mean)	
Alternative or Condition	Salinity (gl^{-1})	Brine Shrimp	Brine Shrimp	Millions of Cysts per Square Meter per Year	Brine Shrimp	Trillions of Cysts per Lake per Year
6,390 Ft	71	120	8.67	5.13	1.69	1,005
Point of reference	92	40	3.07	0.89	0.5	146
No restriction	120	7	0.54	0.05	0.07	6



Source: Adapted from Jellison and Melack 1991

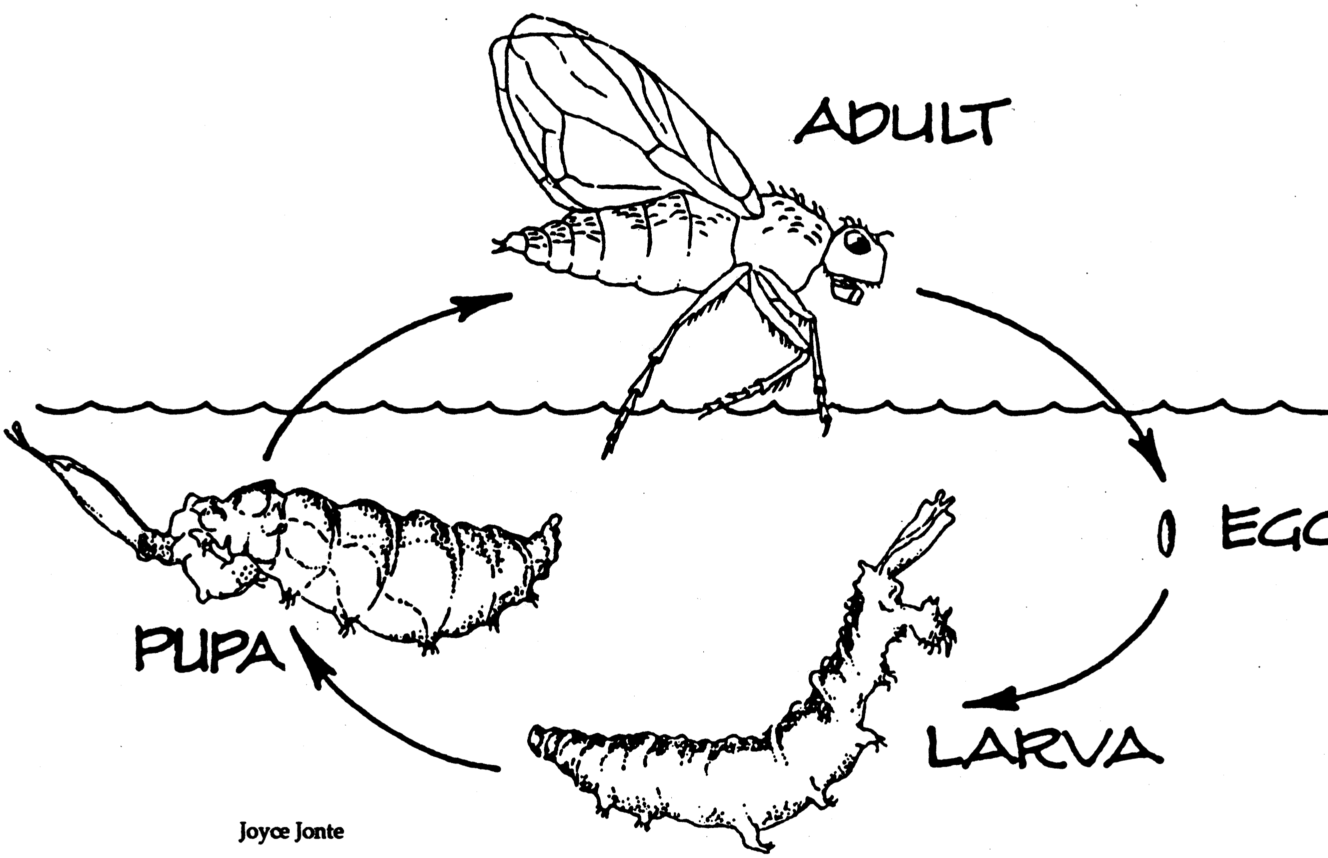
Figure 3E-1.
Meromixis of Mono Lake, 1983-1988



Note: Temperatures measured at depth of 2 meters.

Source: Adapted from Jellison and Melack 1992

Figure 3E-2.
Annual Epilimnetic Temperature Variation in Mono Lake, 1982-1990



Source: Adapted from Gaines 1981

Figure 3E-3.
Life Cycle of the Mono Lake Alkali Fly

Figure 3E-4.
Growth of the Mono Lake Alkali Fly at 20°C

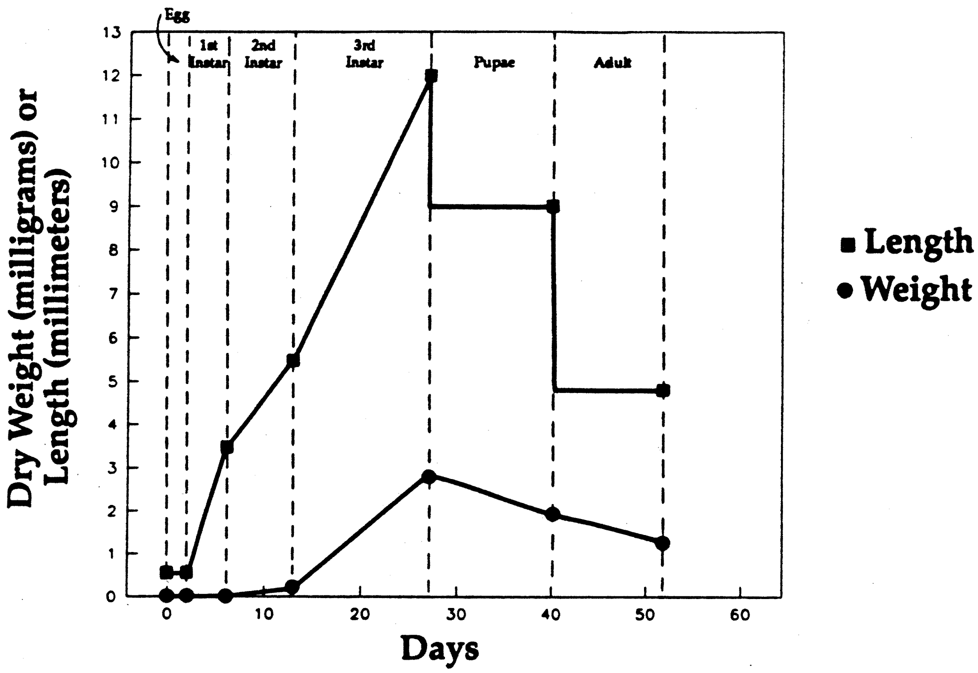
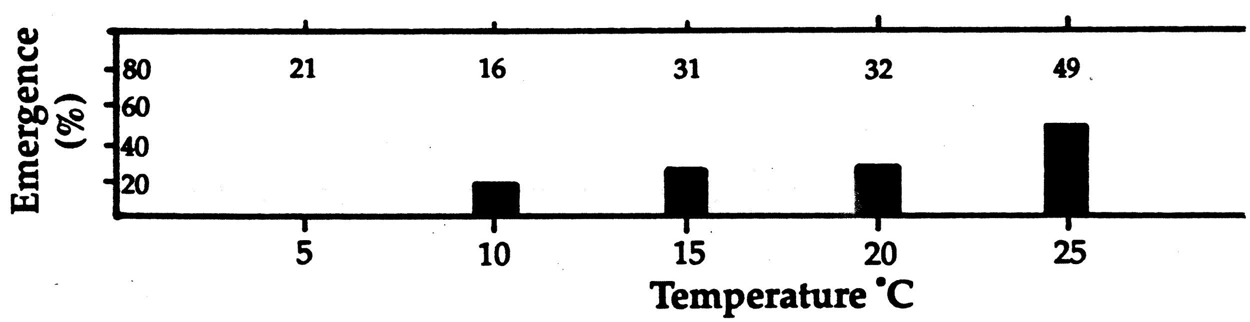
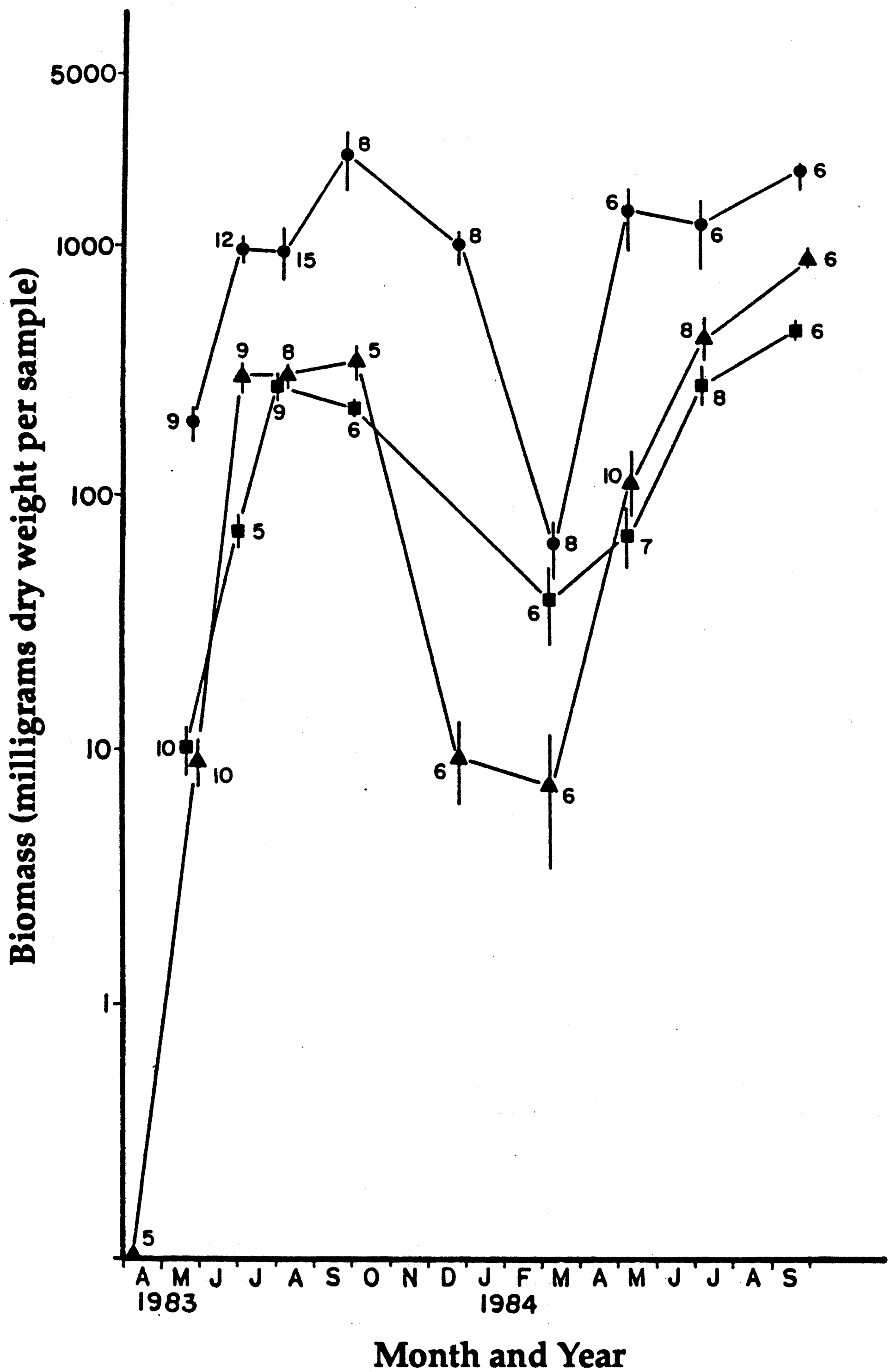


Figure 3E-5.
Percent of Mono Lake Alkali Fly Adults Emerging Successfully from Pupal Stage at Different Experimental Temperatures



Note: Numbers above each bar indicate the sample sizes.

Source: Adapted from Herbst 1986

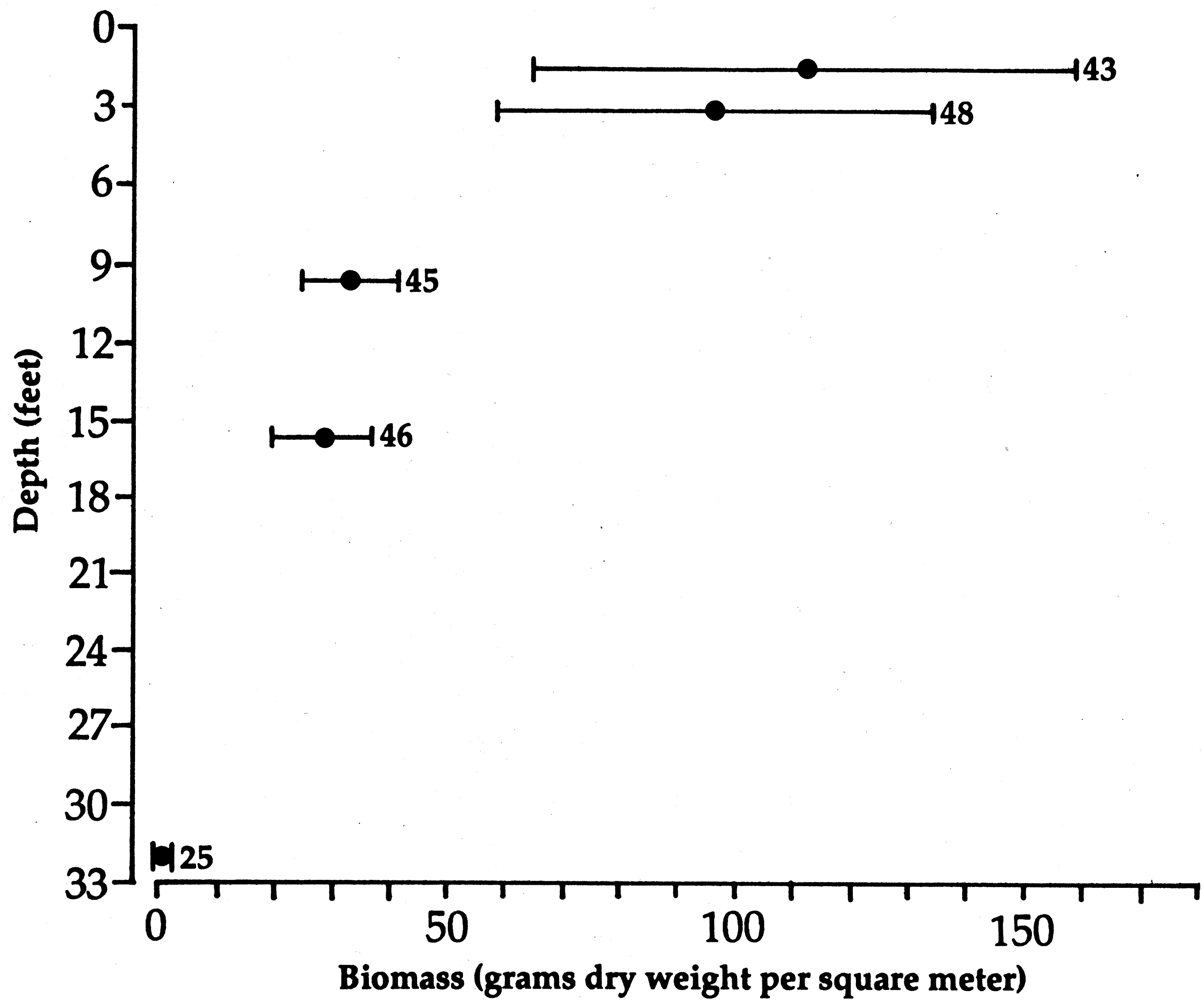


Notes: Numbers beside each point indicate the sample sizes. Vertical lines represent one standard error on either side of the mean. Data are from three sites in the western embayment.

Source: Adapted from Herbst 1986

Figure 3E-6.
Seasonal Variations in Biomass Abundance of the Mono Lake Alkali Fly, 1983 and 1984

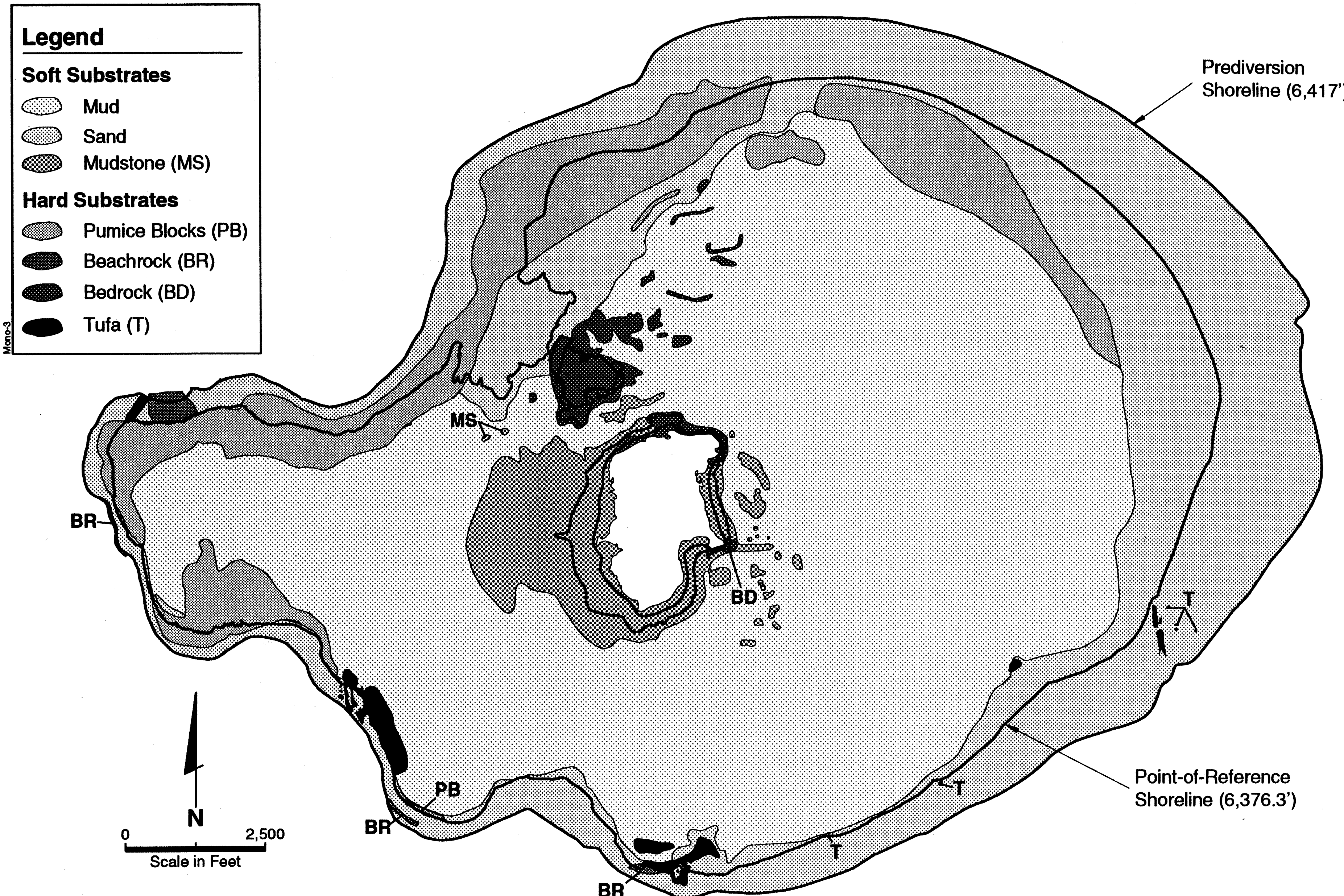
MONO BASIN EIR
Prepared by Jones & Stokes Associates



Notes: Horizontal bars represent 95% confidence intervals of mean.
Numbers next to each bar indicate the sample sizes.

Source: Adapted from Herbst and Bradley 1990

Figure 3E-7.
Biomass of Mono Lake Alkali Fly, Larvae, and Pupae on Hard Substrates at Different Depths

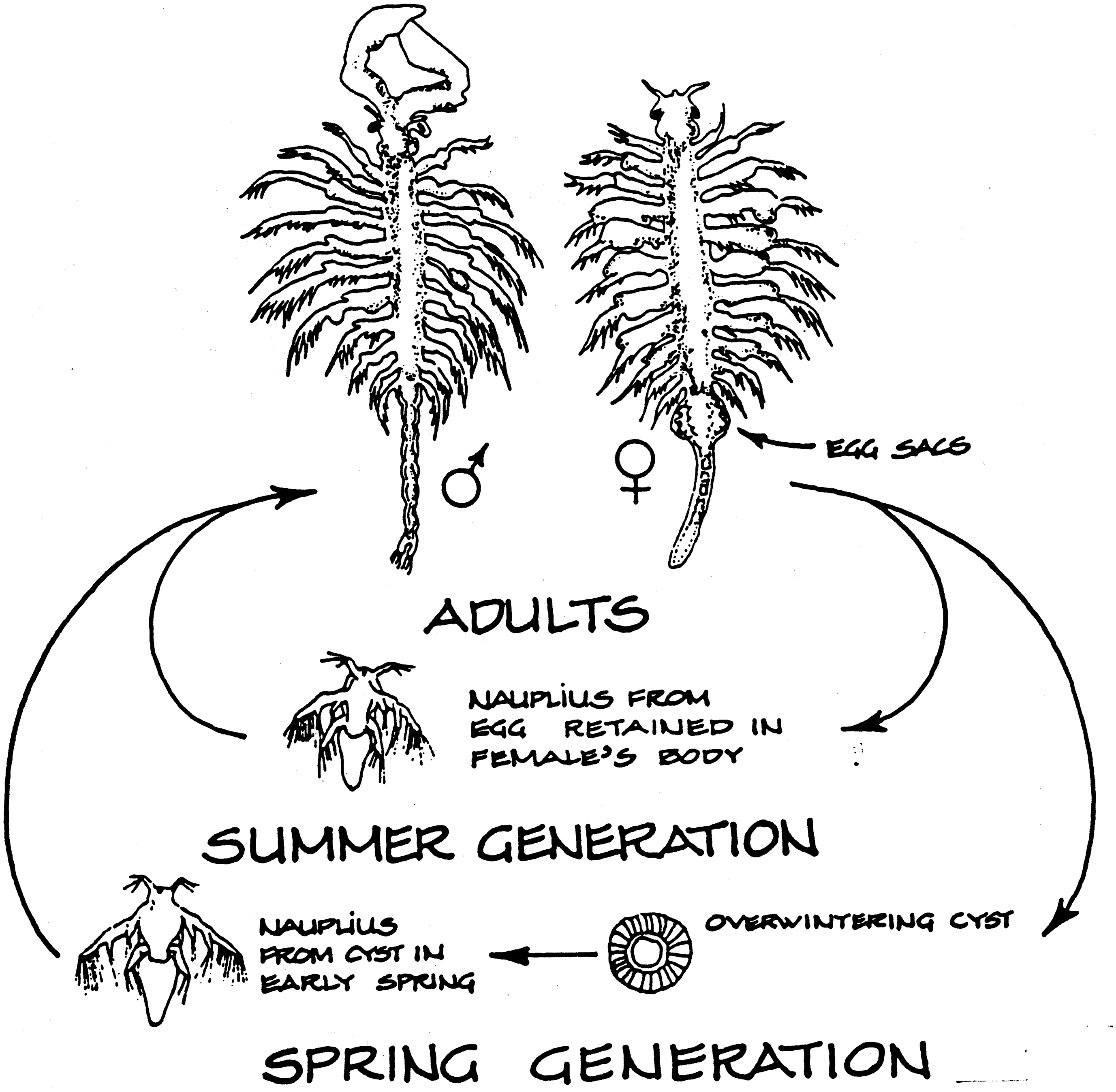


Source: Stine 1992

Figure 3E-8.
Substrates at Mono Lake

MONO BASIN EIR

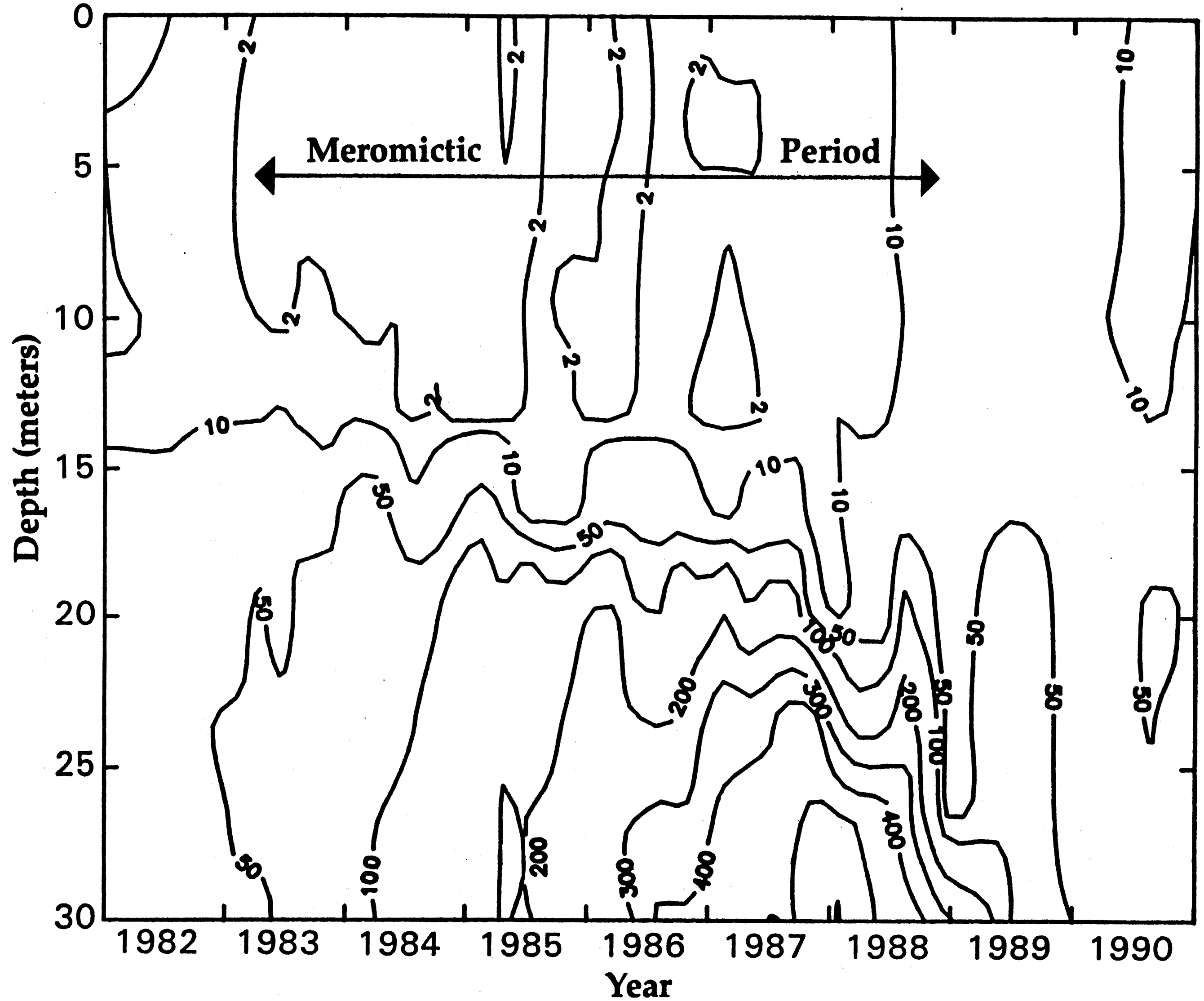
Prepared by Jones & Stokes Associates



Source: Adapted from Gaines 1981

Figure 3E-9.
Life Cycle of the Mono Lake Brine Shrimp

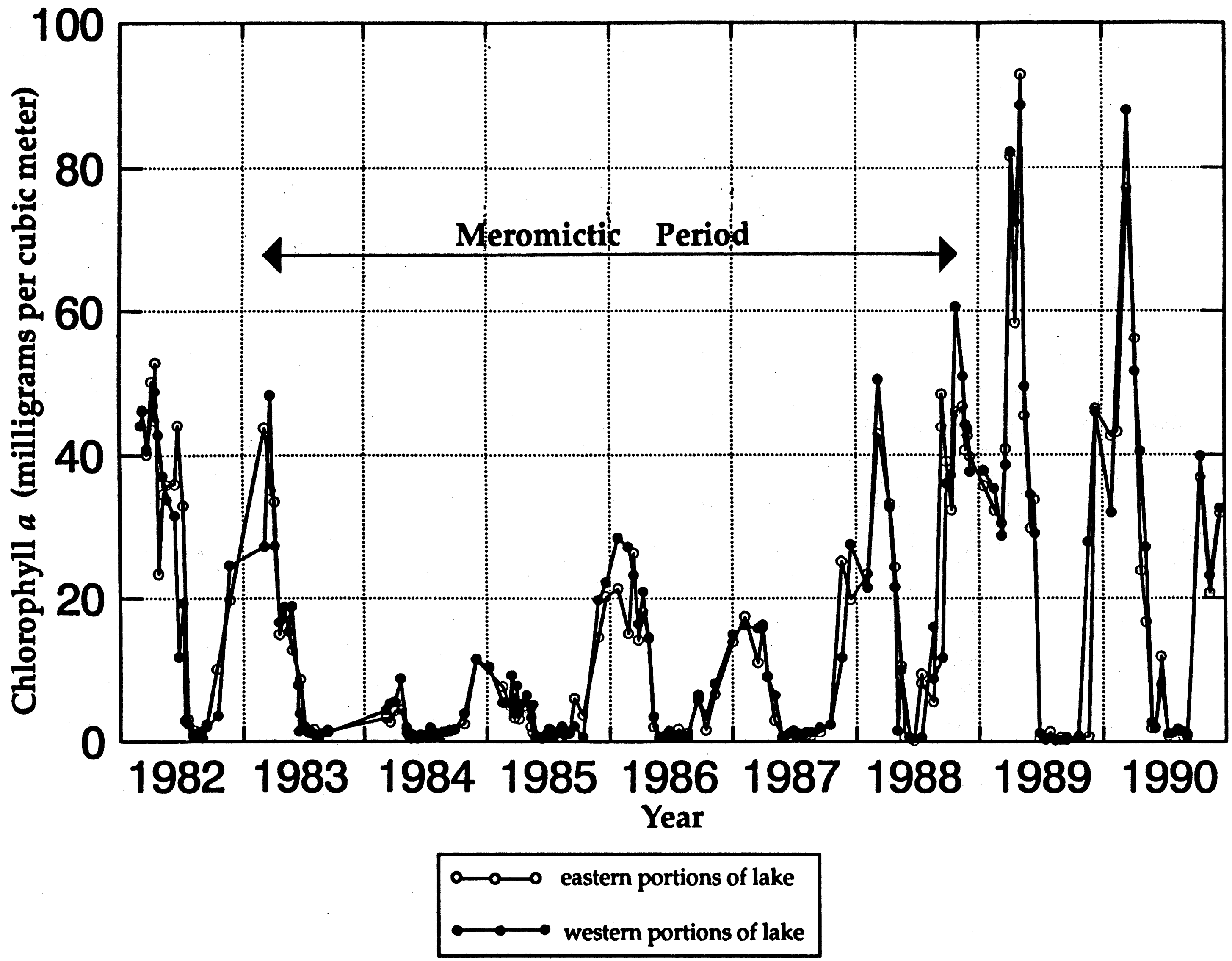
MONO BASIN EIR
Prepared by Jones & Stokes Associates



Note: Values within graph are ammonium concentrations in micromoles per liter.

Source: Adapted from Jellison, Dana, and Melack 1991

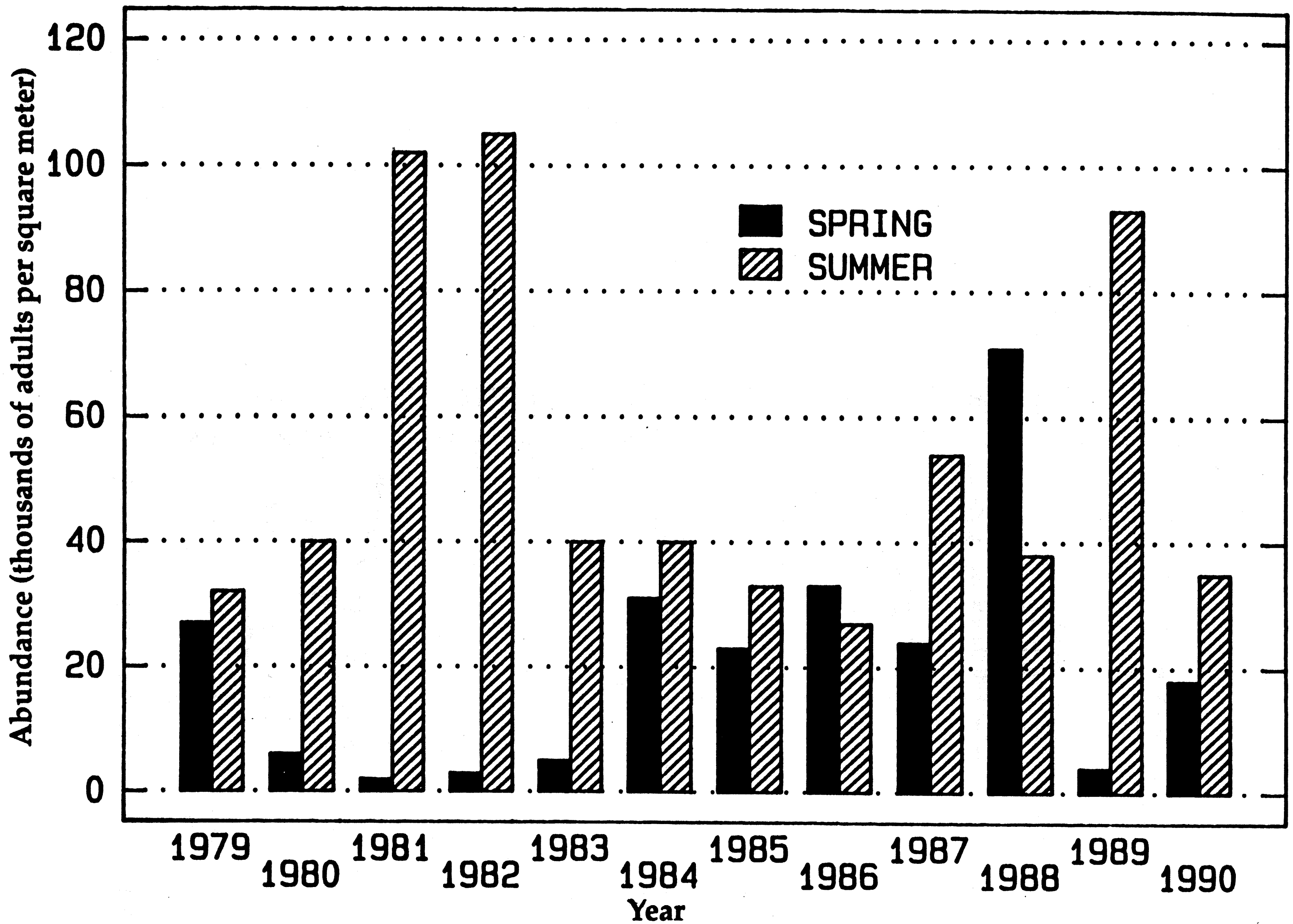
Figure 3E-10.
Contours of Equal Ammonium Concentrations in Mono Lake, 1982-1990



Source: Adapted from Jellison and Melack 1992

Figure 3E-11.
Annual Variations in Chlorophyll *a* Concentration in the Mixed Pelagic Layer, 1982-1990

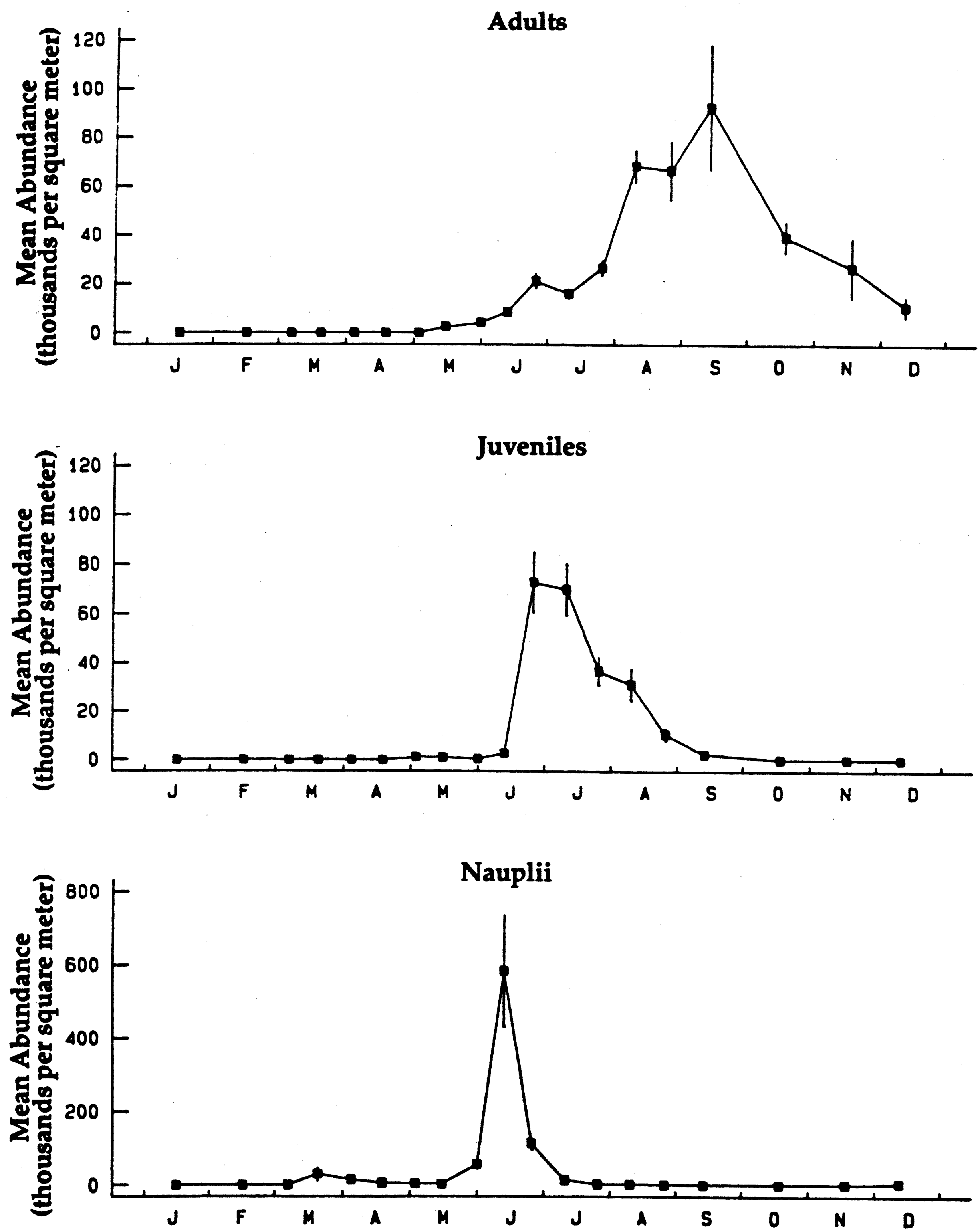
MONO BASIN EIR
Prepared by Jones & Stokes Associates



Source: Adapted from Jellison, Dana, Romero, and Melack 1991

Figure 3E-12.
Peak Abundance of Adult Mono Lake Brine Shrimp, 1979-1990

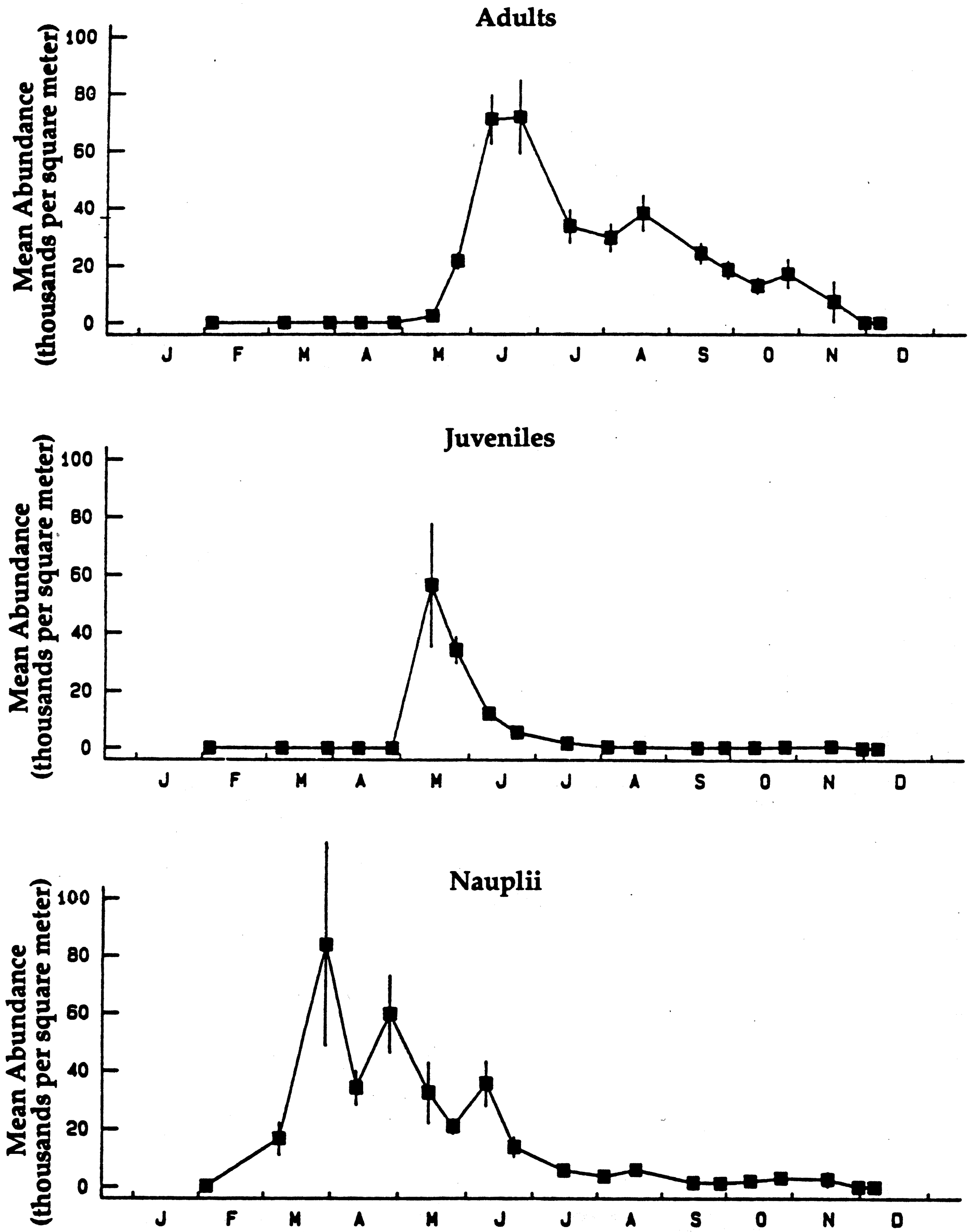
MONO BASIN EIR
Prepared by Jones & Stokes Associates



Note: Vertical lines represent one standard error on either side of the mean.

Source: Jellison, Dana, and Melack 1990

Figure 3E-13.
Mono Lake Brine Shrimp Abundance in 1989



Note: Vertical lines represent one standard error on either side of the mean.

Source: Jellison, Dana, and Melack 1989b

Figure 3E-14.
Mono Lake Brine Shrimp Abundance in 1988

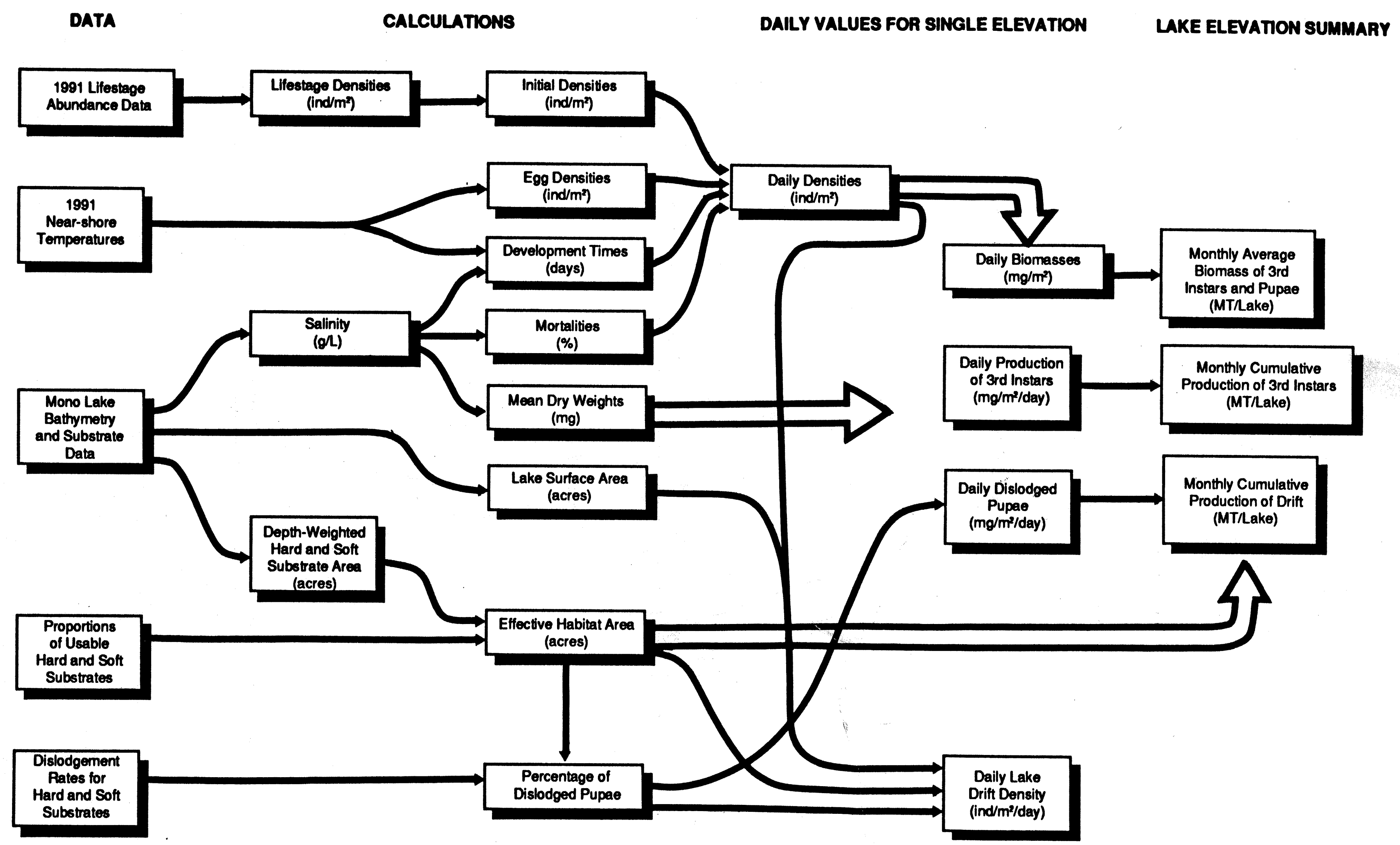
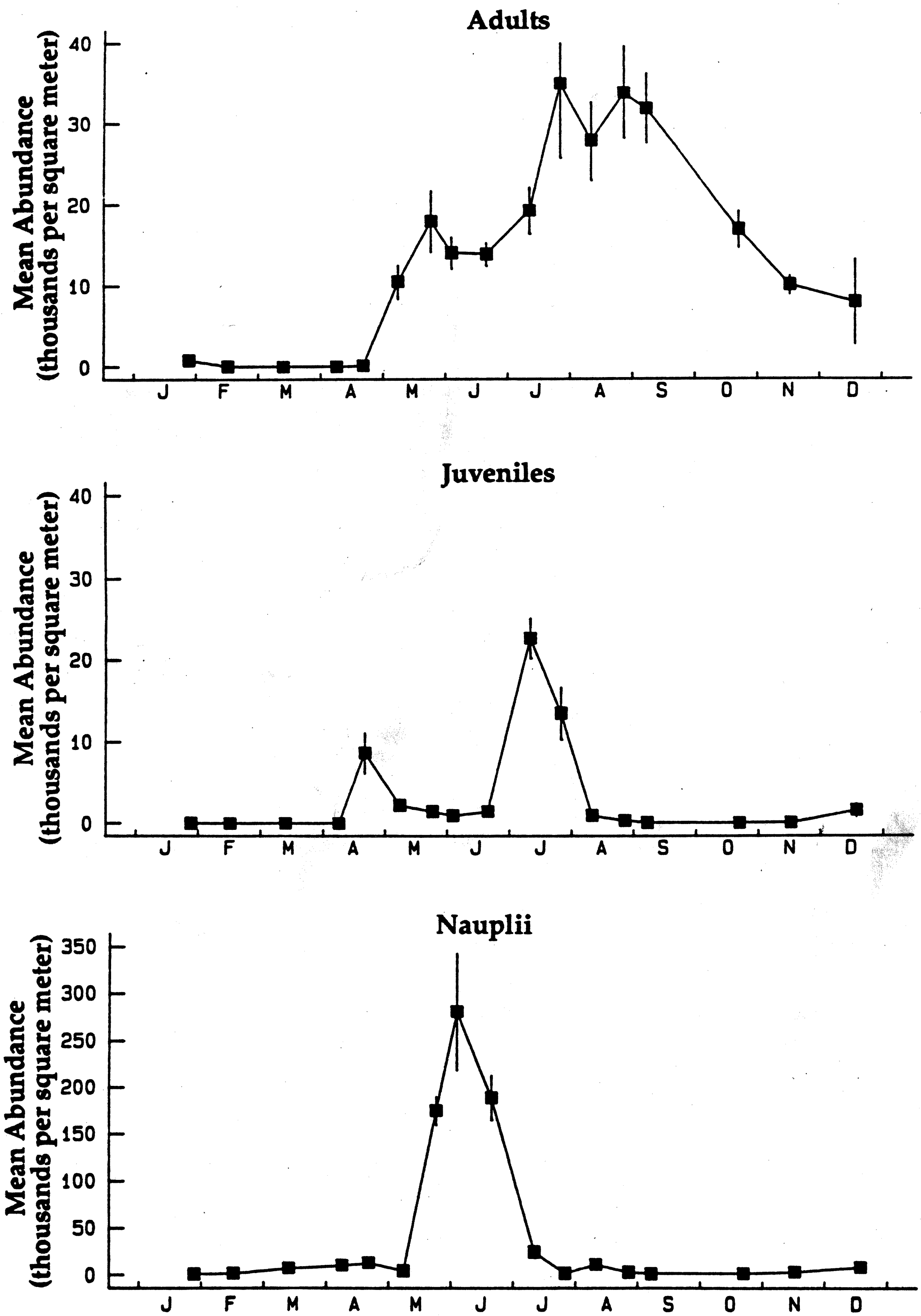


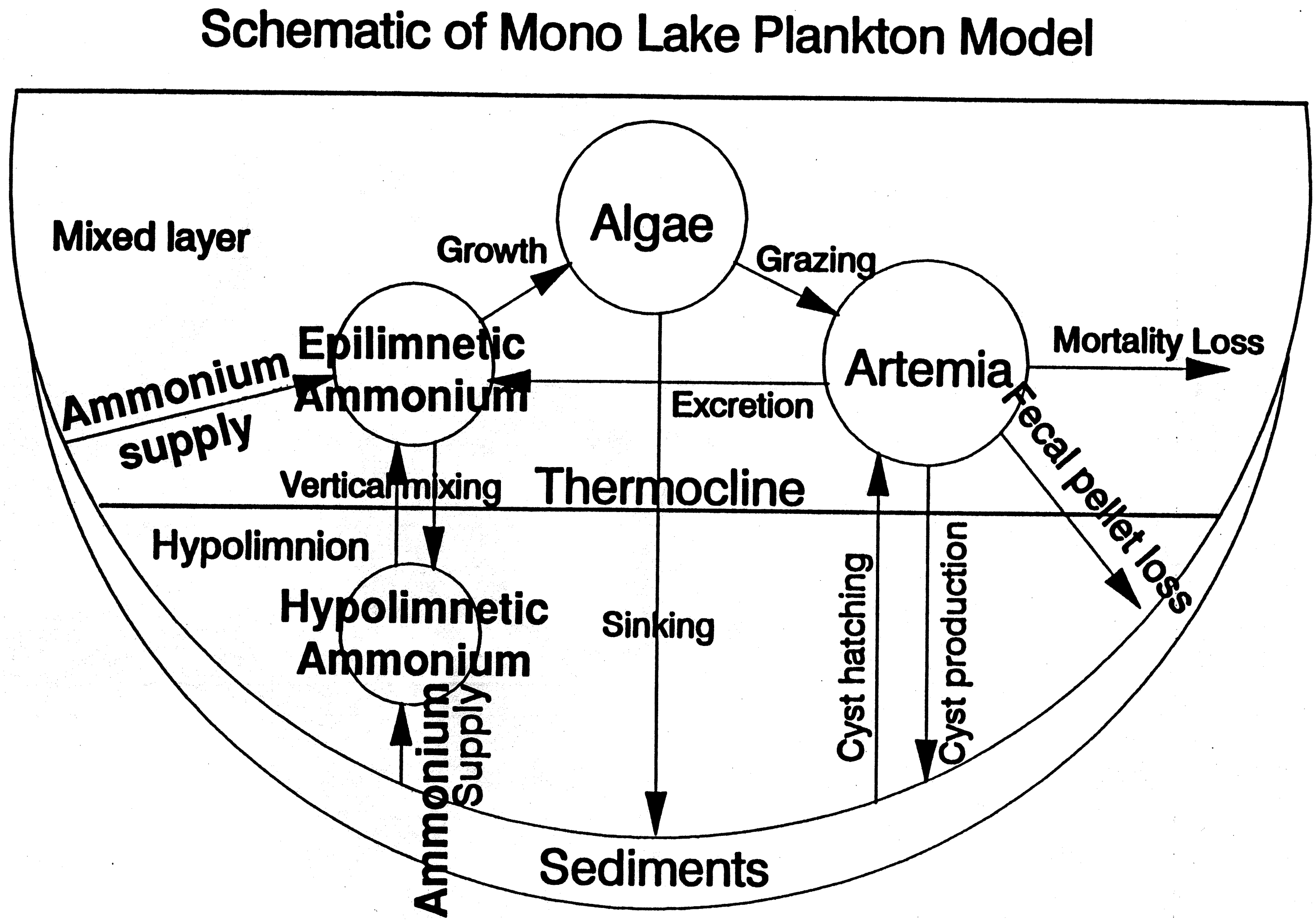
Figure 3E-16.
Schematic of Alkali Fly Productivity Model



Note: Vertical lines represent one standard error on either side of the mean.

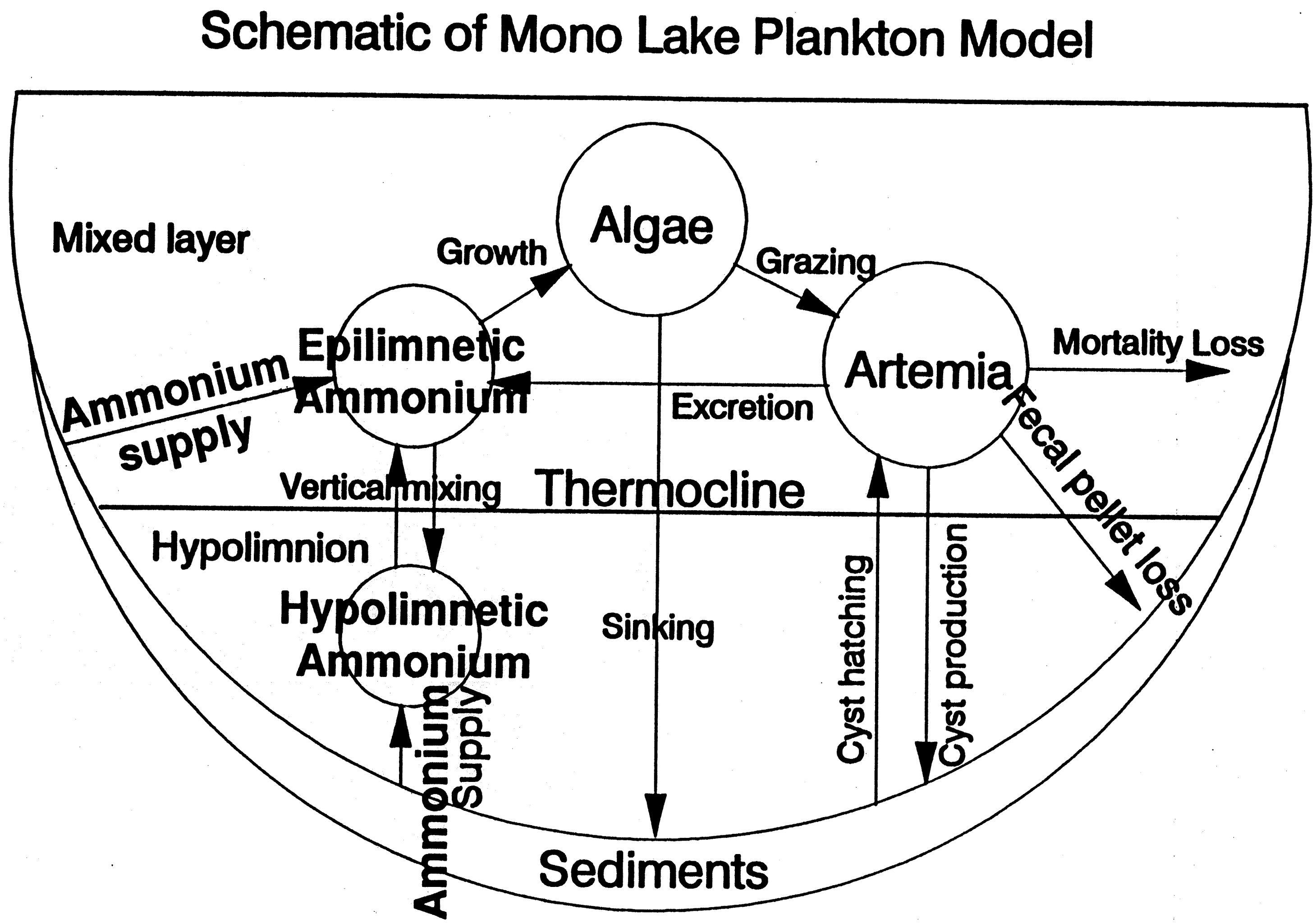
Source: Jellison, Dana, and Melack 1991

Figure 3E-15.
Mono Lake Brine Shrimp Abundance in 1990



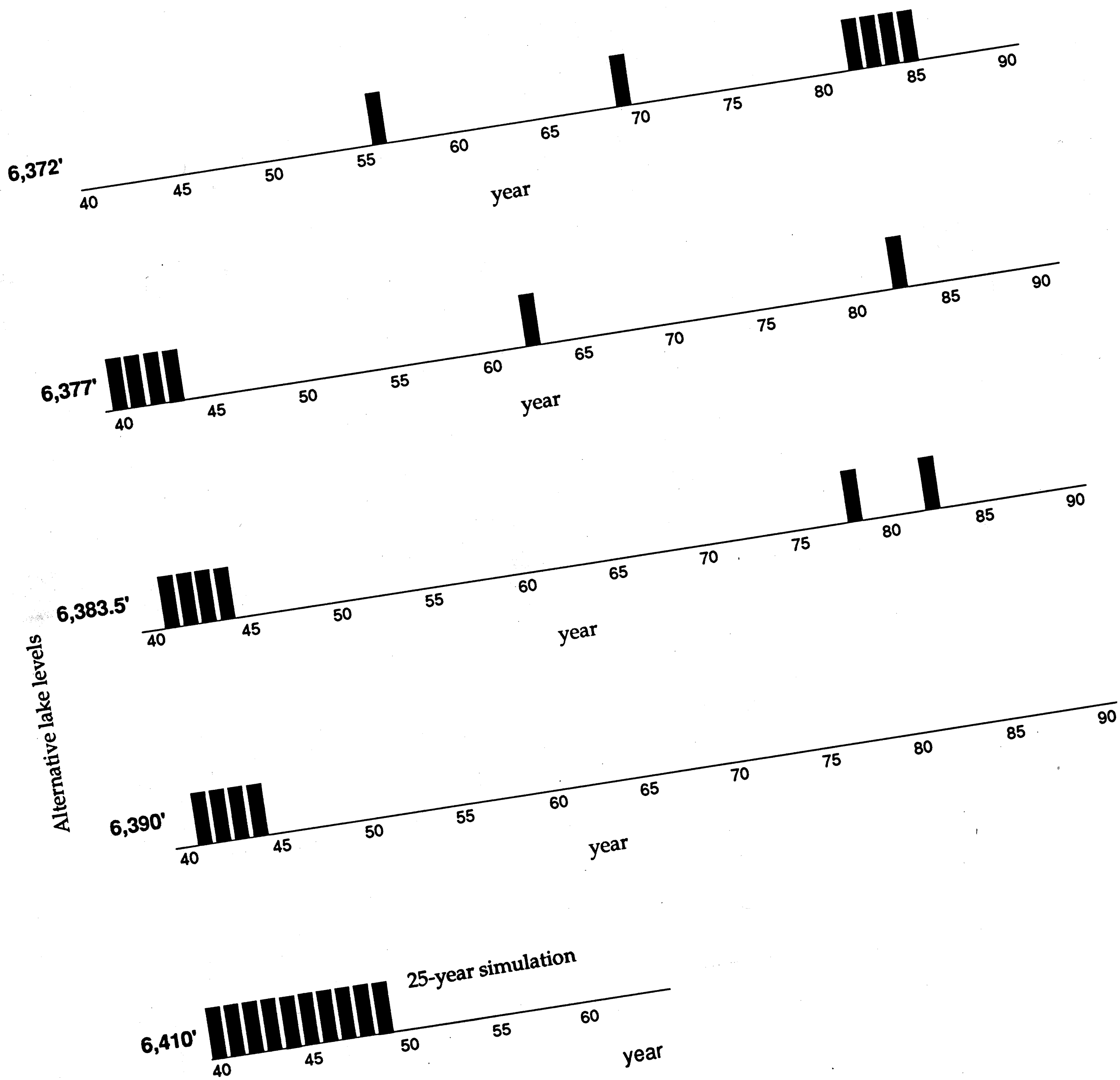
Source: Dana, Jellison, Romero, and Melack 1992

Figure 3E-18.
Schematic of Brine Shrimp Nitrogen Submodel



Source: Dana, Jellison, Romero, and Melack 1992

Figure 3E-18.
Schematic of Brine Shrimp Nitrogen Submodel



Source: Adapted from Dana, Jellison, Romero, and Melack 1992

Figure 3E-19.
DYRESM Predictions of Meromictic Years

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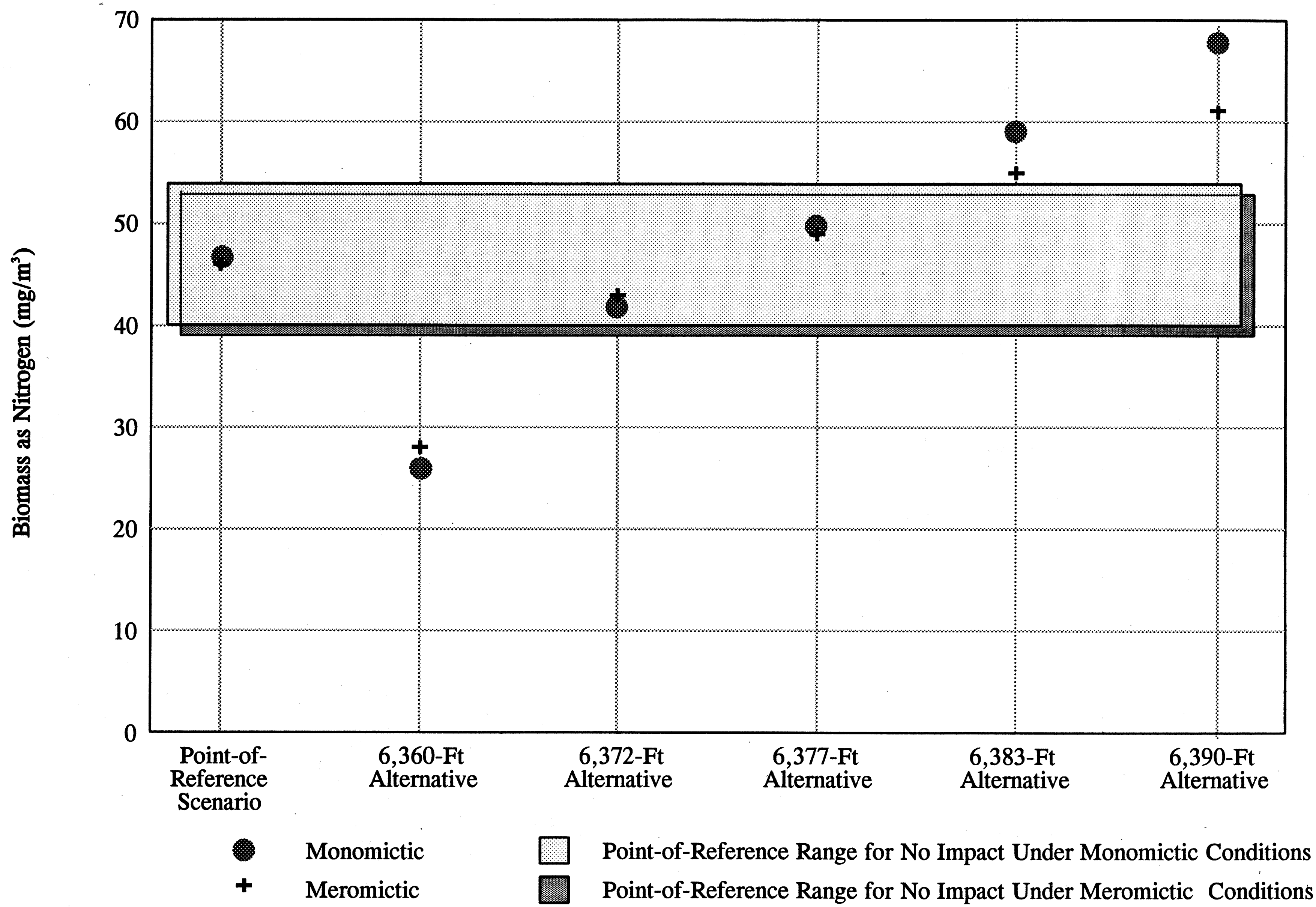

Figure 3E-20.
Predicted Brine Shrimp Biomass

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Figure 3E-21a.
Predicted Brine Shrimp Production
Areal Means

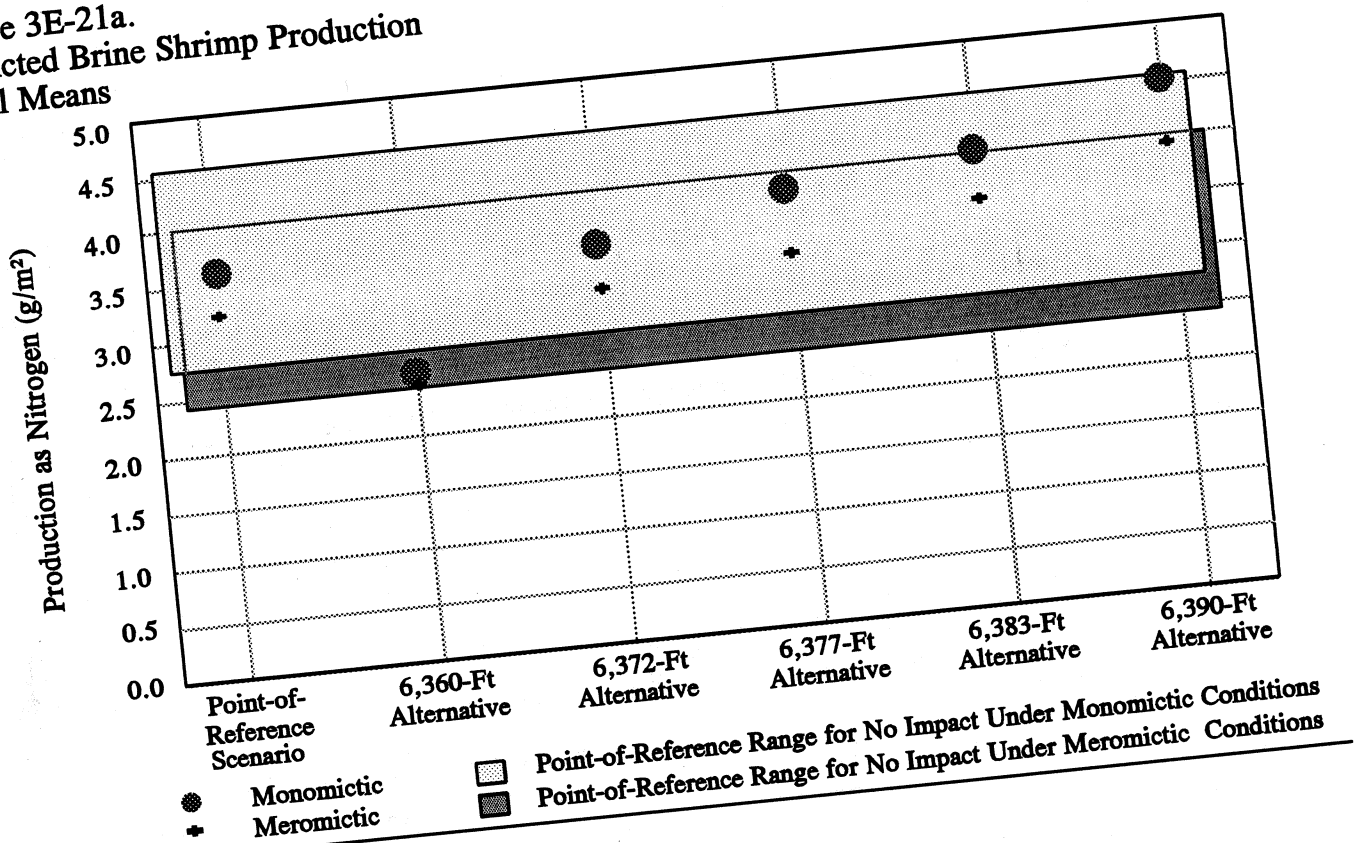


Figure 3E-21b.
Predicted Brine Shrimp Production
Lakewide Totals

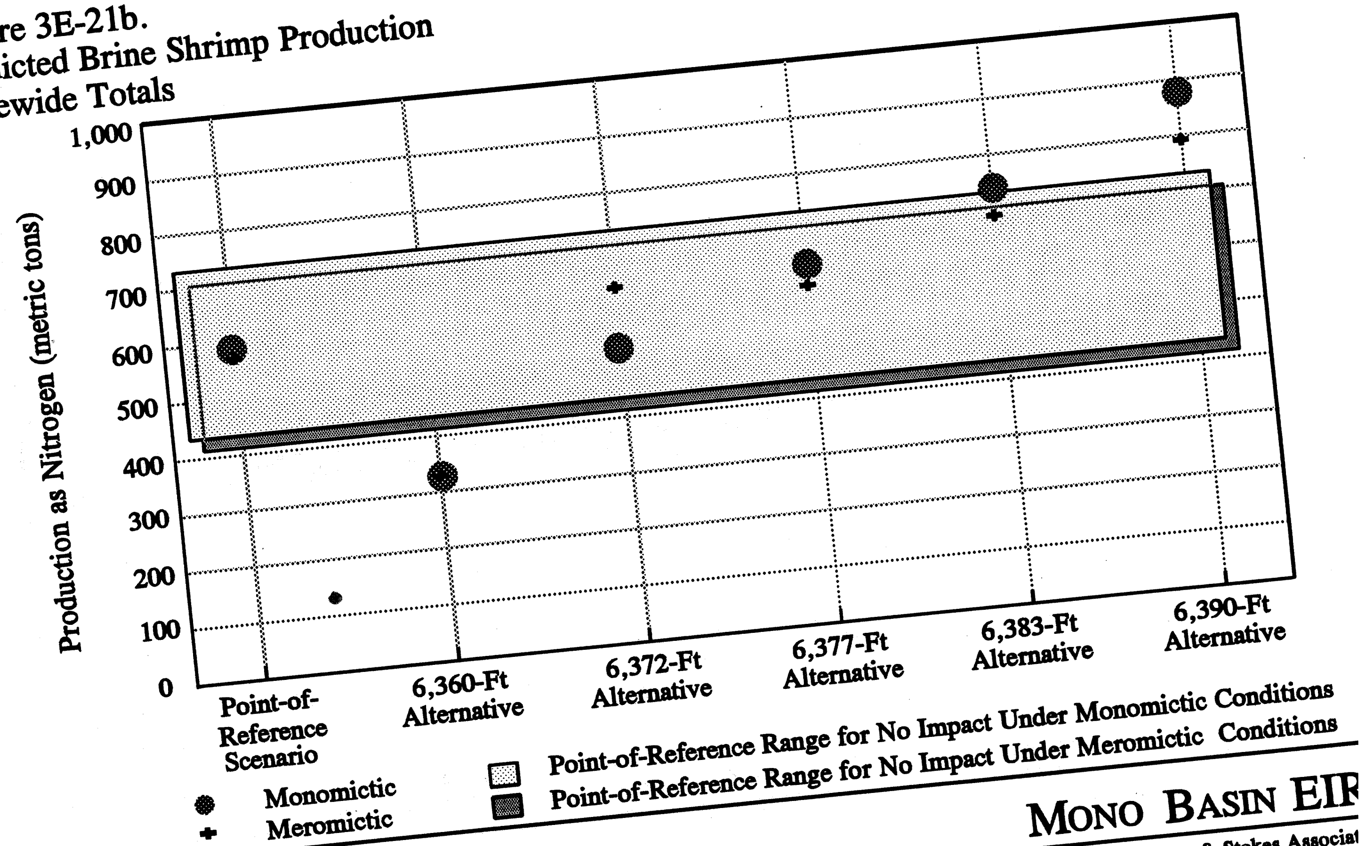


Figure 3E-22a.
Predicted Brine Shrimp Cyst Production
Areal Means

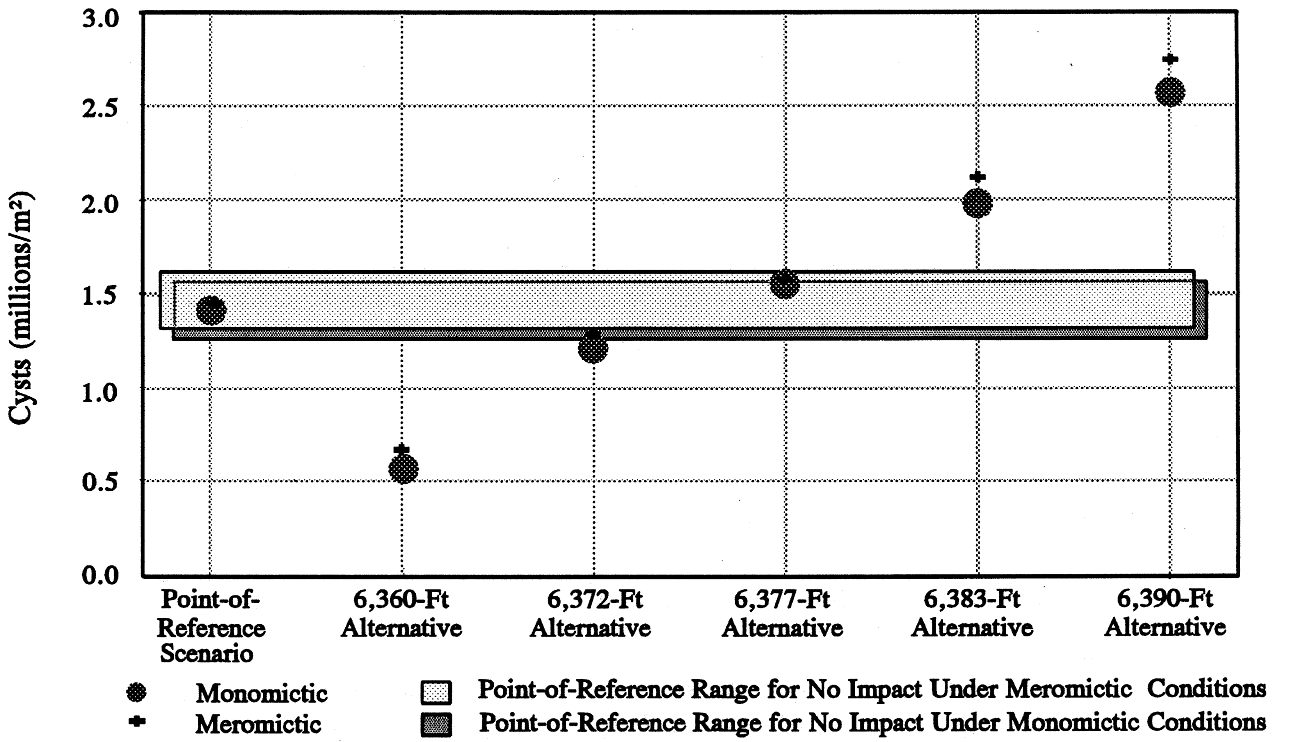
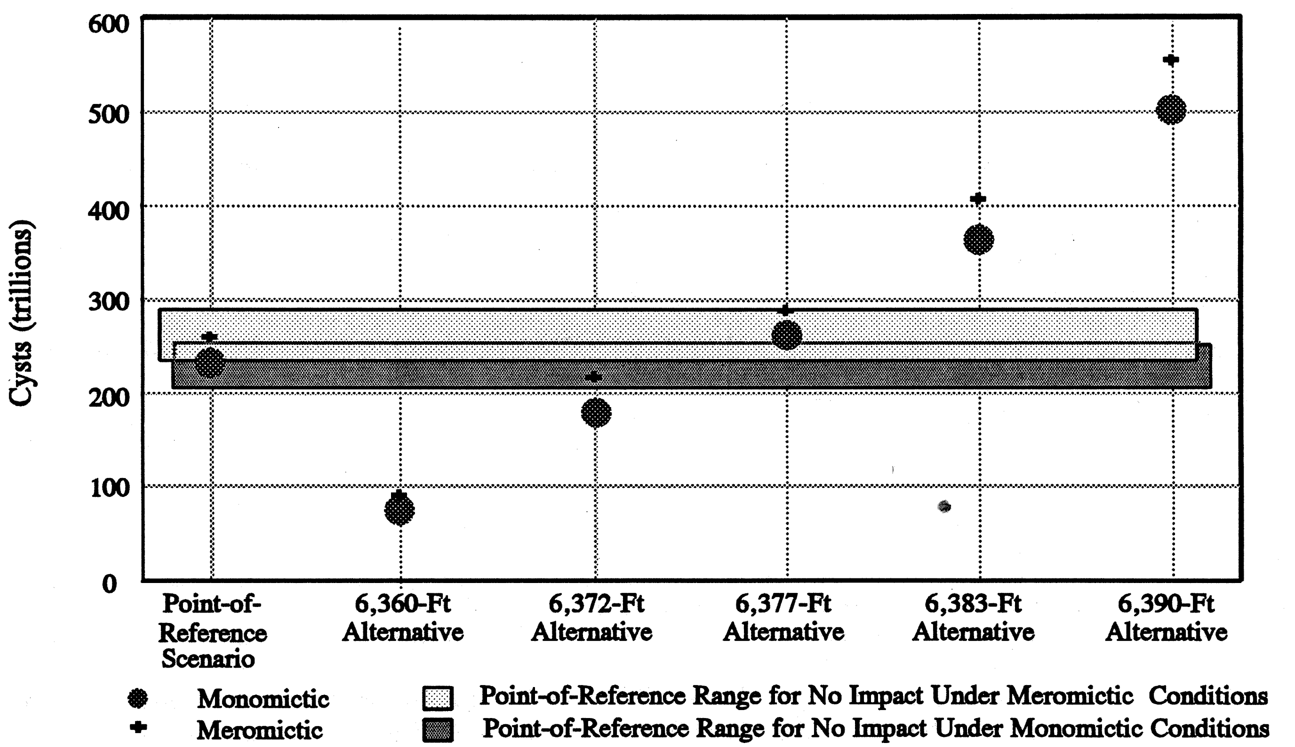
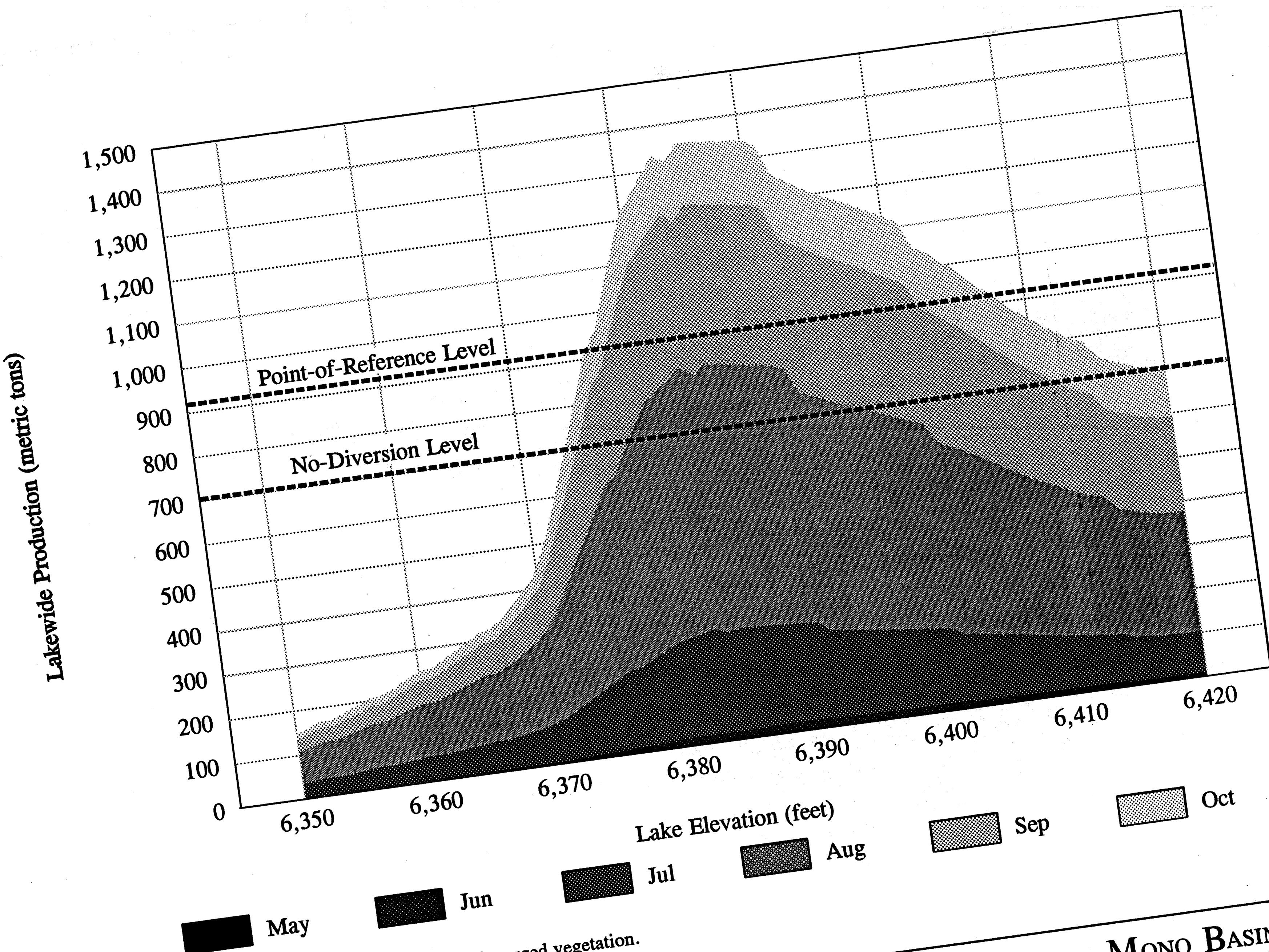


Figure 3E-22b.
Predicted Brine Shrimp Cyst Production
Lakewide Totals





Notes: Predictions do not include potential effects of submerged vegetation.
Little production occurs in May and June due to low temperatures.

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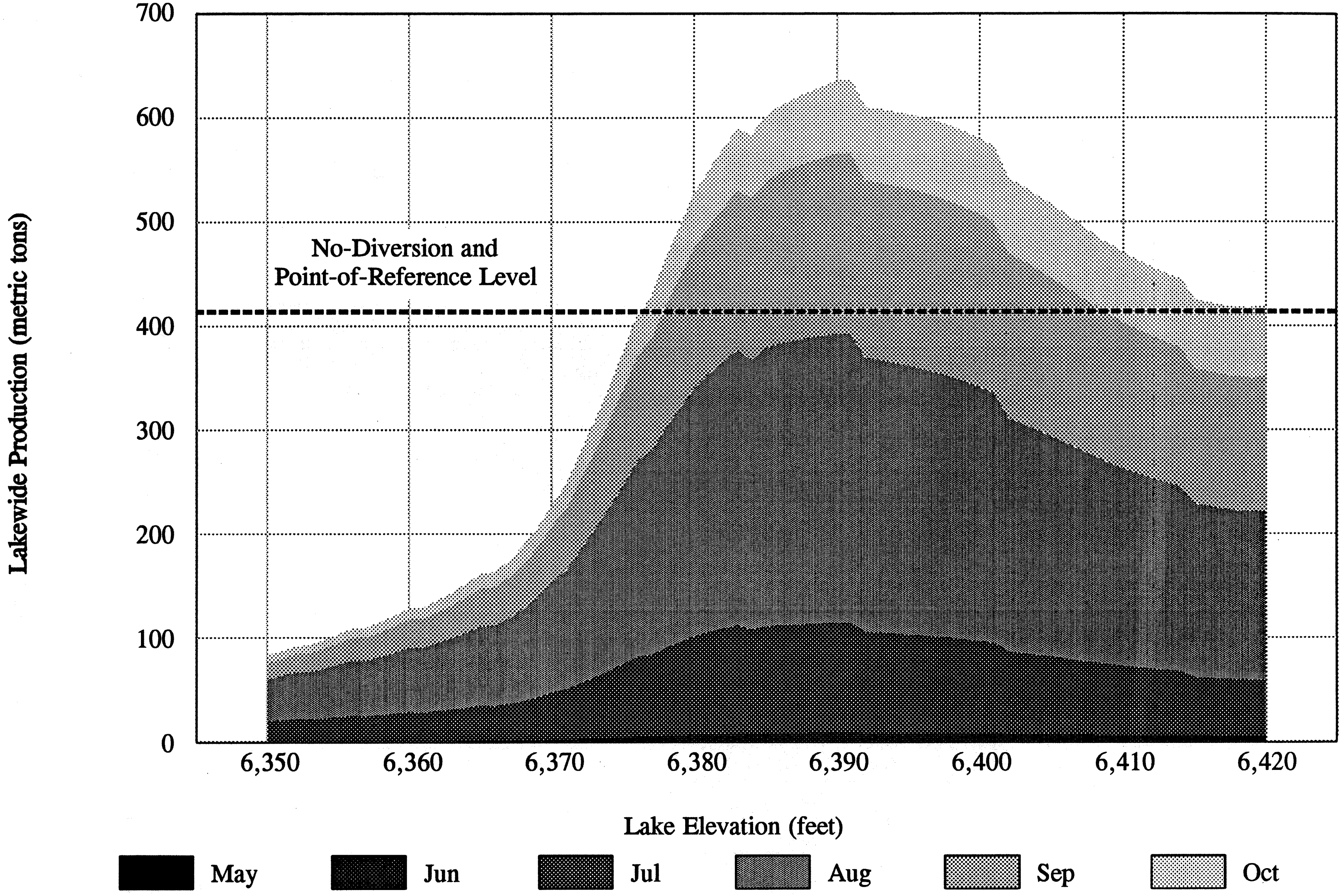
Figure 3E-23. ... Production of Pupating Third Instar Alkali Fly Larvae



Notes: Predictions do not include potential effects of submerged vegetation.
Little production occurs in May and June due to low temperatures.

Figure 3E-24.
Predicted Lakewide Production of Alkali Fly Drift

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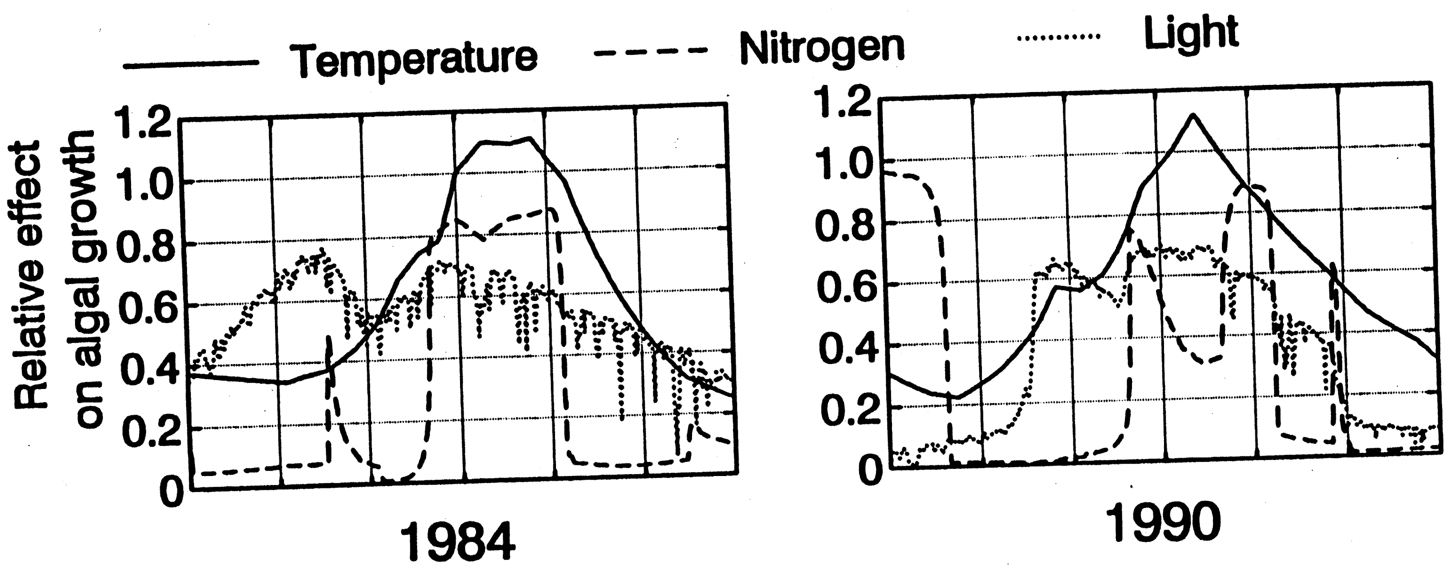
Prepared by Jones & Stokes Associates



Source: Dana, Jellison, Romero, and Melack 1992

Figure 3E-25.
Potential Growth of Algae (Relative to Maximum Growth at 20°C) in 1984 and 1990 when Controlled by Temperature, Nitrogen Concentration, or Light Level Alone