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 statewide 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 µg/l, with an average of 5.8 µg/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 Fg/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 Fg/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 µg/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 µg/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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