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 lake-bed. 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-andwhite 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.

WalkerCreek. 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 lakeshore 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 riverbanks 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 prediversion 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 ground-water 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 interrelationships 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 stream-flow, 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.

Summary of Benefits and Significant Impacts and Identification of Mitigation Measures

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-broad-leaf 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.

WillowScrub 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 live-stock 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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