APPENDIX G

Baseline Considerations

Baseline Considerations

Several non-mining related factors have historically impacted water, land, and associated biological resources in the Upper Arkansas River Basin. Some of these factors may continue to exert impacts on the environment today. The principal non-mining influences include flow regulation, livestock grazing, highway and railroad impacts, and timber harvest.

Reach 0: Above California Gulch

Flow Regulation

Stream flow in this reach is augmented by water imported to both Tennessee Creek and the Upper East Fork. Flow augmentation to Tennessee Creek occurs via the Ewing Ditch, Wurtz Ditch, and Wurtz Ditch Extension, while the Upper East Fork receives flow augmentation from the Columbine Ditch (URS 1998). These ditches generally augment flows into the Upper Arkansas River by as much as 15-22 % of the total streamflow. The most significant impact of flow regulation on natural river hydrology is as much a result of patterns of release as the volume of water released. Rapid fluctuations in flows, for example, will disrupt natural hydrological and geomorphological processes causing riverbank instability and substantial sedimentation. While the Bureau of Reclamation attempts to minimize rapid fluctuations in flows, URS (1998) reported a reduction in daily streamflow of more than 25% 270 times between 1970 and 1994. Currently, the Bureau of Reclamation is attempting to develop "ramping" rates for increasing and decreasing flows. However, over the past three decades, flow augmentation in this reach has likely had (not continuously but on various occasions) a significant impact on hydrological and geomorphological processes in the Upper East Fork and Tennessee Creek.

A fundamental question is the extent to which flow regulation impacts abiotic and biotic resources in riverine systems. Scheidegger and Bain (1995) studied larval fishes in the Tallapoosa River, a highly flow-regulated river, and the Cahaba River, an unregulated river, in Alabama. Dominant families were Catostomidae, Cyprinidae, Percidae, and Centrarchidae. Flow regulation appeared to: 1) reduce the abundance of larval fish in nursery habitat; 2) alter taxonomic composition at the family level; and 3) disrupt microhabitat relations seen in families occupying unregulated rivers.

Converse et al. (1998) studied subadult humpback chub (Gila cypha) densities along 24 kilometers of the Colorado River in the Grand Canyon. One of their objectives was to determine how discharge, during base flow conditions, was related to subadult humpback chub habitat conditions. They concluded the following: 1) habitat conditions varied significantly with discharge for certain shoreline types; 2) mean shoreline depth and velocity increased with increasing discharge, whereas mean cover decreased; 3) subadult chubs appear to quickly disperse and preferentially use specific shoreline types along the river corridor, while avoiding others; 4) densities were highest in vegetated shorelines, followed by talus and debris fan shorelines; and 5) consequently, higher base-flows, which occur a greater proportion of the time in the current flow regime, may reduce subadult chub habitat quality in natural habitats compared with base-flows during pre-dam conditions.

In addition to impacting fish populations and communities, flow regulation may also significantly impact invertebrate abundance, on which salmonids typically depend for most of their diet. Blinn et al. (1995) examined the effects of fluctuating discharge for lotic communities in the Colorado River below Glen Canyon Dam. Some important conclusions included: 1) Periods of daily desiccation and freezing during river fluctuation significantly limited community biomass and energy. The permanently submerged channel supported a mean annual macroinvertebrate standing crop biomass 4 times that of the varial zone. 2) Cladophora glomerata exhibited a 50% reduction in biomass after 2 days of repeated 12-hour summer exposure. Five days of repeated exposure resulted in >70% reduction in C. glomerata and >50% reduction in epiphyton biomass. The same trend continues for both algae and epiphyton biomass with increased exposure and extreme water fluctuations. 3) Recolonization by C. glomerata, Gammarus lacustris, and chironomid larvae was extremely slow (≤ 30% of controls after 4 months) compared with gastropod densities (equaled control cobbles within 1 week) on resubmerged cobbles that were subjected to long-term desiccation. Hence, two 12-hour exposure periods may require greater than 4 months for recovery to achieve the mass of permanently submerged benthos. 4) Discharge maintained at 793 m^3/s is estimated to provide nearly twice the energy in the form of macroinvertebrate biomass at Lees Ferry (15.5 ha) than flows of 142 m^3/s. Consequently, trout biomass was predicted to increase by 42.5 kg/ha at Lees Ferry. 5) They emphasized that Gislason (1985) demonstrated that condition factors for salmon and rainbow trout were higher during periods of stable discharge than during periods of fluctuating discharge in the Skagit River, Washington. He attributed these differences to loss of shoreline insects and habitat during the fluctuations.

Malmquist and Englund (1996) examined the effects of hydropower-induced flow regulation on mayfly richness and abundance in north Swedish river rapids. Important conclusions included: 1) rivers impacted by regulation for hydropower had significantly reduced species richness and abundance of mayflies; 2) type of regime (unregulated, reduced flow, regulated but unreduced flow) significantly influenced mayfly abundance, but not species richness; 3) heptageniids, baetids, ephemerellids and Caenis rivulorum became less abundant in response to flow reduction, and there were clear species level effects in response to flow regulation; 4) sites with high flow constancy, peaking flow, and reduced flow had lowered abundance of most species in comparison with reference sites; and 5) of 20 species occurring at both unregulated and regulated sites, 19 were significantly more common at the reference sites, whereas only one was more common at sites of regulated (but unreduced) flow.

Zhang et al. (1998) examined ecological processes affecting community structure of blackfly (Diptera: Simuliidae) larvae in 51 rapids of regulated and unregulated rivers in northern Sweden. Some important findings include: 1) Sites with high species richness and abundance were characterized by large numbers of small suspended particles (food resources), deep water color, high total phosphorus and nitrogen concentrations, high proportions of forest in the catchment, low frequencies of large flow increments, extended forest growth period, low cover of filamentous algae on the substratum, and low altitude. 2) Simuliid species richness and the total abundance at reduced-flow, regulated, sites were 25% and 50% higher, respectively than predicted. At regulated sites, the abundance of blackfly predators (spinet given) decreased by 35%, and those of assumed competitors, grazers and net-spinning caddis larvae, by 22% and 19%, respectively. 3) Particle concentrations were not significantly different between unregulated and regulated sites and they were positively related to blackfly species richness and abundance. 4) Results indicate that water flow changes greatly influence blackfly larvae. Predation pressure and competition is reduced, and recolonization after disturbance is rapid. Simuliid communities are a feature of disturbed sites and may be a useful indicator for evaluating the impact of flow regulation on river ecosystems.

Cereghino and Lavandier (1998) studied the influence of hydropeaking on distribution and population dynamics of mayflies in a mountain stream in the Pyrenees, France. They found that the lowest density and biomass was downstream of the power plant, suggesting a significant impact of hydropeaking on species abundance. For example, Rhithrogena semicolorata was abundant at all sites, but its density was reduced by 50% downstream from the plant. Below the plant, the flushing action of peaking flows substantially increased catastrophic drift effects on species abundance, with the greatest impact in autumn when the difference between natural and peak flows was greatest.

Finally, Nelson and Roline (1995) conducted a literature review and limited Arkansas River field studies in order to examine the impacts of various discharges on macroinvertebrate communities. General indications were that benthic organisms in the Arkansas River would likely not be negatively impacted by velocity increases up to 1 m/s. Higher flows and velocities, however, may negatively affect large bodied stoneflies and the case building caddisfly, which is a major source of food for trout in the Arkansas River. Data collected in the Arkansas River also indicated that increased flows causes a decrease in the abundance of caddisflies Hydroptila and Brachycentrus, large bodied stoneflies, midges (Chironomidae), and scrapers, such as the caddisfly Oligophlebodes. In contrast, Baetis mayflies and Hydropsyche caddisflies appear fairly tolerant of higher flows. Some mayflies (Acentrella), the caddisfly Rhyacophila coloradensis, and net-winged midges (Blephariceridae) appear to tolerate very high flows. Nelson and Roline (1995) point out that strong negative impacts on invertebrate communities were associated with flows at least 5 times greater than baseflows, and those that rapidly changed from high to low flows. Concerns with regulated low flow impacts are likely not applicable to the Arkansas River.

Clearly, flow augmentation can substantially impact aquatic habitat conditions for both fish and invertebrates, and can exert negative direct and indirect effects on their populations and communities. In terms of Tennessee Creek and the Upper East Fork, it is likely that aquatic biota were detrimentally impacted by flow augmentation on a sporadic rather than continuous basis. While substantial short-term changes in biotic population and community structure and abundance likely occurred, it is not clear whether or not they were impacted detrimentally over the long term.

Livestock Grazing

It is unclear whether or not livestock grazing has significantly impacted the Upper East Fork and Tennessee Creek, although grazing does occur in Tennessee Park. The current vegetation community structure, dense willow thickets mixed with open grassy areas, suggests that historically it did not experience heavy livestock grazing.

Highway 24 and 91

Highway 24, traveling north from Leadville, crosses Upper East Fork, East Tennessee Creek, Tennessee Creek, runs parallel to Tennessee Creek for approximately 2 miles before crossing West Tennessee Creek, and continues north over the Continental Divide. This road heading north of Leadville was in place by 1910 (CDOT 2000) and was paved by the mid-1950s. Available literature, although scarce, suggests a strong association between unpaved roads and increased contributions of sediments to watersheds (Myers and Swanson 1996). Because this segment of the highway crosses the mainstem and three major tributaries to the Arkansas River north of Leadville, prior to paving the highway a significant amount of sediment was likely to have washed into this upper portion of the Arkansas River. However, it is unlikely that these contributions of sediment were substantial enough to cause any long-term effects on water quality and stream biota. Secondly, because this reach of the river is more than four miles upstream of the confluence of the Upper East Fork and Tennessee Creek, its impact on water quality and biota would be effectively non-existent by the time it reached the mainstem below the confluence. Finally, any sediment contributed to the river prior to paving the road would have been flushed from the system the each spring.

Highway 91 continues northeast out of Leadville, following the Upper East Fork floodplain. The highway crosses the river about 2 miles upstream of the entry of Evans Gulch, continues north approximately 0.25 miles west of the river, crosses Chalk Creek, and crosses the Upper East Fork just 0.66 miles southeast of Fremont Pass before continuing north and over the Continental Divide. Highway 91 existed as a dirt road (AKA "Leadville-Breckenridge road") at least since 1910 (CDOT 2000). In 1918, the State Highway Department had designated the Climax portion of the road as State Highway 91 (Voynick 1996 and CDOT 2000). As late as 1928 it remained an unimproved, rough, dirt track closed by snow throughout the winter. By the early 1950s the highway was paved (Voynick 1996). Thus, the Upper East Fork floodplain may have received a significant amount of sedimentation runoff from the unimproved road until the early 1950s. It is important to bear in mind two things when considering potential impacts: first, the dense willow and sagebrush vegetation in the Upper East Fork floodplain between the highway and the stream provides a substantial buffer from sedimentation; and second, because the road crosses the stream at only two points up the valley, and the roadway was paved by the 1950s, it seems unlikely that there would remain any long-term effects of sedimentation.

Railroad

The railroad north of Leadville heads up the Upper East Fork basin towards Climax, and stays approximately 0.5 miles to the east of the river. The tracks finally cross the river in the extreme northeastern corner of Lake County, 1 mile southeast of Fremont Pass in San Isabel National Forest, then continues north over the Continental Divide into Summit County. The point of crossing is the only point of potential impact of the railroad on the Upper East Fork. Considering the proximity of the railroad to the river, it is unlikely that there is any significant impact on river water quality or associated aquatic biota.

At the confluence of California Gulch, the western branch of the railroad tracks continues north along the Arkansas River and Tennessee Creek. The tracks continue, on average, approximately 0.5 miles east of the river until reaching the confluence of Upper East Fork and Tennessee Creek. The tracks cross Upper East Fork and continue for the next 1.25 miles in close proximity to Tennessee Creek. Branching to the east, the tracks continue north, cross the East Fork of Tennessee Creek, and continue 3 miles north before crossing Tennessee Creek and continuing over the Continental Divide. All told, the tracks travel in close proximity to Tennessee Creek for about 4 miles: 1.25 just above Upper East Fork, and 2.75 just south of the entrance of West Tennessee Creek. To our knowledge, there is no literature concerning the impacts of railroad tracks on river water quality or associated biota. The railroad was completed July of 1880 (Voynick 1996), therefore the berm on which the tracks were built has had many decades during which to settle. Sedimentation during the construction phase of the railroad likely had the most significant impact on water quality and aquatic biota. Considering the decades since railway construction and length of time for recovery of resources potentially impacted, it seems unlikely that there are any remaining significant impacts due to the railroad bed.

Timber Harvest

It is difficult to determine the extent to which timber was harvested in the Upper East Fork drainage or Tennessee Creek. Klima and Scherer (2000) point out that timber was a necessary commodity of all mining practices, and by early in 1879 there were 30 sawmills employing about 1000 men in the Leadville area. Without more information concerning patterns of timber harvest (currently being investigated by the Leadville Ranger District of the U.S. Forest Service), impacts to water quality and aquatic biota are difficult to assess. It is important to note, however, that the trees making up the forests in both river valleys are 75-125 years old. Thus impacts due to silvicultural practices, such as sedimentation, have not been present for at least three quarters of a century, and perhaps longer. Therefore, it is unlikely that timber harvest has contributed to negatively impact the natural resources in either valley for decades.

Reach 1: California Gulch to Lake Fork

Flow Regulation

The effects of flow augmentation for this reach will be very similar to Reach 0 since there are no additional sources of water augmentation below that for Tennessee Creek. Because this segment of the river is further downstream, effects would be reduced compared with Reach 0. Therefore, it seems unlikely that flow augmentation exerts any significant influence on this portion of the Arkansas River beyond that mentioned for Reach 0.

Livestock Grazing

Klima and Scherer (2000) noted that Mexican settlers maintained cattle and sheep ranches on the Arkansas River as early as the 1830s, and that Colorado experienced a livestock boom as ranching became a formidable industry throughout the 19th century. As late as 1929 there were 8,800 cattle and horses and 102,328 sheep grazing on National Forests in the Leadville area; these numbers dropped to 758 cattle and 11,000 sheep in 1944 in the Leadville District of the San Isabel National Forest (Klima and Scherer 2000). Klima and Scherer (2000) further note that during the 1800s to the early 1900s overgrazing by livestock had occurred over much of the grass-shrub area. Because this segment of the Arkansas River is in such close proximity to the highly populated Leadville and California Gulch, it is likely that it received heavy use by cattle and sheep.

Through an extensive literature review, Fitch and Adams (1998) report on the interrelationship of livestock grazing and the health of riparian habitats and associated fish and wildlife. The authors first note that grassland and riparian ecosystems and associated fish and wildlife have evolved with use by grazing ungulates, most notably bison. The grazing strategy of bison was likely to disperse throughout various landscape types, unlike domestic livestock that have an affinity for water and tend to linger for long periods around riparian habitats. In pre-settlement, there was grazing followed by a period of rest, and prairie riparian communities evolved under such a regime for millennia.

Fitch and Adams (1998) point out that unmanaged livestock grazing (i.e., releasing livestock into an area without any planned riparian growing season rest or measures designed to protect vegetation health along the stream or on its floodplain) appears to always result in overuse of riparian areas, impairment of plant species vigor, and physical damage to the channel and banks. They noted that if livestock were allowed to freely graze, they would spend a disproportionate amount of time in riparian areas -- 20 to 30 times longer than expected based on the limited extent of the riparian area. Kauffman and Krueger (1984) reviewed 64 papers, Platts (1991) reviewed 21 papers, and Ohmart (1996) reviewed similar references including 30 newer works. Fitch and Adams summarized the results of these three authors and concluded that inappropriate livestock management results in overuse and subsequent degradation of riparian and stream systems in the following ways:

- There are effects on stream channel morphology, the shape and quality of the water column, and soil stability and structure in the riparian zone. Streams become laterally or vertically unstable. The water column is altered by increasing water temperatures, nutrients, and suspended sediments, and by altering timing and volume of flow. Soil compaction on the floodplain from hoof action decreases infiltration rates and leads to increased runoff and accelerated erosion and sedimentation rates.

- There are considerable effects on vegetation, resulting in decreased vigor and biomass, and an alteration of species components, especially trees and shrubs.

- There are decreases in fish and wildlife species numbers following overgrazing of riparian areas.

Belsky et al. (1999) summarized peer-reviewed empirical papers and reviews of the biological and physical effects of livestock on Western rivers, streams, and associated riparian areas. Where there was a paucity of data, non-peer-reviewed reports also were used, usually from government documents or symposia. All conclusions were based on what seemed to be the consensus of experts in the field. The following summaries for fish, invertebrates, and various aspects of riparian and instream habitat were extracted from a more complete summary table in Belsky et al. (1999).

Fish

Higher water temperatures increase salmonid mortality by breaking down physiological regulation of vital processes such as respiration and circulation, and negatively affect fish spawning, rearing, and passage. Greater water turbidity, increased siltation and bacterial counts, lower summer flows, low dissolved oxygen in the water column, and intragravel environment reduce fish survival. Damage to spawning beds, less protective plant cover, fewer insects and other food items, stream bank damage, decreased hiding cover, and reduced resistance to water-bourned diseases all contribute to fish mortality. All lead to a loss of salmonids and other cold-water species, loss of avian and mammalian predators, and replacement of cold-water, riparian species with warm-water species.

Invertebrates

Higher water temperatures from loss of shade, lower dissolved oxygen, and increased fine sediments reduce plant detritus, while increasing algal biomass for food. These factors cause loss of invertebrate species that require cleaner and colder waters and coarser substrates, increase in algae feeders, fewer palatable species, less food for higher trophic levels, and reduced litter breakdown.

In terms of water quality, grazing generally caused an increase in nutrient concentrations, bacterial protozoa, sediment load and turbidity, and water temperature. Regarding stream channel morphology, there was an increase in channel depth, width, and fine sediments, and a decrease in channel stability during floods, streambank stability, number and quality of pools, and quality and quantity of streambank undercuts. Effects on hydrology include increased overland flow, peak flow, and floodwater velocity, a decrease in summer and late-season flows, and a reduced water table. Instream vegetation is generally impacted by an increase in algae and a decline in abundance of higher plants (submersed and emergent). Streambank vegetation generally experiences a decline in herbaceous cover, biomass, productivity, and native diversity. Declines are also noted for overhanging vegetation and tree and shrub biomass and cover. Vegetation structure becomes simplified, plant age-structure becomes even-aged, and plant succession impeded. In terms of riparian zone soils, there is an increase in bare ground, erosion (wind, water and ice) and compaction, and a decrease in litter layer, infiltration, and fertility.

Rothrock et al. (1998) examined land use patterns and biointegrity in the Blackfoot River watershed of Montana. Benthic macroinvertebrate samples were collected in August 1995 to examine the linkage between land use, water quality, and aquatic biointegrity in seven tributaries of the Blackfoot River watershed, Montana. The tributaries represented silvicultural (timber harvesting), agricultural (irrigated hay and livestock grazing) and wilderness land uses. The wilderness stream had the highest aquatic biointegrity. Two agricultural streams had the largest estimated soil erosion and sediment delivery rates, the greatest habitat impairment from nonpoint source pollution, and the most impoverished macroinvertebrate communities. It was clear that livestock grazing had the largest negative impact on stream health; however, timber harvesting also had significant negative impacts on soil erosion and sediment transport.

Given the clearly documented impacts of livestock grazing on riverine habitats, an important question is to what extent these systems, once significantly impacted, recover ecologically. Myers and Swanson (1996) studied long-term aquatic habitat restoration on Mahogany Creek, Nevada. Livestock was excluded from the heavily grazed Mahogany Creek watershed from 1976 to 1990 while rotation of rest grazing on its tributary, Summer Camp Creek, was allowed. Both streams improved since 1976 after cessation of heavy, season-long grazing. Stability and tree cover increased while sedimentation decreased regardless of grazing treatment. Myers and Swanson (1996) suggest this illustrates that long-term recovery is consistent with rotation of rest grazing where rest occurred nine of 14 years. However, the streambank stability decrease due to flooding after two years of grazing suggests that additional rest for Summer Camp Creek at the beginning of the study may have been necessary. Sheep grazing after several additional years of recovery did not apparently have detrimental effects on Summer Camp Creek.
Some variables did not improve due to other management practices, initial conditions, or climatic perturbations. For instance, fine sediment decreased overall, but accumulations during low flow coincided with roads that act as a source of and conduit for fine sediments. Significant improvements to these streams may result from a reduction in roads and crossings.

Brejda (1997) examined changes in chemical and physical properties of soil following 18 years of protection from grazing in an Arizona chaparral. Important conclusions were: 1) results indicated higher levels of silt and clay, increased concentrations of organic C, total N, and soluble bases, and a reduction in bulk density with 18 years of protection from grazing; 2) differences in the concentrations of organic C, total N, and soluble bases indicate that some recovery in soil fertility has occurred with 18 years of protection from grazing. However, there has been no recovery of perennial grasses and forbs in the openings between the chaparral shrubs; 3) changes in soil physical and chemical properties following disturbance may be species dependent; and 4) improvements in soil physical and chemical properties within the exclosure did not result in large increases in plant biomass in the bioassay, indicating that they provided only a small increase in nutrient availability to plants. Furthermore, a very heterogeneous pattern in soil properties, characterized by large differences between soils under shrub canopies compared to open areas between shrubs, was evident within the exclosure and in the grazed area, indicating the presence of a degraded ecosystem. Thus, it was concluded that the improvements in soil properties observed within the exclosure represent only an upward trend within a stable new threshold of lower productivity, not a slow return to a climax of more homogeneous and greater soil fertility. The slow recovery in soil properties and herbaceous vegetation observed at this site suggests that significant improvement in site productivity will not occur on a practical time scale without substantial intervention by land managers.

Similarly, Yates et al. (2000) examined grazing effects on plant cover, soil, and microclimate in Australian woodlands, discussing important implications for restoration. Vegetation and soil surveys were conducted in three woodlands with a history of regular grazing, and in three woodlands with a history of little or no grazing. Grazing was associated with a decline in native perennial cover, an increase in exotic annual cover, reduced litter cover, reduced soil cryptogam cover, loss of surface soil microtopography, increased erosion, changes in the concentrations of soil nutrients, degradation of surface soil structure, reduced soil water infiltration rates, and changes in near ground and soil microclimate. Rates of soil water infiltration in heavily grazed woodlands were half that in rarely grazed/ungrazed woodlands. Furthermore, soils in the grazed woodland were significantly warmer than in the ungrazed woodland with temperatures exceeding 40° C in the summer. This was likely due to loss of foliage and litter cover leading to an increase in the exposure of the soil surface to radiation and compaction, facilitating the rapid conduction of heat through the soil, and resulting in higher daytime and lower night-time temperatures. The loss of foliage and litter cover and increased daytime temperatures were likely to cause an increased loss of water through evaporation from the soil surface.

In terms of restoration, Yates et al. (2000) conclude that livestock grazing changes conditions and disrupts the ecosystem regulatory processes, causing a loss of scarce resources from within remnant woodlands -- resources which maintain the natural biological diversity unique to these woodlands. Consequently, attempts to restore plant species diversity and community structure in degraded woodlands are unlikely to succeed without the repair of the dysfunctional ecosystem processes. An essential component of restoration will be strategies that capture resources, increase their retention, and improve microclimate in remnant woodlands.

Clearly livestock grazing may have substantial, and sometimes irreversible, impacts on aquatic ecosystems and associated biota. If recovery is possible, it may take decades for these systems to regain ecosystem functions responsible for their long-term viability as suitable habitat for fish, wildlife and plants. While livestock grazing has doubtlessly impacted this stretch of the Arkansas River valley historically, livestock interests in this area have greatly diminished over the past several decades. Most likely, since they have received no known aids to restoration, these once overgrazed areas have recovered to a somewhat less productive state than they were originally.

Highway 24

There are approximately 4 miles (6400 meters) of railroad tracks and approximately 3.5 miles (4947 meters) of Highway 24 running through the designated 500-year flood plain of the 11-mile reach. The maximum distance between the river and Highway 24 is 3257 feet (987 meters), and between the river and railroad track is 2303 feet (698 meters). Both the Highway and railroad tracks cross the river at some point. The highway first meets the 500-year flood plain, and could potentially have a constraining influence, acting as a hydraulic barrier to the river, approximately 1500 feet north of the Highway 24 Bridge. Consequently, it is not likely that Highway 24 has had any significant impact on aquatic resources associated with the Arkansas River in this reach.

Railroad

The railroad track extends south about 3 miles, located approximately 0.5 mile east of the eastern edge of the designated 500-year floodplain, before intersecting the Arkansas River. Consequently, the railroad tracks likely have had no significant impact on this stretch of the river.

Timber Harvest

This reach of the Arkansas River valley was heavily used historically in terms of agricultural and livestock production, and it is likely that substantial timber harvest took place as well. Klima and Scherer (2000) reported that during the 1800s to the early 1900s much of the mixed conifer was harvested and burned, surface soils were severely disturbed leaving them susceptible to erosion, and, in many areas, the only tree species that regenerated were lodgepole pine or aspen. However, Klima and Scherer (2000) point out that the BLM and USFS determined that following this heavy-impact mining era, fire suppression, reforestation, and traditional timber management practices have lead to a successful recovery of much of the forested area.

Reach 2: Lake Fork to Highway 24 Bridge

Flow Regulation

In addition to flow augmentation mentioned above for Reach 0, substantial flow augmentation to the Arkansas River occurs via Lake Fork Creek south of Turquoise Lake. Turquoise Lake is augmented by water transported from the Colorado River Basin by the Homestake Tunnel, the Boustead Tunnel, and the Busk-Ivanhoe Tunnel. Flow augmentation on Lake Fork and Lake Creek has dramatically increased flood events, resulting in substantial flood events (1965, 1970, 1972, and 1978) that did not occur on adjacent non-regulated streams (URS 1998). During 1993, 80% of the time flows released from Turquoise Lake were increased 50-90% by flow augmentation.

Consequently, this reach of the Arkansas River has been substantially impacted by flow regulation for the past several decades, and will continue to be impacted in the future. Potential impacts associated with flow regulation to abiotic and biotic components of riverine ecosystems apply to this section of the Arkansas River as well. Flow regulation can greatly impact aquatic habitat conditions for fish and invertebrates, and can exert negative direct and indirect effects on their populations and communities. In terms of this section of the Arkansas River, it is likely that water quality and aquatic biota were detrimentally impacted by flow regulation on a less sporadic basis than in Reaches 0 and 1, although not on a continuous basis. The impacts of flow regulation to population and community characteristics of biota within this reach have likely had a more long-term effect than for the reaches above; however, the discontinuous nature of extremely high flow augmentations over the years suggests that fish and macroinvertebrate populations and communities experience infrequent displacement downstream. When displacement does occur, healthy source populations upriver likely will recolonize within 90 days, but may take as long as up to a year under extremely high flow augmentation conditions. Nevertheless, it seems likely that except on rare occasion, biotic communities will be able to bounce back after perturbations associated with flow regulation.

Livestock Grazing

It is difficult to separate this reach from that of Reach 1 in terms of impacts due to livestock grazing. Based on historical accounts of livestock grazing in the Arkansas River valley in the Leadville area in general (Klima and Scherer 2000), this reach was likely occupied by large cattle and/or sheep ranches and experienced substantial overgrazing not significantly different from Reach 1. This area currently experiences low to high density cattle grazing. Uncontrolled grazing coupled with flow augmentation and the presence of mine-waste deposits has led to eroding streambanks in some reaches of this section. However, in 1999, the Lake County Soil Conservation District and the Natural Resource Conservation Service initiated a riparian fencing and rotational grazing program on portions of this reach.

Highway 24

The first point at which the highway meets the 500-year flood plain, and could potentially have any sort of constraining influence, acting as a hydraulic barrier to the river, is approximately 1500 feet north of the Highway 24 Bridge. The natural flow of the river would likely take it across the highway approximately 500 feet north of the bridge.

Railroad

The railroad track first enters the designated 500-year floodplain approximately 3 miles downstream of the confluence with California Gulch, where it cuts almost due south through the middle of the floodplain. For about 2000 feet, while traveling within the designated floodplain, it appears that the railroad track has acted as a hydrological barrier, constricting the path of the river to the western side along the track. Although the track travels within the designated floodplain for .5 miles, it travels along the eastern edge for about .33 miles before entering at the north, and travels along the western edge of the marked floodplain boundary for approximately .66 miles after exiting the marked boundary just south of the Highway 24 bridge. Because the marked boundary is an arbitrary designation with the floodplain extending well beyond this conservatively marked perimeter along much of its length, this entire length (.5 + .33 + .66 miles) was included in the distance the track travels within the designated 500-year flood plain.

Timber Harvest

Similar to the impacts of livestock grazing for this reach, the impacts of timber harvest do not substantially differ from those experienced by Reach 1. That is, historically, the upper portion of the 11-mile reach of the Arkansas River valley, closest to Leadville and, therefore, mining and smelting operations, was likely heavily logged throughout the 1800s and early 1900s, until recovery took place through a series of management practices implemented by the BLM and the USFS. It is likely that this reach has long since recovered from these early silvicultural practices that seriously impacted ecosystem function.

Reach 3: Highway 24 Bridge to Constriction Downstream of County Road 55

Flow Regulation

As mentioned under Reach 2, substantial flow augmentation to the Arkansas River occurs south of Turquoise Lake via Lake Fork Creek. There is no additional source of flow augmentation between Highway 24 bridge and County Road 55. Therefore, this reach should not significantly differ from Reach 2 with respect to impacts of flow regulation. Impacts may be slightly less since sediments contributed to the Arkansas River at the confluence with Lake Fork would have had more opportunity to settle out, improving water quality as one goes further downstream from the major initial source of sedimentation. However, extremely high flows will contribute sediments in this reach, and will displace macroinvertebrates and fish as in Reach 2.

Consequently, this reach of the Arkansas River has been substantially impacted by flow regulation for the past several decades, and will continue to be impacted in the future. It seems likely that, except on rare occasion, biotic communities will be able to recover following perturbations associated with flow regulation.

Livestock Grazing

It is difficult to differentiate this reach from that of Reaches 1 or 2 in terms of impacts due to livestock grazing. Historical accounts of livestock grazing in the Arkansas River valley in the Leadville area in general suggest that this reach was likely occupied by large cattle and sheep ranches and experienced substantial overgrazing not significantly different from Reaches 1 and 2. In recent history, this segment has received moderate to high density grazing. Much of this segment is currently under a riparian fencing and rotational grazing program. Unrestricted livestock grazing, augmented flows, and mine-waste-deposits have created highly erodible banks in some portions of this segment.

Highway 24

Approximately 1500 feet south of the Highway 24 bridge, the highway exits the 500-year flood plain and extends southward for approximately 2 miles before re-entering the western edge of the floodplain. It then runs parallel to the western edge of the floodplain for approximately 4500 feet, but does not appear to have any constraining influence. The point at which Highway 24 re-enters the floodplain on the western edge and could possibly act as a hydraulic barrier, thus constraining the river, is approximately .5 miles south of County Road 55 at Kobe. At this point, natural topography forces the highway and river close together for a few hundred feet, after which the flood plain re-opens.

Railroad

The track extends due southeast of the Highway 24 Bridge, and re-enters the 500-year flood plain approximately .5 miles north of County Road 55 at Kobe. Until the narrow constriction of the floodplain due to natural topography, the track runs along the western edge of the floodplain about .5 miles south of County Rd. 55 and does not appear to constrict the path of the river.

Timber Harvest

It is likely that timber harvesting in this reach, in contrast with Reaches 1 and 2, was less intense and damaging to the Arkansas River resources. Because local soil conditions begin to change in terms of soil moisture, forests local to Reach 3 are comparatively sparse and sagebrush more dominant compared with Reach 1 and 2 upstream. While it is possible that significant timber harvest did occur in the reach, it seems highly unlikely that ecological impacts historically were as significant as further upstream. It is unlikely, therefore, that impacts to this reach by timber harvest were significant sources of ecological degradation.

Reach 4: Constriction Downstream of Cty. Rd. 55 to Two-Bit Creek

Flow Regulation

There is no additional source of flow augmentation between County Road 55 and Two-Bit Creek. Therefore, impacts are likely less in this reach compared with Reach 3 since sediments contributed to the Arkansas River at the confluence with Lake Fork would continue to settle out, and water quality would continue to improve downstream from the initial source of sedimentation. It seems likely that, except on rare occasion during extremely high flow augmentation, biotic communities will be able to recover following perturbations associated with flow regulation.

Livestock Grazing

It is likely that this reach experienced historical livestock grazing impacts similar to Reach 1-3. In recent history, this segment has received moderate to high density grazing. Much of this segment is currently under the riparian fencing and rotational grazing program described above. Unrestricted livestock grazing, augmented flows, and mine-waste deposits have created highly erodible banks in some portions of this segment.

Highway 24

Although the flood plain widens again just south of the constriction at Kobe, both the highway and railroad tracks run parallel the western edge of the flood plain. While the river meanders along the eastern edge of the floodplain, apparently unconstrained, for the next 1.5-2 miles, historically, it is possible that the highway and/or the railroad tracks constrained the river to the eastern portion of the floodplain, acting as hydraulic barriers. It is not clear by examining the aerial photos whether or not the river could flow to the western side of the highway or railroad tracks.

Railroad

South of the narrow constriction the track continues to run parallel to Highway 24 for about 1.5 miles, along the western edge of the floodplain to the end of the 11-mile reach. As mentioned above, historically, it is possible that the highway and/or the railroad tracks constrained the river to the eastern portion of the floodplain acting as hydraulic barriers—although aerial photos reveal no such evidence.

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