DETERMINING SOURCES OF WATER QUALITY IMPACTS USING BIOLOGICALMONITORING: THE MOLYCORP QUESTA MOLYBDENUM MINE EXAMPLE[1]

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Abstract: Biological monitoring was initiated on the Red River in 1997 to evaluate the effects on aquatic biota of open pit mine operations and mine rock piles over nearly a 40-year period. The general public perception was that the mine has had severe effects on the aquatic biota due to the absence of robust biological populations adjacent to the mine. However, initial biological monitoring data provided evidence that the observed negative impacts to fish and benthic invertebrates in the Red River near the mine were actually caused by naturally occurring thermal scars upstream of, and within, the mine area in the Red River drainage. These data indicated the open pit mine and mine rock piles did not measurably impact the suitability of the Red River to support aquatic organisms. Continued biological monitoring has reinforced these earlier conclusions, and has shown that the aquatic biota is most likely limited by episodic summer rain storms which simultaneously add large amounts of sediment and degrade water quality in the Red River downstream of the hydrothermal scars, although groundwater appears to be a contributing factor in low baseflow periods. Fish and macroinvertebrate parameters decreased immediately downstream of the town of Red River, demonstrating that the negative impacts to the aquatic biota begin well upstream of the Molycorp Mine property. Long term biological monitoring has demonstrated the complex nature of factors structuring the aquatic biota in the Red River, and demonstrated the value of well-designed monitoring programs.

Additional Key Words: Red River, New Mexico, hydrothermal scars, aquatic communities

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Introduction

The Questa Molybdenum Mine began operations in 1919, using underground mining methods (Schilling, 1990). Late in 1965 the mine initiated open pit mining operations, and continued until 1983. Tailings from the mill are piped down the valley to tailings ponds near Questa (Fig. 1). Mine rock was deposited near the open pit on Molycorp property in areas drained by Spring Gulch, Sulphur Gulch, Goathill Gulch, and Capulin Canyon. Claims have been made that the open pit mining operations and mine rock piles have a detrimental effect on the aquatic biota of the Red River adjacent to and downstream of this portion of the Molycorp property (Slifer, 1996). This claim has been echoed by the media, environmental groups, and even referred to in a popular fiction mystery novel. The general perception has been that Molycorp=s mining operation have been primarily, if not solely, responsible for the degraded biological communities in the Red River.

Chadwick Ecological Consultants, Inc. (CEC) began investigating the aquatic biota of the Red River in 1997. Initially, all available historical data on the fish and benthic invertebrate populations of the Red River, from upstream of the town of Red River downstream to the confluence with the Rio Grande River (Fig. 1), was reviewed. Starting in 1997, CEC also began a biological monitoring program of the Red River and its tributaries for Molycorp, Inc. (Molycorp), which owns the Questa Molybdenum Mine.

The purpose of the initial investigations was to evaluate whether the open pit mine and mine rock piles were having a negative effect on the fish and benthic invertebrate assemblages of the Red River. Biological monitoring was expanded in the fall of 2002 as the result of Molycorp entering into an Administrative Order of Consent with the U.S. Environmental Protection Agency (EPA) to initiate the Molycorp Investigation/Feasibility Study (RI/FS) under the Comprehensive Environmental Response, Compensation and Liability Act. This monitoring program differed from previous data collection efforts by increasing the number of sites to isolate the mine property and potential mining affects, collocating invertebrate, fish and habitat sampling, and implementing seasonal and yearly data collections at all sites. This sampling design provided a rigorous and statistically valid data base.

Study Area

For the purposes of this biological monitoring program, the Red River was divided into six reaches. The first river reach is upstream of the town of Red River and includes the headwaters to just upstream of the town of Red River (Fig. 1). There is some residential development in this portion of the river, primarily in the form of vacation homes and commercial lodges. Generally, two sites have been monitored in this reach. One site has been monitored in this reach since 1997 and the other site was monitored from 1999 through 2003.

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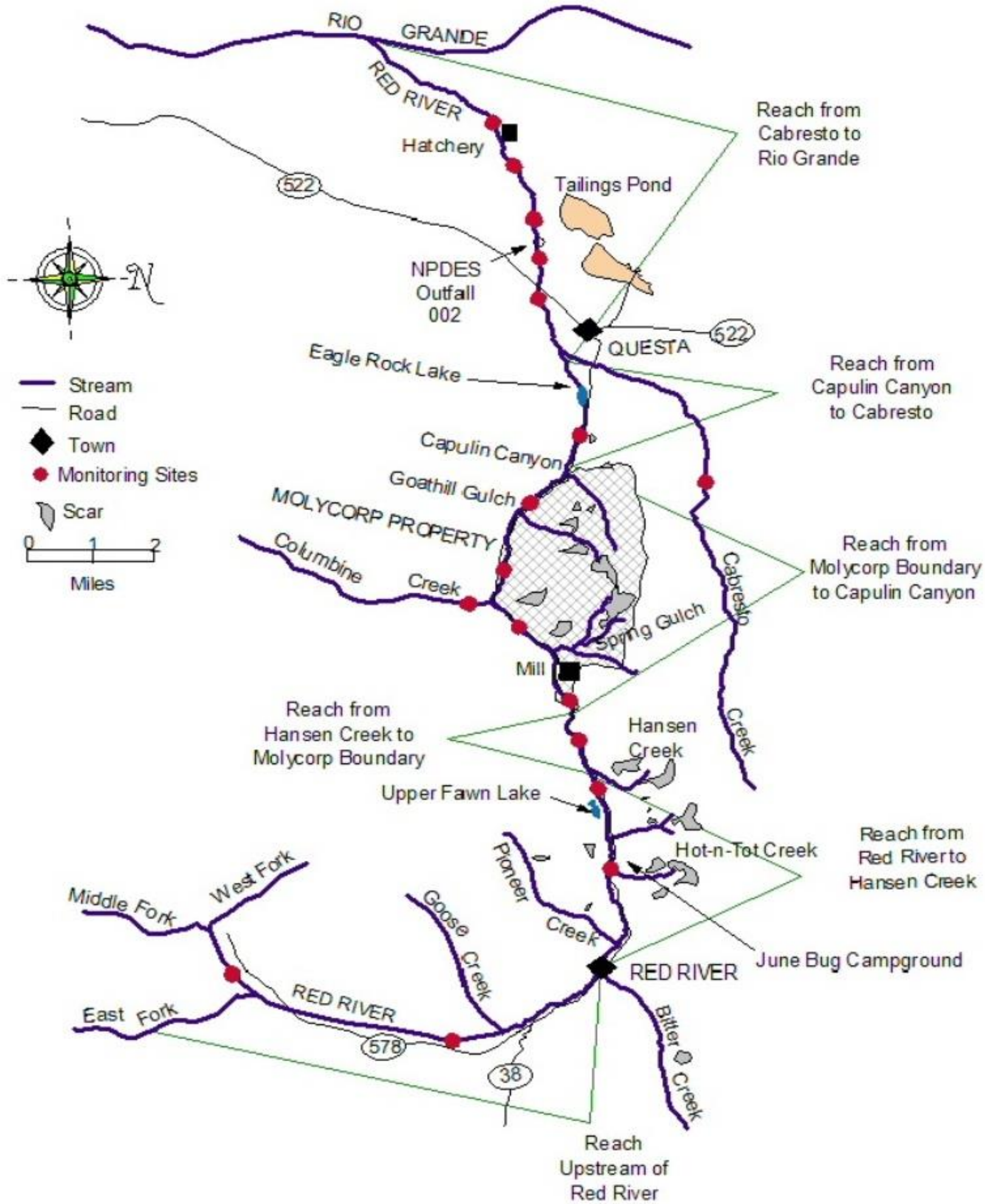

Figure 1. Red River study area with river reaches and Chadwick Ecological Consultants, Inc. biological monitoring sites.

The second reach extends from the town of Red River to just upstream of the confluence with Hansen Creek (Fig. 1). Bitter Creek and Hot-n-Tot Creek, which enter the Red River in this reach, contain historical mining operations and natural hydrothermal scars that contribute sediment and degrade water quality in the Red River. Channelization and development along the river in the Town of Red River and an outfall from the wastewater treatment facility in Red River may also cause impacts to this reach of the Red River. This reach has two study sites that were sampled from 1997 through 2004.

The third reach extends from the confluence with Hansen Creek downstream to the eastern edge of the Molycorp property boundary (Fig. 1). The major characteristic of this reach is the inflow from Hansen Creek, which drains a large area of hydrothermal scarring. Runoff from the scars carries water that is low in pH, is laden with metals, and suspended sediments into the Red River. The one study site in this reach has been sampled since 1997.

The fourth reach extends from the eastern Molycorp property boundary downstream to just upstream of the confluence with Capulin Canyon (Fig. 1). This entire reach lies adjacent to the Molycorp property boundary. This reach contains the confluence with Columbine Creek, a small, clear stream with good water quality and low sediment load that contributes diluting flows to the Red River. There are four study sites in this reach, two that have been sampled since 1997 and two that have been sampled since 2002.

The fifth reach extends from Capulin Canyon downstream to just upstream of the confluence with Cabresto Creek, in the village of Questa (Fig. 1). Capulin Canyon drains hydrothermal scars and inputs into the Red River at the head of this reach. The one study site in this reach has been sampled since 1997.

The final reach extends from the confluence of Cabresto Creek downstream to the confluence with the Red River and the Rio Grande (Fig. 1). At the upstream end of the reach, Cabresto Creek adds clear, high quality water with a low sediment load to the Red River during parts of the year when it is not diverted for irrigation. The valley widens at Questa, and portions of the reach through Questa have areas of unstable stream banks. The river valley and stream channel narrow again upstream of the state fish hatchery, and the canyon remains steep and narrow down to the Rio Grande. There are a total of five study sites in this reach. One study site has been sampled since 1997, one has been sampled since 1999, and three have been sampled since 2002.

In addition to the sites on the Red River, Columbine Creek and Cabresto Creek, tributaries to the Red River, have also been sampled since 1997.

Methods

Fish have been quantitatively sampled each fall since 1997 by making two or more sampling passes through the stream sites using either bank or backpack electrofishing equipment, depending on stream size. Fish captured from each pass were kept separate to allow estimates of population density of each species using the maximum likelihood estimator in the AMicroFish@ program developed by the U.S. Forest Service (Van Deventer and Platts, 1983, 1989). All fish captured were identified, counted, measured for length, weighed, and released. The sampling provided estimates of density (#/km) and biomass (kg/ha) for all species.

Benthic invertebrates were quantitatively sampled at each stream site by taking five replicate samples from similar riffle habitats. Macroinvertebrates have been sampled each fall since 1997 and each spring since 2000. A modified Hess sampler, which encloses 0.086 m^2 and has a mesh size of 500 μm (Canton and Chadwick, 1984), was used to collect the invertebrate samples. Five replicates provide a reliable estimate of both density and species composition of stream invertebrate communities (Canton and Chadwick, 1988).

This analysis provided a list of species, estimates of density, and total number of taxa present at each site. In mountain streams, the presence of mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) taxa can be used as an indicator of water quality. These insect groups (collectively referred to as the EPT taxa) are considered to be sensitive to a wide range of pollutants (Plafkin et al., 1989; Wiederholm, 1989; Klemm et al., 1990; Lenat and Penrose, 1996; Wallace et al., 1996; Barbour et al., 1999, Lydy et al., 2000). Stress to aquatic systems can be evaluated by comparing the number of EPT taxa between reference sites and potentially impacted sites. Impacted sites would be expected to have fewer EPT taxa compared to reference sites.

Results

Historical Data

Historical fish data were collected in 1960 (pre-open pit mining) and from 1974 through 1988 (during open pit mine operation). Fish were sampled in four of the six reaches in 1960, while all six reaches were sampled during the 1974 through 1988 time period.

The trends in trout density in 1960 and 1974 through 1988 both indicated negative impacts to the trout population beginning in the reach immediately downstream of the town of Red River (Fig. 2). A more substantial negative impact occurred downstream of Hansen Creek. The historical data indicate that cumulative effects of these impacts reduced trout density to very low levels prior to the Molycorp property. Adjacent to the mine property, slight increases in trout densities were observed in the data collection in 1974 through 1988. This was believed to be due to the input of water and/or migrating fish from Columbine Creek (CEC 1997). Downstream of Capulin Canyon, trout density was further reduced. Improved resident trout densities were again observed downstream of the village of Questa (Fig. 2).

Historical macroinvertebrate data was collected in 1965 (pre-open pit mining) and from 1970 through 1992 (during open pit mine operation). Macroinvertebrates were sampled in five of the six reaches in 1965, while all six reaches were sampled in the 1970 through 1992 time period.

The longitudinal trend in benthic invertebrate density shows a general decrease from the town of Red River downstream to near Questa (Fig. 3). This trend is evident for both the 1965 data and the 1970 through 1992 data. Both data sets reached their lowest density in the reach of the Red River between Capulin Canyon and Questa. The trend in number of macroinvertebrate taxa among the two data sets also showed a general decrease from upstream of Red River downstream to near Questa (Fig. 3).

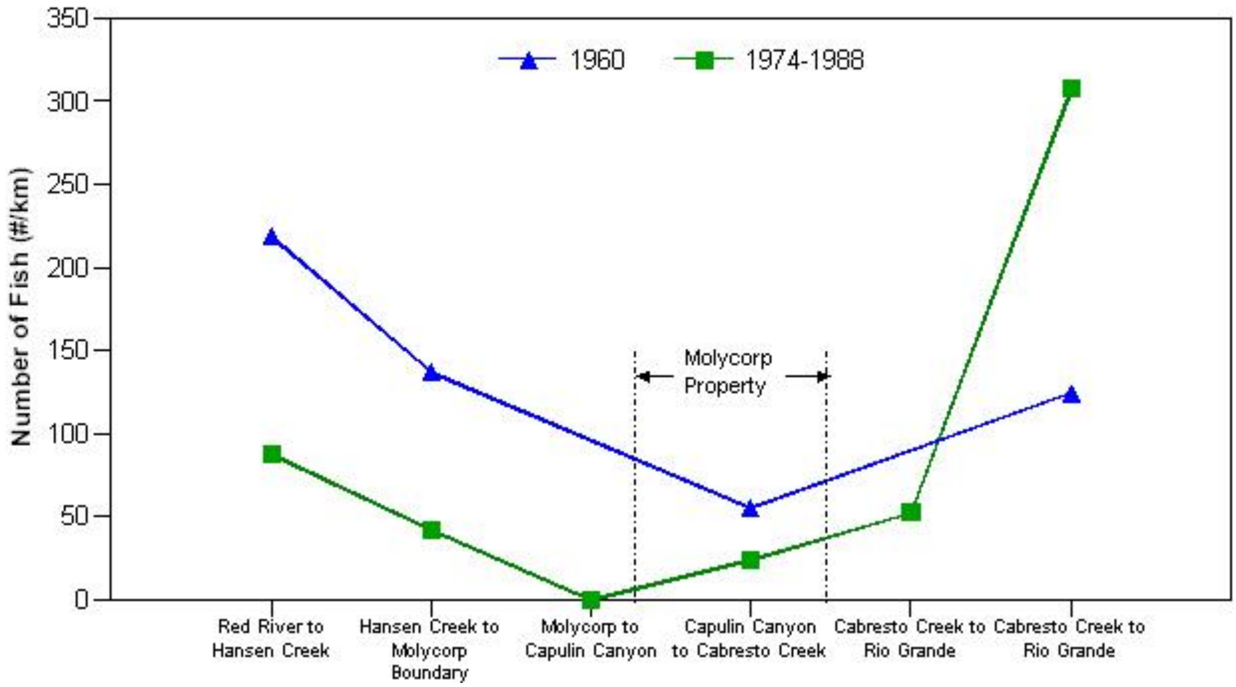

Figure 2. Longitudinal trends in resident trout density (#/km) for baseline conditions (1960 data) and open pit and underground mine operation (1974-1988 data). First pass electrofishing data only.

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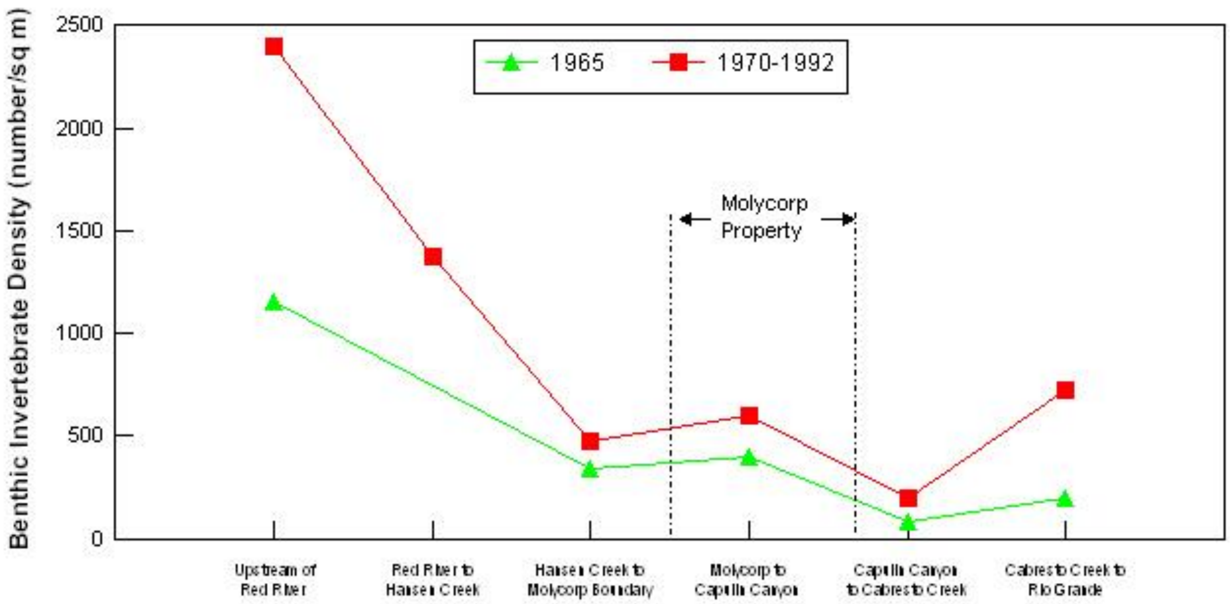
The review of the historical fish and benthic macroinvertebrate data demonstrated three facts: 1) substantial impacts to the fish and macroinvertebrate assemblages had historically occurred upstream of the Molycorp property near the town of Red River, 2) impacts appeared to be occurring downstream of the town of Red River, Hansen Creek, and Capulin Canyon, and 3) this pattern was present prior to open pit mining operations. A review of historical data indicated that the areas of impact were all associated with areas that drained the natural hydrothermal scars in the watershed.



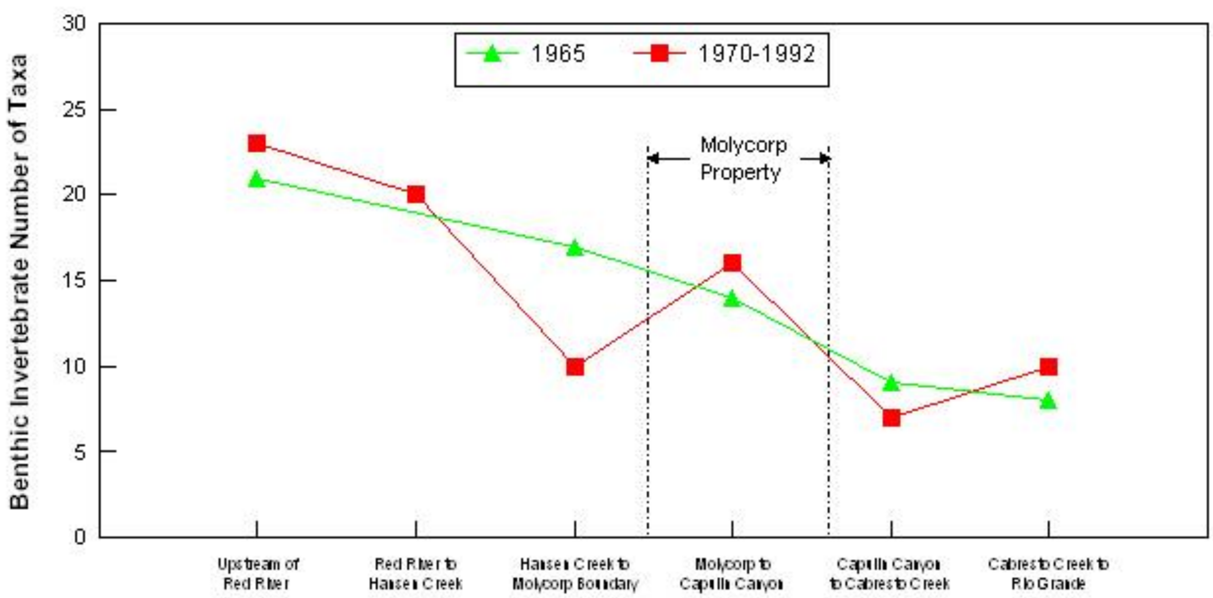


Figure 3. Longitudinal trends in benthic invertebrate density (top) and number of macroinvertebrate taxa (bottom) for baseline conditions (1965 data) and open pit and underground mine operation (1970-1992 data)

Recent Data

Chadwick Ecological Consultants, Inc. began biological monitoring in 1997. Biological monitoring was expanded in 1999 in conjunction with an aluminum Total Maximum Daily Load Study by the New Mexico Environment Department and again in 2002 in conjunction with the RI/FS study.

When the fisheries data from 1997 through 2004 is pooled by reach, the historical data shows a similar pattern as that observed in the current data. Resident trout density (Fig. 4) declines substantially from upstream of the town of Red River to the Molycorp property boundary. A modest increase in density is observed in the reach adjacent to the Molycorp boundary. Resident trout density decreases again downstream of Capulin Canyon before recovering to levels equal to or higher than those observed upstream of the town of Red River.

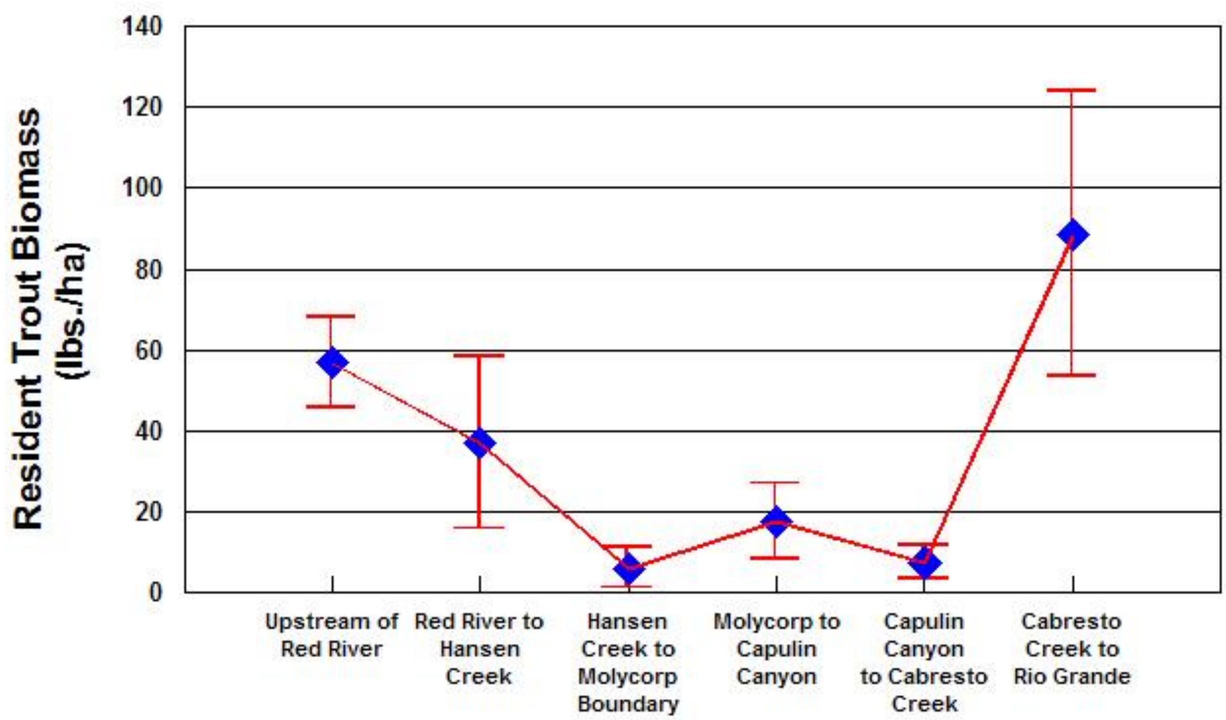


Figure 4. Longitudinal trends in resident trout density (∀ 2 SE) for recent data (1997-2004).

Resident trout biomass demonstrates a nearly identical trend as density through these six reaches (Fig. 5). A decreasing trend in biomass is seen through the reach downstream of Hansen Creek followed by a small increase in biomass in the reach adjacent to the Molycorp property. A decrease is again observed downstream of Capulin Canyon; however, biomass recovers downstream of Questa to values generally higher than those observed upstream of the town of Red River.

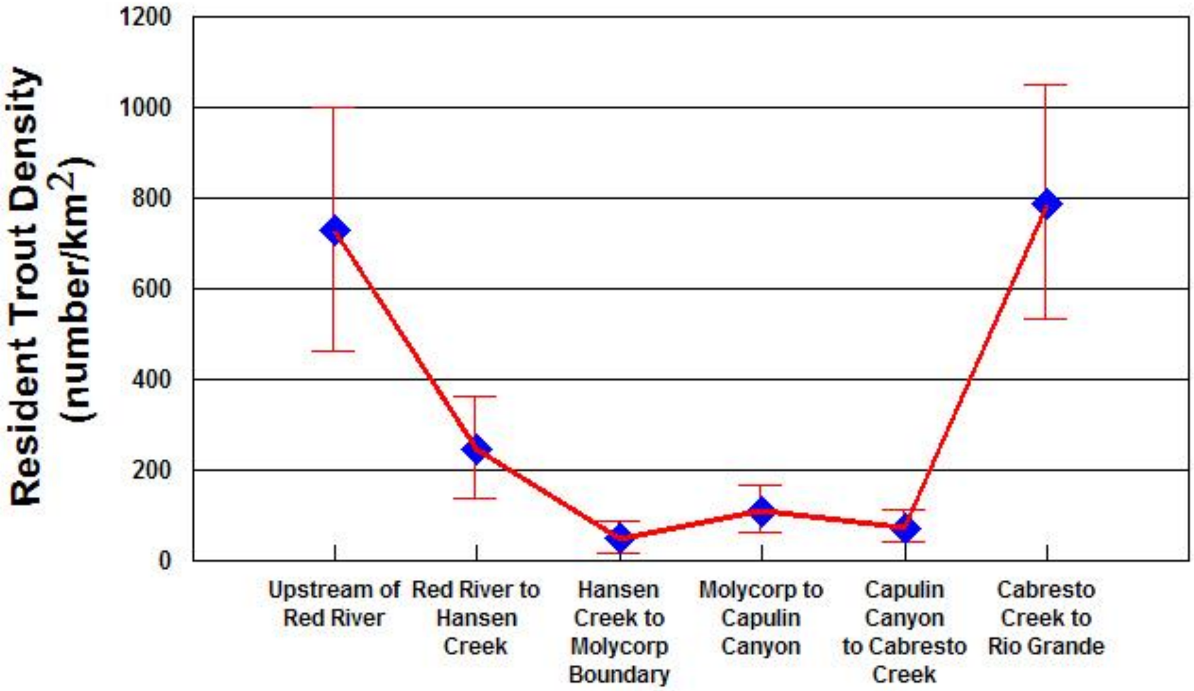


Figure 5. Longitudinal trends in resident trout biomass (∀ 2 SE) for recent data (1997-2004).

While some reaches have shown substantial variation in both density and biomass estimates over the years (Fig. 4 and Fig. 5), this pattern of immediate decreases downstream of the town of Red River upstream of the Molycorp property boundary, with subsequent recovery downstream of Questa, has been observed every year samples have been taken since 1997.

When benthic macroinvertebrate data from 1997 through 2004 is pooled by reach, the patterns are somewhat different than those observed for fish. Macroinvertebrate density data for both the spring and fall shows a substantial decline downstream of the town of Red River, and densities continue to decline to the reach downstream of Capulin Canyon (Fig. 6). There is a substantial increase in mean density in the final reach downstream of Questa.

The total number of macroinvertebrate taxa and the number of EPT taxa demonstrated a fairly uniform decline through the reach downstream of Hansen Creek but then stabilized or slightly improved in the reach adjacent to the Molycorp property (Figs. 7 and 8). The total number of taxa and EPT taxa further declined in the reach downstream of Capulin Canyon, followed by a moderate increase in the reach downstream of Questa. While some recovery was observed in this reach, these two parameters did not fully recover to values observed upstream of the town of Red River (Figs. 7 and 8).

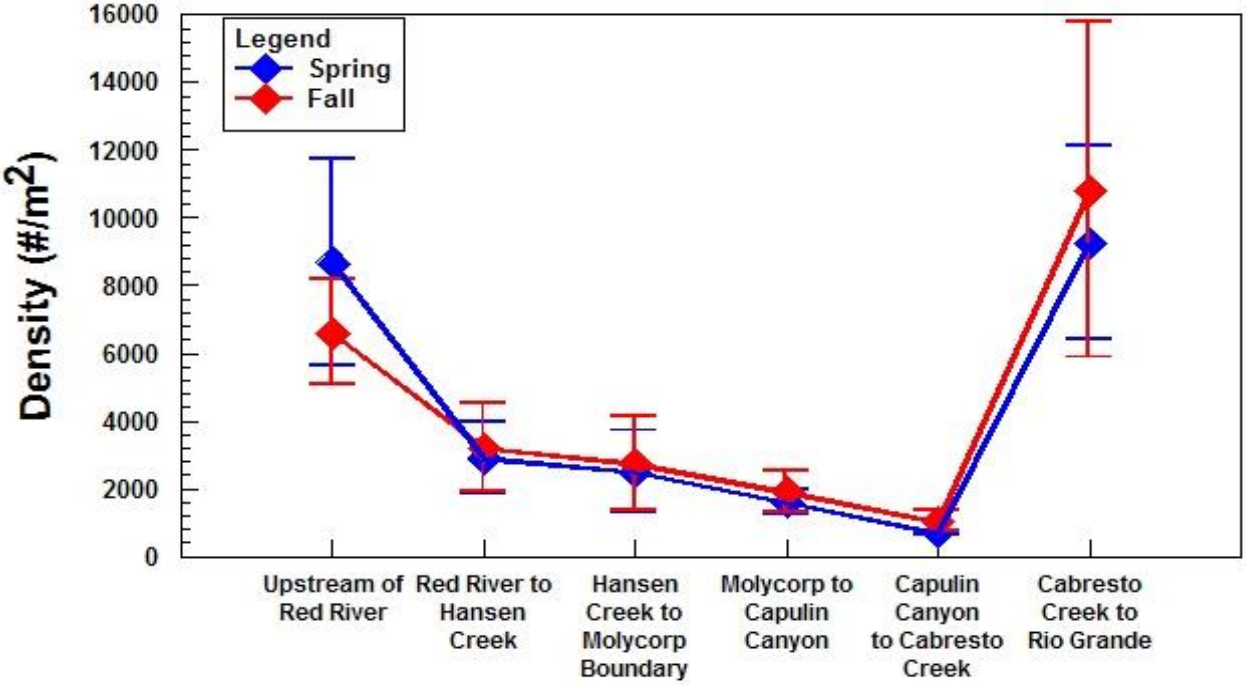


Figure 6. Longitudinal trend in total macroinvertebrate density (∀ 2 SE) in the Red River for Spring 2000-2004 and fall 1997-2003 data.

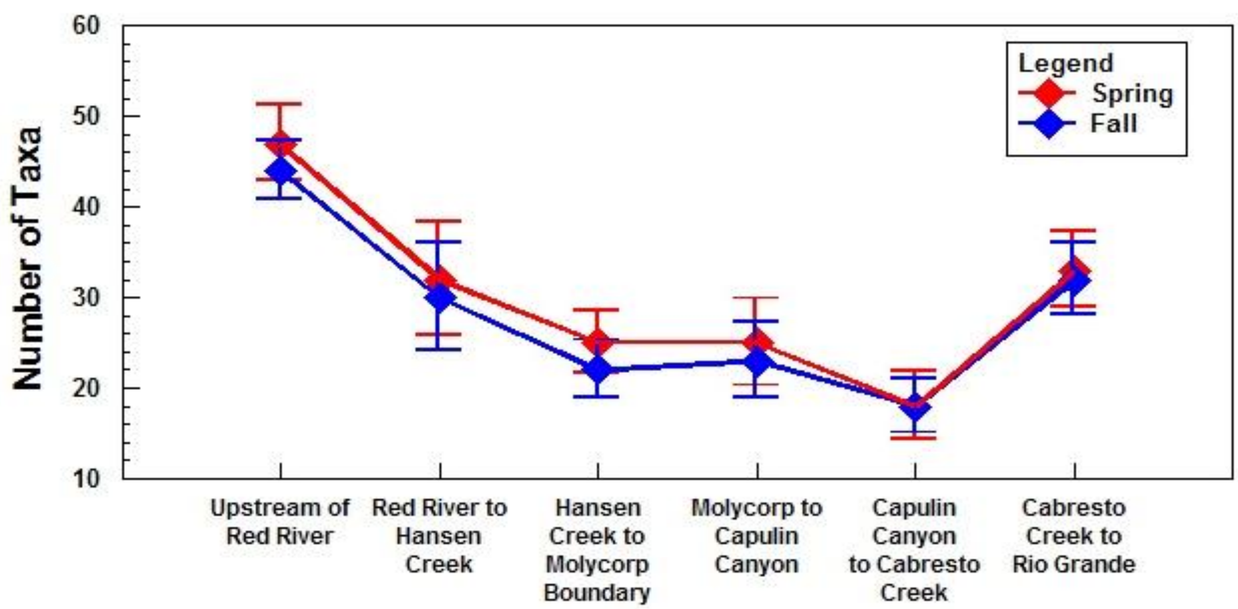


Figure 7. Longitudinal trend in total number of macroinvertebrate taxa (∀ 2 SE) in the Red River for Spring 2000-2004 and fall 1997-2003 data.

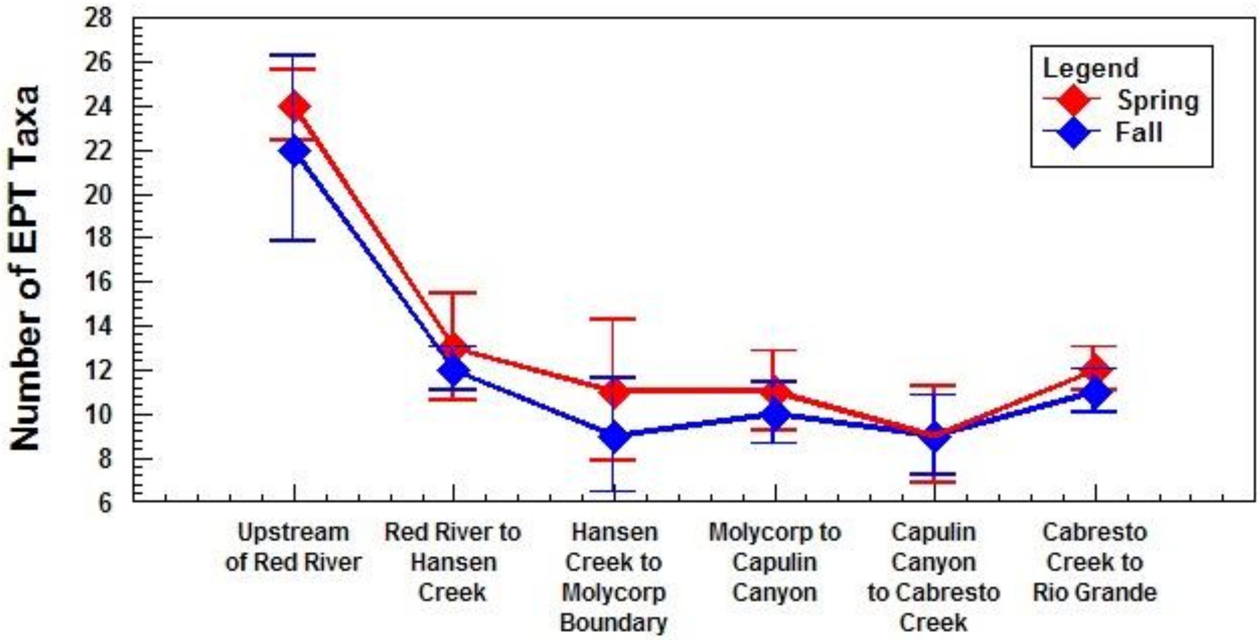


Figure 8. Longitudinal trend in total number of EPT taxa (∀ 2 SE) in the Red River for Spring 2000-2004 and fall 1997-2003 data.

Discussion

The recent macroinvertebrate data reinforces what was observed in the historical fish and macroinvertebrate data as well as the recent fisheries data. Substantial impacts occur in the reach of the Red River downstream of the town of Red River. The recent fish and macroinvertebrate data also indicate three major areas of impact along the Red River. These three major areas of impacts are downstream of the town of Red River, downstream of Hansen Creek, and downstream of Capulin Canyon. All of these reaches are associated with naturally occurring hydrothermal scars.

The trends in trout density and biomass from 1997 to 2004 were similar to the trends observed for resident trout density observed during baseline conditions (data collected in 1960) and the period of open pit and underground mining (data collected 1974 through 1988). All the trends all indicate relatively high densities of resident trout upstream of the town of Red River, decreasing densities in the middle reaches of the river, and increasing densities downstream of Cabresto Creek.

The longitudinal trends in benthic invertebrate density for baseline conditions (data collected in 1965), the period of open pit and underground mining (data collected 1970 through 1992), and recent conditions (1997 to present) all show a similar pattern of decreasing density downstream of the town of Red River, with low density downstream of Hansen Creek. In the middle reaches of the river, from the Molycorp property boundary downstream past Cabresto Creek, low densities continued to occur, reaching a minimum immediately downstream of Capulin Canyon. This is followed by an increase downstream of Cabresto Creek. The general trend has not changed since 1965.

The cause of these impacts is believed to be the input of excessive sediment from a number of sources and decreased water quality, especially at locations receiving drainage from hydrothermal scars (CEC 2003). Episodic summer rain storms simultaneously add large amounts of sediment and degrade water quality in the Red River downstream of the hydrothermal scars. Recent monitoring, including the expansion of monitoring sites and monitoring parameters in conjunction with the TMDL and RI/FS studies, have consistently demonstrated that impacts to the aquatic biota occurred prior to the initiation of open pit mining (CEC 1997), and that substantiates impacts occur well upstream of Molycorp property (CEC 2003).

The long-term biological monitoring program of the Red River has demonstrated the complex nature of factors structuring the aquatic community in the Red River. Additional data collection associated with the RI/FS has reinforced previous conclusions that the aquatic biota of the Red River is limited by poor water quality and sedimentation mainly associated with hydrothermal scars in the watershed. Proper placement of reference sites, placement of sites up stream and downstream of potential sources of impacts, and a continuous long-term biological monitoring program have added in identification of sources of impact other than the mine.

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