A Framework for Assessing The Economic Benefits of Mine Reclamation

A Case Study Addressing Reclamation of the Molycorp Mine, Questa, New Mexico

A Report Prepared for Amigos Bravos

By

Ecology & Law Institute

Amigos Bravos

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Amigos Bravos, Inc., Friends of the Wild Rivers, is a public interest non-profit river advocacy organization with offices in Taos and Albuquerque, New Mexico. Amigos Bravos has been an active participant and has advocated with state and federal regulators and the mining company for responsible mining practices, including requiring adequate plans and financial assurance for reclamation and closure measures. The organization believes that the necessary measures should be taken by Molcorp, consistent with regulatory and industry practices, to eliminate and prevent pollution from the mine and tailings facilities into the environment.

The Ecology and Law Institute (ELI) is a national network of university – based researchers, natural resource specialists, and environmental attorneys who have banded together to provide professional support for grassroots campaigns to protect and restore the natural environment. The ELI network brings expert support in the form of economic analysis, geographic information systems mapping and analysis, conservation biology, land use planning and legal representation to organizations that have difficulty accessing these professional services.

Table of Contents

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by

John Talberth, Rachel Conn, Robert Berrens, and Mike McKee

Abstract

Mine reclamation has become one of the nation's most urgent environmental priorities. In making decisions over the magnitude, composition, and timing of reclamation activities to require, regulators must consider both the costs and benefits of reclamation from a social perspective. While information on reclamation costs incurred by mining companies is readily available, information about reclamation benefits is scarce to non-existent. This paper suggests an approach for assessing the economic benefits of reclamation. Methods for quantifying both market and non-market benefits are discussed. The approach we recommend includes evaluation of market impacts through use of a regional input-output model, and quantification of non-market benefits through use of revealed and stated preference models. We use the Molycorp mine, near Questa, New Mexico as a case study, as this mine exemplifies the range of reclamation issues surfacing throughout the nation. An input output model was used to calculate the direct and indirect effects of a $200 million reclamation investment on output, earnings, indirect business taxes, and employment. Direct and indirect benefits range between $640-$874 million. Through regional multiplier effects, reclamation would support an average of 772 jobs over a 20 year period. During the first 10 years of reclamation there will be an average of 91 on-site reclamation related jobs per year. These jobs will have an annual salary range between $32,000 - $84,000. A benefits transfer technique was used to calculate the aggregated non-market benefits of reclamation. Aggregate benefit categories included recreational fishing, ecological and aesthetic river values, and changes in property value. Non-market benefits for these categories range from $ 30.9-58.3 million. Full reclamation of the Molycorp site could generate $671 to $932 million total economic benefits over the next 20 years.

Reclamation: Action taken to mitigate the effect of mining and, to the extent practicable, provide for the stabilization of the permit area following closure that will minimize future impact to the environment from the mining operation and protect air and water resources.

Reclamation Standard in New Mexico: Mining operations must demonstrate that: "the work to be done will reclaim disturbed areas within the permit area to a condition that allows for the re-establishment of a self-sustaining ecosystem on the permit area following closure, appropriate for the life zone of surrounding areas" (NMMA, Rule 506.J.3)

I: Introduction

The reclamation of open pit mines, tailings piles, and associated infrastructure is emerging as one of the nation's most pressing environmental priorities. A rigorous examination of both the costs and benefits of reclamation should be central to the decision making process at the federal, state, and local levels. Such an examination will help decision-makers answer questions over the appropriate magnitude, composition, and timing of required reclamation activities. While information on costs - particularly the financial burden on mining companies - is readily available, there has been very little information generated on the vast array of public economic benefits associated with reclamation. As we argue throughout this paper, such benefits can be quite significant and merit careful consideration in decisions over mine reclamation and operation that are being made in the public interest.

Indeed, reclamation may provide the impetus for the economic diversification of communities historically dependent upon mining. Depending upon the size of the disturbed area, mine reclamation has the potential to generate substantial direct economic benefits in the form of hundreds of new, long term, family wage jobs in fields increasingly demanded in the global marketplace. The income generated by such jobs, in turn, circulates through local economies creating additional, secondary jobs in a broad range of economic sectors as well as increasing economic output, tax revenues for federal, state, and local governments, and earnings.

While significant, the direct and secondary jobs and additional income generated by mine reclamation may be dwarfed by the benefits associated with restoring the integrity of terrestrial and aquatic ecosystems damaged by mining activities. Such benefits include improved water quality, higher in-stream flows, reduced erosion, enhancement of sport fisheries, increased recreation activity, improved scenery, and rehabilitation of big game habitat. These "ecosystem service" benefits generate both use and non-use values that may exceed direct and secondary benefits several times over. Ecosystem service benefits, in turn, translate into improved property values and enhance the ability of economic development interests in both the public and private sectors to market their communities as high quality environments in which to locate businesses and raise families.

This paper suggests an approach for assessing these economic benefits of mine reclamation that may prove useful to public agencies in the context of permitting decisions for mine operation and closure. We use the Molycorp mine, near Questa, New Mexico as a case study, as this mine exemplifies the range of mine reclamation issues surfacing in reclamation debates throughout the nation.

Part two of the paper underscores the urgency of mine reclamation nationwide, and suggests that reclamation can play a vital role in the diversification of mining-dependent regions. Part three focuses on Molycorp, explaining why this site was chosen as a case study and describing some of the significant attributes of the local socio-economic environment that play a role in the debate over reclamation of this site. Part four describes the regulatory framework, and explains the essential role economic analysis should play in reclamation decisions made by the New Mexico Environment Department, Mining and Minerals Division, and Office of the Natural Resource Trustee. Part five suggests a methodology for estimating economic benefits associated with reclamation that is consistent with statutory requirements. The paper concludes with a partial application of this methodology to reclamation of the Molycorp mine in order to provide decision makers with a sense of the magnitude of economic benefits that should be documented in a comprehensive economic impact study for Molycorp and similar sites throughout the United States.

II: Background: *Reclamation and the revitalization of mining communities.*

While mining played an essential role in the development of the West, its legacy may now limit the ability of remaining mining communities to capitalize on the economic forces shaping the modern landscape. Mining and other extractive industries no longer contribute significantly to economic growth and development in most western regions. The share of extractive industry employment in the West has fallen considerably over the last two centuries. When the West was first settled in the early 1800s, employment in mining and agriculture accounted for 85% of all jobs. Today that figure is less than 3%. (Power 1996). Over the last two decades, the contribution of extractive industries to total income has decreased by 50%. Id. Mining, once the dominant economic sector in most western societies, has since diminished in importance so that now it represents no more than a sliver of total jobs. (Wilkinson 1992).

Globalization has contributed significantly to the diminished role of mining and other extractive industries. Lax environmental standards and cheap labor have lured many large natural resource companies to developing nations, where profits can be maximized. (Konz 2000). In addition, the vagaries of global resource markets have destabilized remaining employment in mining and other extractive industries in the West. Wild swings in resource prices and supply coupled with increased mechanization has contributed to chronic poverty in communities that still rely on resource extraction to a significant extent. (Power 1996).

Instead of relying upon logging, mining, grazing, and oil and gas development as a tool for economic growth, many western communities have now found that the most promising avenue for economic prosperity lies with businesses and industries that make use of the environmental amenities that make western communities attractive to residents seeking a higher quality of life. Id. Such amenities - clean air, clean water, access to undeveloped wilderness, scenery, wildlife, and recreation - are, of course, essential for businesses dependent upon recreation and tourism. However, the importance of such amenities is significant in a far more fundamental way. In an economy where business location decisions are less and less tied to traditional factors such as transportation, energy supplies, and population centers and more and more tied to owner preferences, communities that can offer first-rate environmental amenities that serve as a kind of “second paycheck” have an obvious competitive advantage. (Whitelaw and Niemi 1989).

Given these forces shaping the modern West, mining’s legacy may prove to be a hindrance to communities seeking to market themselves as high quality environments in which to live, work, and raise families. The legacy of mining in the West is of obvious concern. Acid mine drainage, the most conspicuous form of mining-induced environmental degradation may adversely affect 40% of all western watersheds, according to the Environmental Protection Agency. (Mclure and Schneider 2001). Over 12,000 miles of U.S. rivers have been contaminated. (Mineral Policy Center 2001). Streams and rivers contaminated by acid mine drainage often become biological dead zones, devoid of native fish and other aquatic organisms. By creating vast areas of exposed soils, mining greatly increases erosion and triggers more frequent landslides and flash floods that further disrupt sensitive aquatic habitats. The EPA recognizes that mines and associated infrastructure are a major source of sedimentation in many large watersheds throughout the United States. (EPA 1997).

Impacts to aquatic ecosystems are not the end of the story. Mines and associated tailings piles degrade ecosystems and fragment what remains, thereby diminishing native biological diversity. (Noss and Cooperrider 1994). In addition, mines create health hazards to humans and wildlife in the form of toxic air and water pollution that may impact communities far downstream and downwind of the mining site.

The degradation of terrestrial and aquatic ecosystems has many adverse economic impacts. Economists recognize that many ecosystem functions generate economic value to humans, and call these functions "ecosystem services." Such services include maintaining habitat for economically important game and non-game wildlife species, pollinators, and edible plants and fungi. They include flood control, water purification, and regulation of climate. Conservatively, it is estimated that ecosystem services contribute over $33 trillion each year to the global economy. (Costanza and Daly 1992). When ecosystem services are lost through land degradation, economies suffer. Economists call these economic losses "negative externalities."

When mines are developed, the most immediate and direct negative externalities include degradation of fish and wildlife habitat and associated losses in related recreation activities. More indirectly, but no less important are a host of indirect impacts: increased costs of water filtration downstream, lost tourist revenues, more damaging floods, increased expenditures on health care, and increased road maintenance costs. Both individually and cumulatively, such costs can be quite significant. For instance, a recent study in the Appalachian region concluded that erosion from a variety of industrial land uses imposes costs of at least $1.94 per ton on downstream municipalities and landowners who are forced to install filtering devices to remove sediments from their drinking water. (Ribaudo 1989).

Another significant indirect cost resulting from loss of ecosystem services is the deflationary effects on nearby property values associated with both real and perceived threats from air and water pollution as well as loss of scenic and aesthetic values. Denuded mining sites deflate property values by causing both an out migration of residents concerned about the health impacts of nearby mining and by reducing housing demand. (Clark 1992). The bottom line is that "by permanently degrading the landscape and releasing toxins into the air and water, mining can threaten a community's long run economic future." (Power 1996).

Although mining and other extractive industries have diminished in importance, such traditional industries will always be an important component of western economies. However, given their negative externalities there is a fast growing movement to reform the practices of extractive industries to be more in line with principles of ecological and economic sustainability. (Wilkinson 1992). This is, in part, why mining companies are under increasing pressure to adopt sustainable practices and to repair environmental damage caused by over a century of unregulated mining. High on the list of sustainable mining practices is full reclamation, completed simultaneously with continuing operation. (Dahlberg 1999).

According to the Mineral Policy Center "MPC", there are currently 557,000 abandoned hardrock mine sites left unreclaimed in the United States. (MPC 2001). Sixty six of these sites are so contaminated that they are included on EPA's Superfund National Priorities List. For these sites, any hope of reclamation lies with major public expenditures leveraged through the legislative process, an increasingly difficult task in today's political environment. Cost estimates for minimal reclamation of abandoned sites range from $32 to $72 billion, a hefty sum for any Congressional appropriation, and one that clearly presents an uphill battle for reclamation activists. Id.

However, for mines that are still operating, and for reasons developed further in this report, full reclamation is a worthy and attainable goal for regulators negotiating the terms and conditions of operation and closure plans and permits. In the past, mining companies have often resorted to threats of layoffs and bankruptcy to avoid reclamation requirements. (Mclure and Schneider 2001). Because of this, there has been far too much emphasis on the financial costs associated with reclamation from the mining company's perspective. Lost in this debate are the vast economic benefits mine reclamation can generate for local communities. Such benefits should receive equal consideration in decisions over the magnitude, composition, and timing of reclamation activities since statutes governing mine reclamation require that regulators make decisions that are in the public interest. These decisions must incorporate information on social costs and social benefits of reclamation and not be restricted to considerations of private costs incurred by the mining company.

Mine reclamation can benefit local communities in several ways. Reclamation activities create skilled, well paying jobs, ranging from project planners, engineers, biologists, hydrologists, and ecologists to heavy equipment operators and laborers. (Kuipers 2001). Many of these jobs fall into the broad category of environmental remediation, a sector rapidly gaining importance in global labor markets. (Economic Research Associates 1991). Such employment can play a valuable role in stabilizing mining related employment, since the positions required are similar to those employed in mine development and operation. Thus, instead of repeating the cycles of layoffs, unemployment, and associated social stress every time minerals markets are softened, companies can use reclamation as a bridge to promote greater economic stability.

A significant portion of income earned by individuals employed in reclamation activities is circulated through the local economy and generates, through the multiplier effect, additional jobs, income, and wealth in a broader range of economic sectors. (Miernyk 1965). Direct and secondary employment and income effects may, however, be overshadowed by other, more indirect benefits associated with restoring ecosystem services. As mining sites are reclaimed, local economies receive benefits in the form of cleaner water and air and more abundant fish and wildlife as well as reductions in hazards that arise from floods, air pollution, and water contamination. As environmental quality improves, property values increase, recreation and tourism recover, and communities are better able to market themselves as attractive places to live and work.

These potential benefits strongly suggest that reclamation may be an important bridge between a community's extractive past and a future based on amenities and quality of life. In order to capture these benefits, however, they must first be fully addressed in the context of mine reclamation decisions made by regulators at the federal, state, and local levels. By failing to tailor reclamation plans and programs to maximize these economic benefits, post-mining communities may find themselves shortchanged in their capacity to capitalize on the economic forces shaping the modern West.

III: The Molycorp Questa Mine: *An economic anomaly in the Enchanted Circle*

A. Description of the Mine Site

The Molycorp, Inc. site (Molycorp)[1] is a molybdenum mining site located near the town of Questa, Taos County, New Mexico and consists of two general areas: the mine and the tailings ponds. The mining operation as a whole includes open pit and underground mine workings with associated subsidence areas, waste rock dumps, an ore processing mill, a tailings pipeline, a tailings impoundment facility, and various other roads and facilities. (Kuipers 2000). The total disturbance area includes 750 acres of waste rock dumps, 300 acres for the open pit, 80 acres for the mine subsidence area, 640 acres for the tailings facilities, and 310 acres for roads and other facilities. Id.

[1] This site description is based primarily on the Environmental Protection Agency's Hazard Ranking System Documentation Record, Record NPL-U32-2-9-R6, unless otherwise noted.

The Molycorp Corporation of America (MCA) began underground mining at the site in 1923, and continued underground operations on and off through 1965, when open pit mining was initiated. In 1978, the Unocal 78 Corporation purchased MCA, and changed its name to Molycorp. In 1985, Molycorp ceased open pit mining and began new underground workings. Since the 1980s, production and employment at the mine site has varied dramatically. In 1998, molybdenum disulfide recovery from the mine was 6.5 million pounds, production value was $22.1 million, and the mine employed 225 people. In 1999, the mine produced just 2.85 million pounds valued at $11.2 million and employed 154. (Energy, Minerals, and Natural Resource Department 1999).

The mine is located near the Red River and several side drainages, including Sulphur Gulch, Spring Gulch, Goathill Gulch, and Capulin Canyon. The mine occupies approximately three square miles of land owned by Molycorp. The mine is surrounded by the Carson National Forest. The federally-designated Latir Peak Wilderness Area is located approximately two miles north of the mine. The tailings ponds occupy approximately one square mile of land also owned by Molycorp and consist of two large ponds and two smaller ponds. The tailings ponds are located approximately two miles west of the town of Questa and approximately 6 miles west of the mine.

The Red River is located immediately south of the mine and the tailings ponds, and flows in a westerly direction. Two tributaries to the Red River are located between the Molycorp mine and the tailings ponds: Columbine Creek and Cabresto Creek. The Red River flows into the Rio Grande approximately 3 miles downstream of the tailings ponds. In 1968, the Red River and the Rio Grande (in the vicinity of the confluence) were designated Wild and Scenic Rivers by the Bureau of Land Management (BLM).

B. The Local Economy

The debate over reclamation of the Molycorp site exemplifies the how the reclamation debate is unfolding throughout the western United States. The mine is located in northern New Mexico's Taos County, in what is referred to as the "Enchanted Circle," a scenic route connecting the towns of Taos, Angel Fire, Eagle Nest, Red River and Questa. (Bridges 2001). As with many western regions known for their pristine natural resources, northern New Mexico has long ago moved away from reliance upon extractive industries and now depends much more heavily on amenity oriented sectors such as recreation and tourism.

As one indicator, a recent study estimated that in 1996, the value of timber cut on National Forests in northern New Mexico and southern Colorado was just under $4 million, while the value of recreation in these same areas exceeded $800 million, or 200 times greater. (Talberth and Bird 1998). In Rio Arriba County, which borders Taos County to the south and west, a recent analysis concluded that over the past three decades, real income derived from natural resource sectors including mining, logging, agriculture and electric power generation has declined by 50%, while real income generated by other economic sectors expanded by 150%. (Power 1997). Since 1969, income derived from natural resource sectors in Rio Arriba County has hovered below $30 million, while amenity-related income, derived from increases in property values, payments to retirees, and tourists, expanded from roughly $70 million to nearly $250 million. Id.

In Taos County, the declining importance of extractive industries relative to amenity-oriented sectors is reflected in quarterly employment statistics. Between 1985 and the present, employment in three extractive sectors, including agriculture, mining, and lumber manufacturing declined 57% from 707 to 307. During that same period, employment in four sectors commonly associated with amenities and tourism rose by 97% from 1295 to 2559 employees.[2] Tourism is now recognized as the largest economic sector and one that is experiencing the most rapid growth. In 1995, the latest year where such values were calculated, tourism accounted for almost 28% of total gross receipts, and between 1990 and 1999, tourism ranked as the largest contributor to gross receipt gains. (New Mexico Taxation and Revenue Department 1999). In 1999, retail trade and services-of which tourism is a significant component-accounted for 60% of all employment in Taos County, while mining accounted for 2.6% of the total. (Bureau of Labor Statistics 1999).

Mirroring trends in extractive sectors throughout the West, extractive industry employment in Taos County not only declined in relative economic importance, but has also destabilized. Production and employment at the Molycorp mine is illustrative. Since 1985 when employment peaked at 600, the mine has shut down completely for a total of seven years, including one three year period and one four year period. (Taos News 1998). While operating, wild swings in production and employment have made it extremely difficult for workers to maintain steady incomes. (Thompson 1998). For instance, molybdenum sulfide production in 1999 was just 44% of the volume produced in 1998. (Energy, Minerals and Natural Resource Department 1999).

And as with other western extractive industries, one of the chief culprits in the destabilization of molybdenum production is globalization. In a recent article published in Central Colorado Magazine, Steve Voynick finds that "Third World copper mines, enjoying cheap labor and World Bank subsidization, dumped huge amounts of by-product molybdenum on the world market" in the 1980s, which began an era of oversupply and price instability which

[2] These figures were derived from the Bureau of Labor Statistics publication "Covered Employment and Wages" for the third quarter of 1985 and 2000, as well as mining employment data reported in the Taos News,

has lasted to this day. (Voynick 1994). Other contributing factors cited by Voynick include steep drops in oil prices, which killed demand for high-molybdenum oil field steel and sluggish markets for U.S. steel. Id. At the 12th annual general meeting of the International Molybdenum Association, President Dick de Cesare cited oversupply and inadequate demand as factors contributing to sluggish markets in 2001. (International Molybdenum Association 2001). In a 1999 article industry consultant Michael Anthony suggests that instability in molybdenum prices may be here to stay as a consequence of erratic and unpredictable exports from foreign nations. (Anthony 1999).

The instability of employment at Molycorp may be an important factor explaining the discrepancy in per capita and household income in Questa compared to other communities along the Enchanted Circle. Questa is the town closest to the mine and the home to the majority of the mine's workforce. As shown in Table 1, the latest census figures available indicate that per capita and household income in the Questa area are significantly lower than income in Taos, Angel Fire, and Red River. While 1990 median household income in Questa was comparable to Taos and somewhat lower than Angel Fire, it amounted to just 55% of Red River's household income. Per capita income disparities are much greater. Questa's 1990 per capita income was 59% lower than Red River, 39% lower than Taos, and 18% lower than Angel Fire.

Because of the declining importance and instability of extractive industries, Taos County, like many western regions, is using its reputation as a high quality living environment as a primary economic development strategy. Economic development efforts throughout the County are implemented under the umbrella of New Mexico's "Vision Plan," which sets forth a six-pronged strategy for defining the state's "New Economy." (New Mexico Economic Development Department 2000). One of the key strategies included in the Vision Plan is to

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Thursday, October 29, 1998.

“Enhance the Quality of Life for all New Mexicans.” Id. This component recognizes that “preserving and enhancing a high quality of life in New Mexico must be an important objective of all state and local economic development efforts,” and that “prosperous communities understand that quality of life goes hand in hand with quality and quantity of jobs.” Id. The state recognizes that in the New Economy, businesses are often free to locate wherever they choose, and that quality of life and physical attractiveness are the most important factors in business location decisions. Id.

Table 1:
Per Capita and Median Household Income in the Enchanted Circle, 1990[3]

Census Tract	Median Household Income	Per Capita Income
Questa	**$16,549**	**$6,205**
Red River	**$30,179**	**$15,278**
Taos	**$16,605**	**$10,080**
Angel Fire	**$18,333**	**$7,509**

In Taos County, long range goals for economic vitality include attracting businesses that are “sensitive to the historic, cultural, and environmental heritage” of the region and promoting tourism, which remains the most important industry. (Roth 1999). The County also recognizes the importance of preserving amenities, such as fish, wildlife, scenery, and pristine recreational opportunities in order to maintain the influx of amenity-seeking individuals, including retirees. Id. The development of locally based enterprises such as arts, crafts, and organic agriculture that are compatible with preservation of these amenities is also highly emphasized. For instance, the Taos County Economic Development Corporation “TCEDC” operates a highly successfully business incubator that offers an alternative to "mainstream economic development" by jumpstarting small, locally based businesses which are grounded in principles of sustainability and respect for "land based cultures and traditional life styles" native to northern New Mexico. (TCEDC 2001). Among the many businesses assisted by the incubator include furniture makers, tinworkers, upholsters, potters, artists, and non-profits. Id.

Taos County's focus on amenities and sustainability may prove difficult in Questa, where the legacy of the Molycorp mine may inhibit this community's reputation as a high quality environment in which to live and work. There is extensive documentation in the public record to indicate that the adverse direct, indirect, and cumulative effects to both terrestrial and aquatic ecosystems in the vicinity of the mine have been catastrophic, and long lasting. As a result, the many products, functions, uses and values generated by once intact native ecosystems have been lost. Loss of ecosystem services imposes a cost on landowners, businesses, and residents who derive economic value from such services. In addition, the mine has exposed humans and wildlife in the vicinity to a variety of environmental contaminants and, as a result, is generating additional costs associated with diminished value, demand for, and enjoyment of nearby properties.

C. Environmental Impacts

Although Molycorp vociferously denies that its mining operations have had any "substantial" adverse effects to native ecosystems (ENSR 1994), the preponderance of scientific evidence to the contrary should, at minimum, force regulators to thoroughly investigate the extent and magnitude of these ecosystem service losses before decisions over appropriate levels of reclamation are finalized.

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[3] These data were taken from the U.S. Census Bureau's report "1990 Income and Poverty Status in 1989: 1990", Summary Tape File 3 (STF 3) Sample data.

The most conspicuous impact to terrestrial ecosystems has been the replacement of high elevation mixed conifer forest, ponderosa pine forest, pinyon-juniper woodland, sage flats, and grasslands with the open pit, tailings facilities, roads and other infrastructure. The mine has displaced roughly 2,000 acres of these habitats. (Kuipers 2000). These terrestrial ecosystems surround the mine and tailings facilities, and support a wide diversity of mammals such as mule deer, elk, black bear, mountain lion, bobcat, coyote, and gray fox and birds such as Merriam's turkey, blue grouse, scaled quail, mourning dove and at least 133 other avian species including migratory birds. (ENSR 1994). Because the mining operations have completely eliminated cover and food sources, use of the mine area by such species is now just transitory, at best. Id. Impacts from the mine are not simply limited to the mine site itself. Edge effects of the mine, such as increased sunlight penetration, increased wind and wind damage, drying, and competitive effects from species that are adapted to open areas are all well-known, detrimental effects of habitat fragmentation in forest and woodland communities. (Finch 1995).

Exposed soils in the mine area have led to a dramatic increase in soil erosion, which compounds impacts to terrestrial ecosystems by removing the accumulated soils that make ecosystem recovery possible. Current soil loss rates for the site range from 8 to 34 tons per acre per year, which is 2.5-10 times the natural rate. (URS 2001a).

Impacts to aquatic ecosystems in the vicinity of the mine and tailing facilities have been catastrophic. The New Mexico State Water Quality Commission states that: " The Red River is one of the most severely impacted perennial stream systems in regard to metal loading in New Mexico. (WQCC 1994). Impacts include direct loss of riparian habitat, surface and groundwater contamination, alteration of in-stream flows, and loss of in-stream biota. Waste rock dumps buried riparian habitat in Capulin Canyon, Goathill Gulch, Spring Gulch, Sulfur Gulch, (SWQB

1996). The tailing impoundments were built on two deep arroyos. (Kuipers 2000). A hydrological connection between the tailings ponds and seeps adjacent to the Red River have been verified, indicating a direct negative influence by Molycorp on water quality. (Abshire 1998) An article that appeared in the Taos News in July of 1981 reported that several fishing ponds once used by local residents were buried in LaCandita canyon. A portion of the riparian zone along the Red River has also been degraded by mudslides and erosion from waste rock piles and construction associated with mine facilities. (Beacham 1991).

Surface and groundwater in Red River have been severely contaminated by acid mine drainage, heavy metals, and sedimentation. "Sources of acid mine drainage from the Molycorp mine include sulfide material in the waste-rock dumps, open pit, underground workings, and tailings deposits near the mill." (Surface Water Quality Bureau 1996). The only probable source for elevated levels of sulfate and metals concentrations in groundwater near the Red River in the tailings facility area is leakage from the tailings ponds (Abshire 1998). Frequent slurry spills have exacerbated these drainage problems. There were over 100 documented slurry spills into the Red River during the mine's operation. (Mineral Policy Center 1999). Metal loading is the most widespread and significant form of surface and groundwater pollution. Id. The primary metals contaminants include aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, and zinc. (EPA 2000 A). Molycorp has repeatedly attributed high metal concentrations to naturally occurring scars that appear periodically in the canyon walls along the Red River. Yet studies have shown that metal concentrations in river water and stream sediments downstream from the mine area are, in some cases, more than five times the values recorded for the natural scar areas. (Allen, Groffman et al. 1999). The main precipitate of concern is a white aluminum hydroxide compound that coats the steam bottom in reaches below the mine, and during low flows, clouds the stream. (Allen, Groffman et al. 1999)

In stream flow has been impacted by mine operations in two ways. The first manner is the diversion of surface and groundwater into the mine subsidence area. Water that formerly fed into the Red River from the forests, woodlands, and grasslands now occupied by the open pit now flows into the underground mine workings. (EPA 2000 A). The second manner is the extraction of water from the alluvial aquifer for use in various mining and waste treatment operations. (Kuipers 2000). Together, these aspects of the mine and its operation are likely causing a decrease in the baseflow of the Red River. Id.

The combined impacts of water quality contamination, sedimentation, and alteration of flows have had a catastrophic impact on the biota of the Red River. According to New Mexico's Surface Water Quality Bureau, "[a]t least eight miles of Red River from Molycorp to the Red River Fish Hatchery is essentially a biologically dead reach." (Surface Water Quality Bureau 1996) In this stretch of the river, not only are resident fish absent, but so are the wide diversity of riparian and in-stream organisms that form the basis of a healthy fishery. According to the Office of the Natural Resource Trustee, "[t]he patterns of hyporheic invertebrate diversity, abundance, and composition all indicate substantial negative impact of mining activities on the hyporheic portion of the Red River ecosystem." (Allen, Groffman et al. 1999) The spatial pattern of invertebrate organisms living beneath the streambed reveals a spatial pattern of greatly diminished numbers and diversity of organisms in the reach of high metal loading below the mine. Id. The New Mexico State Water Quality Control Commission states in its annual report on Water Quality and Water Pollution Control, that " the largest sources of metal loading within this watershed are located on private patented inholdings removed from the public trust under provisions of the General Mining Law of 1872." (WQCC, 1994).

The destruction of both terrestrial and aquatic ecosystems in the vicinity of the mine have, in turn, greatly diminished the value of ecosystem services once provided by nature, free of charge, from the forests, woodlands, grasslands, streams and rivers in the area. The impact to the fishery resource is particularly well documented. Once a world class blue ribbon fishery, in the vicinity of the mine, the Red River now supports little or no fishing use. (Mineral Policy Center 1999; Beacham 1991). In contrast, areas below Questa and above the mine enjoy tremendous use by fishers. According the State Game and Fish Department, in 1998, there were 30,785 angler days on the Red River below Questa and 45,138 in the upper reaches. (NMDGF 1998).

A wide range of beneficial uses of the river have been degraded or eliminated. Before impacts from the open pit operations began, the water quality of Red River near the mine was exceptional and the chemical quality and the biological conditions were good. (EPA 2000 B) The Lower Red River, from the Rio Grande to the mine, once was one of the finest trout fisheries in the state where plenty of large trout could be found. (New Mexico Department of Game and Fish 1938). In 1990, water quality survey data revealed that the Red River, from the Molycorp mine to the state fish hatchery was not supporting its designated uses as a high quality coldwater fishery, as a source of irrigation water, and for livestock and wildlife watering. (EPA 2000 A). Adverse water quality impacts to the designated Wild and Scenic section of the Red River are also of concern. Id.

The loss of terrestrial ecosystems on the mine site has eliminated habitat of species important to hunters and wildlife viewers. The mine "scar" mars once pristine scenery. Mine operations result in major episodes of "fugitive dust," which greatly limit visibility in an area otherwise known for its exceptional air quality. There is an extensive record of air quality problems associated with operation of the mine, most notably, the closure and relocation of a high school.[4]

D. Public Health Impacts

There has been growing concern in the Questa community about the potential health impacts from air and water pollution from the mine site. At a public hearing held in Questa on 3/29/01 several community members reported a variety of symptoms that could be related to heavy metal contamination such as various neurological problems, digestive problems, fatigue, respiratory problems, weight loss, and elevated liver enzymes. Although, to this date, a causal link between health problems and contaminants from the mine site has not been proved (for which a detailed epidemiological study would be needed) the increasing weight of evidence points to some connection. The possible association of health impacts with the alleged contamination of air and water from mine operations is another potential cost incurred by local residents and visitors above and beyond the loss of ecosystem services. Substances such as aluminum, arsenic, and cadmium, are of great concern from a public health standpoint. For instance, aluminum adversely affects breathing, the nervous system, and bones, and has been linked to Alzheimer's disease and to anemia. (U.S. Department of Health and Human Services, "USDHHS" 1999a). High levels can also cause birth defects. Id. Exposure to high levels of aluminum has been known to cause considerable damage to cerebral function (brain damage) to some individuals. (Altmann 1999). A local veterinarian recently examined a number of cattle that died after grazing near the tailings ponds, and found that aluminum levels in each were 100

[4] Air quality problems associated with operation of the Molycorp mine have been extensively reported on by the Taos News. See for instance, the 5/10/79, 5/17/79, 5/29/80, 4/9/81, 5/16/85, and 4/18/93 editions.

times normal levels.[5] Arsenic, one of substances listed by the EPA potential contaminants from the mine can cause severe gastrointestinal damage, facial edema, cardiovascular reactions, peripheral nervous system damages, respiratory tract cancer, skin cancer, and noncancerous skin lesions. (EPA 1985). Cadmium, another substance of concern, can severely damage lung tissue, cause kidney damage, and weaken bones. (USDHHS 1999b). Ingestion of high levels of cadmium through food or water can severely irritate the stomach and can cause vomiting and diarrhea. Id. Beryllium is yet another cause for alarm. Beryllium has been found in unusual quantities in mine area water. These unusually high levels have prompted Molycorp to warn its employees not to drink the water at the mine. (Kuipers 2000) Even a small dose of beryllium can cause severe reactions similar to those triggered by asbestosis Id. Exposure to beryllium in the air can cause lung damage, skin eruptions, an increase in risk of lung cancer, and can produce a disease that resembles pneumonia. Some people, upon exposure to beryllium, develop chronic beryllium disease that can cause symptom of weakness, fatigue and difficulty breathing (USDHHS 1999c; EPA 1988). With reclamation these potential health impacts could be avoided. The threats posed by such contaminants have prompted the Environmental Protection Agency to include the Molycorp mine on its National Priorities List (NPL), a list of proposed Superfund clean up sites.[6]

E. The Call for Full Reclamation

Mirroring trends in post-mining communities throughout the West, the legacy of the Molycorp mine has triggered an outcry from local residents, businesses, community leaders, and conservation organizations for full reclamation of the site. In 1999, with the aid of a respected mining consultant, the conservation group Amigos Bravos developed a full reclamation plan for

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[5] Personal communication with Dr. Shupbach, 7/30/01.

the site that involves resloping and revegetating the waste rock piles, the open pit, the subsidence area, the tailings facilities, and unnecessary roads. (Kuipers 2000). The plan also includes improvements to water treatment facilities. Id. The total cost of full reclamation by a third party was estimated to be approximately $382 million. Aside from the obvious benefits to fish, water quality, wildlife, and scenery, full reclamation has been proposed as a tool to stabilize mining employment during times when global markets compel a drop in production.

Molycorp has resisted full reclamation. In a plan submitted to the New Mexico Mining and Minerals Division in June of 2001, Molycorp proposed a closeout/reclamation plan permit revision in which they request a waiver from state reclamation requirements for the open pit. (URS 2001b). Economic feasibility was cited by Molycorp as the reason for requesting a level of reclamation far below that proposed by Amigos Bravos, and for requesting a waiver. Id. However, in its analysis of economic feasibility, Molycorp entirely overlooked the benefits side of an economic feasibility analysis. Instead, the only factor used by Molycorp in determining that full reclamation was economically infeasible was direct financial costs to the company. Id.

While Molycorp is certainly free to rest its economic case solely on its own financial costs, public regulators must, as we discuss in more detail in the next section, carefully examine both costs *and* benefits of reclamation in determining the optimal level of reclamation from the public standpoint. Once these are taken into account, it may certainly be the case that full reclamation of the Molycorp site is not only feasible, but highly desirable from an economic standpoint.

[6] Federal Register/ Vol. 65, No. 92/ Thursday, May 11, 2000/ 30489-30495.

IV: The Regulatory Framework: *Regulators must take the economic benefits of reclamation into account.*

Depending on location, scale, and the minerals involved, the operation and reclamation of mine sites in the United States may involve regulators from over a dozen agencies at the federal, state, and local levels. These agencies, in turn, make their decisions under the authority of many overlapping, sometimes conflicting, statutes, ordinances, rules, and regulations. While there is a dizzying constellation of regulations affecting mine reclamation, the primary objective of almost all these regulations is the protection and restoration of both terrestrial and aquatic ecosystems *and the economic uses that benefit from these ecosystems*. Because the statutes governing mine reclamation purport to protect and restore such uses, any economic analysis supporting decisions over mine operation and reclamation ought to address how such decisions alter patterns of employment, income, and wealth generated by various protected uses such as fishing, hunting, recreation, forestry and agriculture. Economists recognize five major categories of economic values associated with use of any particular environmental resource: (1) direct use values; (2) indirect use values; (3) option values; (4) bequest values, and (5) existence values. (Kopp and Smith 1993). Direct use values are determined by the contribution of an environmental asset to current production or consumption. Examples include edible plants, herbs, and mushrooms from forests, irrigation water from streams, or forage from grasslands. Indirect use values are determined by the functional service flows, or ecosystem services, from the environment that support current and future production and consumption Examples include flood control and purification of water. Option values refer to the value individuals place on the potential future use of a resource and are usually measured by the willingness to pay now for the option to exercise future use of an environmental asset. Bequest values refer to the present generation's preference for bequest to future generations. Existence values refer to the contemplative values for the existence of a resource arising independent of any current or future *in situ* use of the resource. For instance, many people place economic value on the existence of polar bears, although few will actually visit regions where polar bears are found. Decisions made in the public interest should incorporate information about all of these uses and values when weighing the costs and benefits of alternative courses of action that affect environmental conditions. (Boardman, Greenberg et al. 2001).

B. Molycorp – Federal Regulations

Almost all of the various federal and state statutes and associated regulations governing reclamation of the Molycorp mine contain requirements for protection and restoration of beneficial uses of the lands and waters affected by both operation and reclamation of the mine, and the values associated with such uses. The Environmental Protection Agency is the primary federal agency involved with permitting activities at Molycorp. The EPA is responsible for issuing, monitoring, and amending permits for discharges of pollutants into surface waters under its National Pollution Discharge Elimination System. (URS 2001b). The EPA is also responsible for issuing an air quality permits under its Title V Operating Permit Program. Id. These programs are implemented pursuant to the federal Clean Water Act and the federal Clean Air Act. Both these statutes call for protection and restoration of a wide range of beneficial uses. Clean Water Act permits must protect a wide range of economic uses such as fishing, swimming, boating, aesthetic enjoyment, recreation, irrigation and domestic water supply. 33 U.S.C. § 1314; 1311. The Clean Air Act was passed to "protect public health and welfare including injury to agricultural crops and livestock, damage to and the deterioration of property, and hazards to air and ground transportation." 42 U.S.C. § 7401 (2).

The EPA is also bound by the National Environmental Policy Act ("NEPA"). The Council on Environmental Quality Regulations implementing NEPA include explicit requirements to consider economic impacts of all federal actions, require that environmental effects and values be considered in a manner that facilitates comparison with other economic variables, and requires that "environmental impacts, values, and amenities" be incorporated into benefit-cost analyses. 40 C.F.R. § 1508.8; 1501.2 (b); 1502.23. Finally, since operation and reclamation of Molycorp affects the Wild and Scenic section of the Red River, the EPA must comply with regulations implementing the Wild and Scenic Rivers Act, which require full protection and restoration of "scenic, recreational, and fish and wildlife values present in the area." 40 C.F.R. § 6.302 (e) i.

B. Molycorp – State Regulations

At the state level, there are three key agencies involved with decisions over the appropriate magnitude, composition, and timing of Molycorp reclamation activities. These include New Mexico's Environmental Department ("NMED"), the Mining and Minerals Division ("MMD") and the Office of the Natural Resource Trustee ("ONRT").

New Mexico's Environment Department oversees a variety of programs designed to protect and restore surface, ground, and air quality and the beneficial uses associated with these resources. In order to accomplish this, NMED has promulgated regulations establishing standards for air and water quality and procedures for obtaining permits to discharge pollutants that present public health hazards and which impair beneficial uses and their values. Such regulations are intended to protect "the use and value of the water for water supplies, propagation of fish and wildlife, recreational purposes and agricultural, industrial and other purposes" as required by New Mexico's Water Quality Act. NMSA 74-6-4.

For instance, NMED's regulations governing discharge permits for groundwater include provisions for protecting "all groundwater of the state of New Mexico…for present and potential future use as domestic and agricultural water supply." NMAC 20.6.2.3101. The protection of potential future use here generates what economists call "option value," discussed earlier. An economic impact analysis of groundwater impacts should, then, incorporate information on both existing use and option values in order to be consistent with regulatory requirements.

In another example, NMED regulations for interstate and intrastate surface waters include provisions for protecting "instream water uses and the level of water quality necessary to protect the existing uses" and prohibit water quality impacts that "interfere with the reasonable use of the water." NMAC 20.6.4.12.A; 20.6.4.12.D. Again, to insure that reclamation activities meet these standards, an economic impact analysis must be completed that documents whether or not reclamation is sufficient for eliminating the adverse effect past mining has had on protected uses.

New Mexico's Mining and Minerals Division ("MMD") is the agency primarily charged with implementing the state's Mining Act ("Act"), which requires all existing mine operators to develop and implement plans for eventual closure and reclamation of mine sites. NMSA 69-36-11. Reclamation activities authorized by MMD under the Act must meet the substantive requirement to "reclaim the physical environment of the permit area to a condition that allows for the reestablishment of a self-sustaining ecosystem." NMSA 69-36-11 (B) 3. The definition of "self sustaining ecosystem" includes requirements for "hydrologic and nutrient cycles functioning at levels of productivity sufficient to support biological diversity." NMAC 19.10.1.7. While the definition of ecosystem sustainability and productivity can certainly be interpreted purely in physical terms, such an interpretation neglects the human dimension of sustainability.

An increasing number of ecologists now recognize that human uses and interactions with ecological systems are as important as physical factors such as sunlight and soil composition to the sustainability and productivity of such systems. Preserving the diversity of social, cultural, and economic interactions with the land may not only be consistent with, but essential to preservation of biological diversity. "On the face of it, inclusion of social diversity in a definition of biodiversity makes sense. We are fundamentally as much a part of Nature as any other species and share kinship and ecological interactions with all of life." (Noss and Cooperrider 1994). In light of this, any approved reclamation plan ought to incorporate information about the various goods, services, uses, and values generated by healthy ecosystems and essential for sustaining critical human interactions with the land.

The Mining Act also includes more specific requirements for sustaining approved post mining land uses. "Post mining land use means a beneficial use or multiple uses which will be established on a permit area after completion of a mining project." NMAC 19.10.1.7 (P) 5. The approved post mining land use selected for Molycorp's tailings facility is "wildlife habitat/self-sustaining ecosystem" and for the open pit, the proposed post mining land use is forestry. An economic analysis of the reclamation plan should, then, incorporate information about the economic benefits associated with such uses.

The Mining Act also makes specific mention of the need for economic analysis. The Mining Commission, the body in charge of implementing the provisions of the New Mexico Mining Act, is explicitly charged with the task of analyzing environmental and economic impacts of the Act: "The commission shall…. consider the economic and environmental effects of… their [regulations] implementation." NMSA 69-36-7 (A) 1.

Economic analysis by the operator is specifically required when seeking a waiver of reclamation requirements for open pits or waste units: "The operator should show that achieving a post-mining land use or self-sustaining ecosystem is not technically or economically feasible or is environmentally unsound." NMAC 19.10.5. Since MMD is a public agency operating in the public interest, we believe an adequate analysis of economic feasibility must incorporate *all* benefits and costs associated with reclamation to society as a whole, and not be based solely on an operator's alleged costs. Furthermore, economically feasibility means that *cost does not unreasonably exceed benefits.* In this interpretation the costs of a proposed action could exceed the benefits to a reasonable degree and the action would still be economically feasible.

As discussed earlier, Molycorp has applied for a waiver of open pit reclamation requirements. To justify such a waiver, Molycorp and MMD must determine that full reclamation is "economically infeasible." NMSA 69-36-11 (B) 3. In the Molycorp waiver request information about the public costs and benefits of the waiver have not been addressed. The only analysis supporting the waiver request is a listing of financial costs to Molycorp and a simple allegation that reclamation beyond the minimal level suggested by Molycorp is "not economical" and produces "essentially no benefit." (URS 2001b). This analysis, which is simply limited to one factor-private financial costs-is facially inadequate for use by MMD, as a public agency, in determining the socially optimal level of reclamation from a public perspective. Again, and as we have argued throughout this section, such economic analyses must be conducted in a manner that incorporates information on whether or not the wide range of public uses and values associated with healthy ecosystems will be damaged, sustained, or improved since other regulatory requirements protect such uses and values. Unless the analyses are completed in such a manner, MMD regulators have no information about the public costs and benefits of their decisions.

The third, and, perhaps, most important state agency involved with regulatory decisions over reclamation of the Molycorp site is New Mexico's Office of the Natural Resource Trustee ("ONRT"). The ONRT was established by the state legislature as part of a nationwide effort to implement the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA"). CERCLA makes certain potentially responsible parties (PRPs) liable for monetary damages resulting from injury to, destruction of, or loss of natural resources caused by a release of a hazardous substance. 42 U.S.C. § 9607 (a)(4)(C). Only designated federal, state, and Indian tribe natural resource trustees may recover natural resource damages. Damages may be recovered for those natural resource injuries that are not fully remedied by response actions (such as mine reclamation) as well as public economic values lost from the date of the release until the resources have fully recovered. (DOI 1995). All monetary sums recovered in compensation for natural resource loss must be used to restore, rehabilitate, replace, or acquire the equivalent of the injured natural resources. 42 U.S.C. § 9607(f)(1).

New Mexico's Natural Resource Trustee Act ("NRTA") was passed to implement CERLA. The NRTA establishes the ONRT, and charges the Trustee to: (1) act on behalf of the public to protect New Mexico's natural resources by recovering damages for injury to, destruction of, or loss of those resources; (2) investigate injury to, destruction of, or loss of natural resources; (3) determine the amount and cause of injury to, destruction of, or loss of natural resources; (4) determine the liability of any person for injury to, destruction of, or loss of natural resources; (5) assess and collect damages for injury to, destruction of, or loss of natural resources; and (6) expend monies to repair such damage. NMSA 75-7-3 (A). In determining the economic value of damages to natural resources, the ONRT must include the cost of restoration as well as the "loss of use or enjoyment of the natural resources." NMSA 75-7-4. The Department of Interior has published a manual for conducting natural resource damage assessments that explains and demonstrates methodologies for quantifying all of the categories of use and value described earlier-direct use values, indirect use values, option values, bequest values, and existence values. (Unsworth and Peterson 1996).

The activities of the ONRT will directly influence the composition, magnitude and timing of reclamation activities at Molycorp. In a letter dated October 19, 1999, the ONRT issued a letter to Molycorp indicating that the ONRT "has determined definitively, for the first time, that the mining operations of Molycorp have caused natural resource damages beyond that caused by natural weathering of mineralized rock." (Turner 1999). That letter initiated a 3 year period in which the ONRT has to recover all costs associated with the natural resource damage assessment process. Id. The ONRT natural resource damage assessment, if conducted in compliance with all relevant state and federal laws, will determine the ultimate amount of reclamation that is necessary to compensate the public for the loss of use and enjoyment of the lands, waters, fish, and wildlife damaged by mining operations. In determining the appropriate level of reclamation, all public costs and all public benefits must be evaluated so that the net economic impact is equivalent to the economic value of the damage caused by mining. Thus, should MMD and NMED fail to require a level of reclamation sufficient for full recovery of this loss, the ONRT will be forced to collect and expend reclamation funds to make up the difference. In this way, the ONRT has the "final" say on how much reclamation should occur, and, in determining this amount, must fully account for all of the public economic benefits reclamation activities will generate.

The statutes, rules, and regulations governing reclamation of the Molycorp site necessitate a full accounting of economic benefits associated with reclamation from a public perspective. We now turn to an explanation of methodologies regulators can use to assess the magnitude of such benefits.

V: The Analytical Framework: *Methodologies for measuring mine reclamation benefits.*

Public decision makers acting in the public interest should use a social benefit/ cost analyses ("BCA") to determine the overall efficiency of decisions affecting economic uses and values and use such analyses as a basis for comparing the net public benefits associated with various alternatives. (Boardman, Greenberg et al. 2001). In some instances, such analysis is required by statute (such as executive order 12291 issued by President Reagan).

BCA extends beyond the usual profitability or return analysis conducted by an enterprise when deciding whether to undertake an investment. Specifically, BCA includes all costs and benefits that accrue to society at large. To conduct a BCA requires that the entire spectrum of benefits and costs be enumerated and assigned a value. The net benefits (may be negative) are then computed for each period of the project life. To compare across projects with different time paths the common basis is the net present value (NPV). Thus, BCA is a systematic method of evaluating a project or undertaking that includes all benefits and costs to society at large and places all possible projects on a common footing – the NPV – for comparison.

Some have tried to infer a decision rule from the BCA – take the project with the highest NPV. While this has merits, such a basis is not sufficiently comprehensive to form a decision rule. The BCA, however, can inform the decision process by eliminating projects with negative NPVs and by indicating those projects with high NPVs. Further, by forcing the enumeration of the benefits and costs, BCA requires the analyst to specify all attributes of the projects.

The key steps in BCA are:

1. identify or catalog the benefits and costs associated with the project.

2. evaluate these benefits and costs at their shadow or full prices. That is, all costs must be evaluated at their full resource costs – the costs they impose on society. A construction project that utilizes heavy equipment in a residential district imposes costs in the form of equipment costs as well as noise, dust, etc. in the neighborhood. The full cost then would include these external costs as well as the direct costs of the machinery. The same is true of the benefits.

3. discount the stream of net benefits at the appropriate discount rate. Benefits and costs that arise in the future are worth less than those that arise in the present for several reasons. Individuals place a lower value on a dollar received in the future even in the absence of inflation. This is due to a variety of factors including impatience, foregone opportunities for consumption, and uncertainty. There is a great deal of discussion concerning the appropriate level of this discount rate. A well accepted argument has the real (net of inflation) discount rate as being the long run rate of growth of the economy plus an adjustment for risk and impatience. This typically yields values in the 4 percent range.

4. conduct sensitivity analysis to deal with measurement difficulties and potential sources of uncertainty regarding projected streams of benefits and costs. One simple means of conducting such sensitivity analysis is to vary the discount rate. However, the analysis can also be conducted with ranges on the computed benefits and costs.

While BCA incorporates all social benefits and costs, our discussion here will focus on methodologies for incorporating social benefits into economic analyses supporting mine operation and reclamation decisions. This is because while information on the costs of reclamation-especially financial costs to the mining company-is readily available, what is usually lacking in the equation is any consideration whatsoever of benefits. And this is certainly the case in the decisions surrounding the reclamation of the Molycorp site.

The benefits side of the equation falls into two broad categories: market and non-market benefits. What follows is a discussion of methods economists can use to quantify such benefits.

A. Market Benefits

To calculate the market benefits of natural resource management decisions, economists use models of regional economic impacts that generate numerical estimates of the changes in output, earnings, tax revenues, and employment caused by implementation of a particular natural resource policy, program, or project. Such models are typically known as “input-output” models. Input-output models are a device for organizing the basic accounting relations that describe the production sector of the economy.

The input-output method starts with a very simple idea. All the sectors of the economy are tied together by virtue of economic relations called “linkages” and the production of a good or service can be described by a “recipe”. The ingredients of this recipe are the outputs of the other sectors of the economy as well as the primary inputs such as labor, capital, and other raw resources. A simple example will serve to demonstrate.

Consider a commodity such as steel. A particular economy with a given technology will allocate the steel it produces in a unique way. Some of the steel will be used to make equipment for making more steel (e.g., rolling mill equipment), some will be exported (or some will be imported), and some will be used in the manufacture of cars, buildings, bridges, etc. Obviously, all of the steel that is allocated or used up must add up to all of the steel made. If the total amount of steel made is 1,000,000 tons an allocation might be as follows:

Steel used to make steel	100,000 tons
Steel used to make cars	500,000 tons
Steel used to make bridges	100,000 tons
Steel used to make buildings	290,000 tons
Steel sold to households	10,000 tons
TOTAL steel production/allocation	1,000,000 tons

The steel used to produce other commodities in the economy reflects the "linkages" mentioned above. The extent to which the economy is an integrated whole depends on the strength of these linkages. Linkages that tie steel to the output of more finished products are known as forward linkages while those (not shown in this example) that relate steel to basic raw materials and labor are known as backward linkages. A similar table could be constructed for every commodity in the economy and, taken together, these would describe the entire economy.

A common unit of measurement is necessary if the sectors are to be linked into a single model of the economy. Thus, all inputs and outputs are measured in dollar units rather than physical units. To make use of all of these tables for the various commodities in the economy requires an analytical device that relates all of the backward and forward linkages in the economy in a manner which permits investigation of "what if" scenarios. This analytical device is the input-output table. Appendix I provides an overview of how to construct an input output table and use such a table to generate estimates of changes in final demand for a wide range of goods and services in the economy resulting from increases in economic inputs. In the case of mine reclamation, such inputs include the purchases of labor and capital necessary to carry out reclamation activities as well as the improved ecological conditions that generate increasing marketed uses of reclaimed land for recreation, water, timber, forage, and other products and services.

B. Non-Market Benefits

1. Nonmarket Valuation

Economic value is premised on the notion of individuals being able to express preferences over a choice set, and then being willing to pay (or accept compensation) in monetary terms for realizing a given outcome. Thus, understanding economic tradeoffs between nonmarket environmental protection (or restoration) and market goods and services requires assigning monetary values to various quality dimensions of the environment. This area of economic research is known as nonmarket valuation.

Nonmarket valuation refers to the assessment of economic values for goods and services that are not typically priced and traded in a market (e.g., outdoor recreation, air and water quality, species and wilderness preservation). Absence of a functioning market does not imply the absence of economic value – willingness to pay or be paid for some change in environmental quality (such as eliminating some external effect, or providing some positive one) is just as much an indicator of economic value; however, it does complicate benefit-cost analyses and natural resource damage assessment and liability cases. While largely developed and applied within the context of environmental goods and services, nonmarket valuation techniques can be applied to any public good. Further, although nonmarket valuation techniques were primarily developed in the U.S., within the regulatory framework of benefit-cost analysis, their application has spread to Canada, Europe, Australia and elsewhere (Bateman, 1999; Loomis 1999). Literally thousands of studies applying nonmarket valuation techniques to value environmental goods and services have now been published. Considerable effort has been invested by environmental and resources economists over the last four decades into developing and refining a battery of techniques for measuring nonmarket values of individuals for environmental goods and services. While considerable debate over the application of nonmarket valuation techniques remains, as the Nobel Laureate economist Kenneth Arrow (1994, pg. 1) notes: "the typical economist's argument today for government intervention to protect the environment rests on individual valuation."

2. <u>The Set of Valuation Methods</u>

The set of techniques for nonmarket valuation can be divided into two broad types: (1) revealed preference approaches; and (2) stated preference approaches. Both approaches rely on the standard microeconomic framework of individual utility and consumer demand theory (Freeman 1993).

Revealed preference approaches attempt to infer economic values for some nonmarket dimension of environmental quality by some other observed or revealed economic behavior. For example, the travel cost method (TCM), and its variants such as the random utility model (RUM), use information on travel cost expenditures and recreational site choice to statistically estimate the demand for recreation site(s), and from there to infer values for various changes in access or environmental quality. By statistically decomposing the determinants of price variation in real estate transactions, the hedonic pricing method (HPM) can isolate the positive or negative value of various dimensions of environmental quality (e.g., proximity to wetlands or a hazardous waste site, air and water pollution).

Stated preference approaches include a variety of survey-based methods for eliciting preference information in response to some constructed scenario, such as a proposed policy change. The contingent valuation (CV) method places the respondent within some constructed market scenario (either private or political), and elicits statement of willingness to pay (WTP) or willingness to accept compensation in response to some hypothetical change in environmental quality. Various elements of survey design (e.g., identification of property rights, definition of the good, payment vehicle, elicitation format, and implementation rule for providing the public good) must be carefully considered in order to minimize potential biases and increase the incentive compatibility of the responses (i.e, to provide accurate value estimates). Rather than directly asking for valuation responses, the contingent behavior (CB) method follows a similar approach but asks for an intended behavioral response to the posited change in environmental quality (e.g., change in recreational fishing trips in response to hypothetical change in water levels).

Finally, for both stated and revealed preference approaches, generating valid estimates of the economic benefits of environmental protection involves a host of statistical and econometric issues. That is, they are both empirical approaches and there is large literature that has developed investigating appropriate statistical modeling and inference.

3. Typology of Economic Values

Total economic value (TEV) refers to the composite set of values that might be associated with some real or proposed change in the environment. The first important split is between market values (both direct and indirect impacts), which can be assessed from available market information and regional economic modeling of an economy, and nonmarket values, which are themselves commonly considered to have several different types. In any typology of values for nonmarket goods and services the critical distinction is between use values (e.g., values for outdoor recreation) and nonuse values (Freeman 1993; Loomis 1993). Use values refer to some direct, typically in situ or on site, use of some environmental good or service. Nonuse values, sometimes also referred to as passive use values, are purely contemplative values that by definition have no discernible trail to market behavior (Carson 1999). Perhaps the archetypical nonuse value is existence value, which is argued to arise from “simply knowing that some desirable thing or state of affairs exists.” (Randall 1991). For example, existence values may be attributed to simply knowing that endangered species or wilderness areas exist. Another example of a nonuse value is option value. Specifically, individuals may hold an option value for an environmental good or service, even though they currently do not use the resource; they value retaining the option of potential future use (Freeman 1993).

A significant change in environmental quality may be the source of both nonmarket use values, and nonmarket nonuse values. It is important to note that revealed preference approaches (e.g., TCM, RUM, HPM) can only be applied to measure use values. Stated preference methods (e.g., CV, CB) can also be targeted to use values. In the statistical meta-analysis of literally hundreds of comparisons between matching stated and revealed preference approaches, no statistically significant difference in estimated values is identifiable, with the revealed preference (RP) behavioral approaches producing slightly higher estimates on average (Carson 1996). However, since the analyst constructs the frame of reference and contingent scenario, survey-based CV methods can be applied to measure both use and nonuse value. Thus, CV is literally the only recognized way of measuring nonuse values for changes in environmental quality. As such, applications of the CV method to measuring nonuse values represent the most controversial and problematic element within nonmarket valuation research (Bateman, 1999). Evidence of this controversy is best seen in the public debates surrounding the initiation in the early 1990s of including nonuse value estimates in natural resource damage and liability cases (e.g., the Exxon Valdez case). However, a blue ribbon panel including several Nobel Laureate economists, and convened by the National Oceanic and Atmospheric Administration (NOAA), provided their qualified endorsement of the CV method in measuring nonuse values for consideration in natural resource damage assessments (Arrow 1994).

4. Benefit Transfers

Applications of all types of nonmarket valuation approaches have continued to grow rapidly over the last two decades. There is considerable track record in the use of these approaches by a wide variety of federal and state agencies (Walsh, 1992; USACOE, 2000); and for lengthy reviews see Loomis (1999) and Loomis (1993). For example, the U.S. Forest Service has for some time regularly used nonmarket values for their periodic RPA (Resource Planning Assessment) process in reviewing forest management. For any given setting, the most accurate estimates of the nonmarket economic benefits of environmental quality will be obtained by designing and conducting an original ("de novo") study. Given that high quality studies can easily cost several hundred thousand dollars or more, collecting original information is not always feasible. As such there has been considerable interest over the last decade in conducting benefit transfers.

A benefit transfer can be defined as the transfer of a nonmarket benefits estimate from one or more study settings to the policy setting of interest. For example, in attempting to estimate the nonmarket economic benefits of wetlands preservation in the particular policy setting, A, the analyst may directly use or calibrate results from previously conducted studies and settings B, C and D. A benefit transfer can be as simple as a point estimate of value, or may include using a statistical confidence interval, a statistical benefits function, and the results of a meta-analysis (a statistical model of previous related studies). A benefit transfer may also be calibrated to the particular environmental or socio-economic characteristics of the policy setting. Benefits transfer can also be used for different purposes. For example, a study setting and a policy setting may involve a close mapping of community characteristics and highly similar environmental changes (or changes in public goods), such as similar changes in water treatment in two comparable cities along the same waterway. Then, the benefits transfer may be reasonably targeted to generating a very specific value estimate for a benefit-cost analysis. At the other end of the spectrum, the policy setting may involve fairly unique circumstances, or no close mappings to previous studies may exist. The purpose of the benefits transfer may simply be to inform and allow general inferences about the magnitude and kinds of values that have been found for the various categories of environmental benefits in other circumstances [e.g., see Walsh, 1992; USACOE, 2000). The role of the benefits transfer may be to help acknowledge that important nonmarket economic values exist (and shouldn't be ignored in policy decisions), or may serve as the precursor to future original investigations of nonmarket values. More properly, this type of analysis might best referred to as a scoping of study of possible environmental benefits. In this case study we would be interested in the environmental benefits of mine reclamation.

VI: The Molycorp Example: *Filling in the holes on the benefits side of the equation.*

As discussed earlier, to date, there has been no analysis of the potential economic benefits associated with reclamation of the Molycorp mine. A rigorous analysis of such benefits would be far beyond the scope of this paper. However, in order to establish that such benefits may, indeed, be quite substantial and worth serious investigation, we have partially applied the methodologies discussed in Section V. The results of this application are discussed below.

In the analyses which follow, we have assumed that the final reclamation plan for Molycorp will resemble something greater than what is currently proposed by the company but something less than the full reclamation plan proposed by Amigos Bravos. We chose an intermediate amount-$200 million-as an estimate of the price tag associated with a reclamation plan that could satisfy statutory regulations and represent a reasonable financial burden for Molycorp. Direct expenditures and job projections for reclamation at the Molycorp mine site were calculated using this $200 million figure. It is estimated that a total of $45 million over a 20 year period will be spent directly on salaries for the numerous jobs created. During the first 10 years of reclamation there will be an average of 91 on-site reclamation - related jobs per year. These jobs will have an annual salary range between $32,000 - $84,000. Over a 20 year period approximately $15 million will be spent on locally purchased supplies. All of these factors will positively impact the Questa economy. Appendix II provides a table describing $200 million in labor and capital costs associated with resloping and revegetating the waste rock piles, the open pit, the subsidence area, the tailings facilities, and necessary roads. (Kuipers 2001).

Implementation of this level of reclamation will enhance a wide range of ecosystem services, described in detail in Appendix III. These include such services as improved water quality and flow, enhanced scenery, erosion control, improvement of fish and wildlife habitat, and other uses and values associated with native ecosystems existing in the Molycorp vicinity. These also include public health benefits associated with reductions in air and water pollution and diminished exposure to safety hazards. Appendix II and III form the basis of the estimates of both market and non-market economic benefits associated with reclamation of the Molycorp site which follow.

A. Market Benefits

1. <u>Defining the Model</u>

To calculate the net market effects of the mine reclamation activity a multi-sector model of the economy of the region was constructed. The basis of this model is an input-output (I-O) model that relates the linkages in the local economy. A brief overview of the I-O methodology is provided in Appendix I. The mine reclamation scenario constructed on behalf of Amigos Bravos is projected via impacts to the local economy. The results of the present study quantify the market economic benefits of mine reclamation as measured by the increase in the level of economic activity in the regional economy. Much of this study focuses on the economic activity associated with the mine reclamation and the consequent economic activity associated with having the area restored to a viable ecosystem.

The data set to construct the I-O model of the region was derived from the IMPLAN database. This database provides information on inter-industry transactions, employment, output, employee earnings, indirect taxes, and payments to capital for all of the firms in the county. In the full database, the economic activities are grouped together (aggregated) into approximately 300 industrial categories.[7] For the purposes of analysis, these are further aggregated into 18 economic activities. The 18 sectors are reported in Table 2. In economic analysis aggregation is done for several reasons. First, many of the sectors in the regional economy are small and models are poorly behaved when small sectors are included. Second, it is extremely difficult to analyze the sector level changes associated with an impact, such as growth in the economy, with many economic sectors depicted. For this reason, most regional analysis is conducted with aggregated models. A third reason for aggregation is that it allows the analysis to focus on key sectors of concern to the question at hand. A brief discussion of the aggregation is included in Appendix IV.

In addition to designing the sector aggregation scheme, the analyst must also select the appropriate spatial aggregation – that is the region for analysis. The IMPLAN database is organized at the county level. Thus the question is the number of counties to include in the study region. The Molycorp mine is located a short distance from the town of Questa in Taos County. However, the impacts associated with reclaiming the mine site will extend beyond the immediate area of Taos County. As discussed elsewhere, the reclamation will confer direct benefits to housing in the immediate area, to recreation, and to health. In all cases these benefits will accrue to a larger geographic area constituting an economic region. Recreation activities, housing investments and health benefits will generate purchases in areas outside Taos County. On the basis of the patterns of regional commerce, the economic region affected by the mine reclamation activities was deemed to include Taos, Mora, Santa Fe, Colfax, and Rio Arriba counties.

Once the aggregation was completed some further adjustments to the database were made to reflect local information. The IMPLAN database is constructed by applying some local data (primarily employment levels available from the Bureau of Labor Statistics) to national data to derive local I-O coefficients and also earnings data, and so on. For areas in which New Mexico is unique, the database needs to be modified based on local data. There are two differences between the local region data and what IMPLAN reports. The first concerns the measurement of employment. IMPLAN records all jobs rather than reporting full time equivalent (FTE) positions. This will lead to higher employment levels being reported in the current study than similar analyses being undertaken by those utilizing FTE categories. The differences will be greatest in those sectors characterized by a greater incidence of part-time employment (such as Retail Trade, Agriculture, and Recreation Services). The average earnings per job are, consequently slightly reduced by the inclusion of part-time workers in the analysis but the total earnings are consistent with the Bureau of Labor Statistics data in use by others doing analysis of the labor market in New Mexico. Since reliable data on part time jobs are not readily available,

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[7] Such aggregation is required to preserve confidentiality among the firms in a region. That is, the firm data are reported by firm category known as Standard Industrial Classification (SIC). Each SIC category must contain enough firms that one would be unable to discern the activities of a particular firm.

the IMPLAN employment levels were utilized for the analysis reported here and the interpretation of the results incorporates the differences.

The second major adjustment concerns the computation of indirect business taxes. New Mexico is unique among the states in its reliance on the gross receipts tax (GRT), which has a much broader coverage than the retails sales tax that is more typical of state revenue structures. The GRT is imposed "for the privilege of doing business in New Mexico" and its coverage includes services, construction, and many other activities not typically covered by sales tax. Further, New Mexico relies very little on property taxation and somewhat less than other states on the corporate income tax. The net effect is that the IMPLAN database (which employs national averages) reports low indirect tax levels for sectors such as Business Services and Medical, Legal and Education Services while reporting very high property tax levels for Finance, Insurance, and Real Estate (FIRE). In some earlier work done with the State Government (Clifford and McKee, 1996; McKee, et al, 1995) we developed effective indirect tax rates for many sectors of the economy. These rates are used for the present study (see Table 3).

Table 2: Economic Sectors Represented in I-O Model

Sector No.	Sector Name
1	Agriculture
2	Mining and Mine Services
3	Construction
4	Food Processing
5	Textiles
6	Wood Processing
7	Print & Publishing
8	Mfg.
9	Misc. Mfg.
10	Build Materials
11	T.C.U.

12	Personal Services
13	Wholesale & Retail Trade
14	Recreation Services
15	Finance, Insurance, and Real Estate (F.I.R.E)
16	Business Services
17	Medical, Legal, and Educational Services
18	All Govt.

Table 3:
Effective Indirect Tax Rates Applied to Sector Output

Sector No.	Sector Name	Effective Rate
1	Agriculture	0.002
2	Mining	0.100
3	Construction	0.025
4	Food Processing	0.001
5	Textiles	0.010
6	Wood Processing	0.010
7	Print & Publishing	0.010
8	Mfg.	0.010
9	Misc. Mfg.	0.010
10	Build Materials	0.010
11	T.C.U.	0.044
12	Personal Services	0.017
13	Wholesale & Retail	0.191
14	Recreation Services	0.049
15	Finance, Insurance, and Real Estate (F.I.R.E)	0.068
16	Business Services	0.045
17	Medical, Legal, and Educational Services	0.065
18	All Govt.	0.000

2. Reclamation Analysis

Once the aggregated and updated I-O model is constructed, it is ready for use in analysis.[8] The analysis requires projecting the economic activity that would occur under two different scenarios. These scenarios are projected for the period 2001 – 2020. This period is used for the analysis since the bulk of reclamation activities would take approximately 10 years to complete and the attendant effects of either the reclamation or the failure to reclaim the site will persist for many years beyond that. The impacts of the reclamation activity are calculated

[8] Although IMPLAN provides software for the purposes of conducting impact analysis it is relatively cumbersome to use in practice. Thus, the analysis reported here is conducted with a model programmed in GAUSS. This software was developed by the author and has been used in several other studies (see, eg, Berrens, McKee, and Farmer, 1999).

by computing the present value of the difference between the economic activity with reclamation and without the reclamation.[9] The process of discounting reduces the contribution of periods beyond 20 years hence the analysis is conducted for a 20-year horizon.

The first step in the analysis was to construct a "No Reclaim" scenario. This represents a regional growth pattern projected for 20 years that would result if the Molycorp mine site were not reclaimed. The second step was to construct a regional growth pattern that would arise were the mine site returned to a viable ecosystem. The differences in various economic aggregates are compared between these scenarios and the stream of differences over the 20-year horizon discounted to compute present values.

If the mine site were reclaimed, the level of economic activity in the region would be affected by the reclamation activities (filling, grading, etc), by the enhanced recreation activities, and by the enhanced aesthetics that would induce further investments in the housing sector. Absent the reclamation, these direct effects would not emerge. In addition to the direct effects associated with the reclamation, there are the resulting indirect effects as the expenditures associated with the reclamation circulate through the regional economy.

The direct impacts of the reclamation were classified into two categories. The first is activities associated with the reclamation activity itself. These impacts are captured as employment associated with reclamation as per the study conducted by Kuipers (2000). The employment impacts were assigned to the "Mine and Mining Services" sector. The majority of the employment impacts occur in the period 2001 – 2010. The second category of direct impacts is that associated with the improved amenity levels following the reclamation. The primary effects are projected to occur in the wildlife and fishing activities. The methods for estimating

[9] Reclaiming the mine site requires resources, which could be utilized elsewhere, but it also generates a stream of benefits that have been described in this report.

the levels of these activities are discussed in Appendix I. For this analysis the projected impacts are six thousand fishing days per year and 639 wildlife days per year.[10] Based on a variety of recreation demand studies the daily expenditures occurring in the region are estimated as $25/day for the fishing trips by area residents, $50/day by non-residents, and $75/day for the wildlife trips. These are quite conservative estimates. With an estimate of fifty percent of the fishing trips being area residents, the total annual direct impacts to the area economy from wildlife and fishing amount to approximately $300,000. These are introduced as increases in the final demands for the affected sectors (Recreation and Wholesale and Retail Trade).

Given the limited resources available for the present study, several categories of benefits were not included in the analysis. For example, there are many recreation effects not enumerated above. For example, in addition to the fishing in the immediate area, improved water quality in the eight-mile stretch of the Red River directly affected will also improve water quality in the downstream stretches. This will benefit fishery quality in those reaches. By increasing the net total of fishable miles in the region the stress on other area rivers– the Costilla, Culebra, and Cimarron rivers-will be reduced by spreading out anglers over a greater area. Non-fishing uses of the water (such as rafting) are not calculated at this time. Land based recreation including hunting and wildlife viewing will benefit. Housing values will increase as the levels of environmental amenities increase due to mine reclamation. This will generate a wealth effect that will allow households to increase their current consumption levels.[11] The result will be

[10] Reclamation is expected to have a beneficial effect on wildlife in terms of increased populations of both game and non-game species in the area. Enhanced wildlife populations, in turn, generate benefits in the form of increased wildlife viewing opportunities, increased ecosystem services from wildlife (such as pest control from migratory birds) and increased hunting of large and small game species that benefit from enhanced habitat. As a proxy, we assumed that all of these wildlife benefits would be equivalent to those generated by an additional two big game hunts in the region.

[11] The argument is based on households having a savings target. Households are assumed to maximize utility by choosing a level of savings and this savings consists of a portfolio of instruments. An increase in the value

increased local demand in the Wholesale and Retail Trade sector as well as the Personal Services sector.

The employment and population growth figures in the no reclamation scenario are based on regional projections available from the Bureau of Economic Analysis (BEA). Absent reclamation activities, we assumed that the mining sector in the region would decline. The Molycorp mine is projected to be uneconomic throughout the study period.

Table 4 presents the direct impacts associated with the mine reclamation. The major categories are the labor required for the reclamation itself and several final demand (consumption or investment) categories assigned to housing construction, recreation services (includes lodging and accommodations), and retail trade. The initial labor impacts for the mine reclamation activity are not large (see column 1). However, the improved amenities resulting from completion of the reclamation lead to increased investment in the local housing stock (see column 3) and this construction activity adds jobs to the area. Further, there are increases in the recreation sector due to improved wildlife and fishing activities and the employment generated here also adds to total employment impacts. Finally, the retail and personal services sectors experience a direct impact due to both the recreation activity and (to a lesser extent) the increased wealth levels of those living in the area as the mine site is restored.

The Jobs figures reported in Table 5 are generated by the sum of these direct impacts and from the accumulated indirect effects as the local economy multipliers augment the direct effects.

Overall, the direct impacts were chosen to be somewhat conservative. The wildlife and fishing activity is low relative to the range of background studies we surveyed. The housing

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of an element in the portfolio allows the household to reduce other elements and this reduction translates into increased consumption in the current period. In the case of the mine reclamation, increased housing values investment is modest given the projected improvement in amenities (less dust, visual improvements, etc).

3. Results

The aggregate results are presented in Table 5 where the changes in output, employment, earnings, and indirect business tax revenues are reported. The stream of impacts is converted to present values under two different discount rates, 4% and 8%. The net present value (NPV) of the increase in the value of output in the region is approximately $874 million (1990$). Indirect tax revenues have a NPV of almost $80 million. There is no NPV computation for employment but the earnings component is just less than $149 million. Employment increases by an average of 772 jobs per year. The time stream of the reclamation and the no reclamation scenarios are presented in Figures 1 through 4

There are several sources of the impacts and each is projected to occur at different times during the 20-year horizon. Thus, the reclamation activity generated employment impacts contribute to the increase in economic activity during the initial 10 years of the period. However, the recreation activities and the improved housing market (due to the restoration of the ecosystem) contribute to the growth in the period from 2005 on. After 2010, these are the major sources of beneficial impacts.

associated with the mine cleanup will result in higher consumption levels by households.

Table 4: Direct Impacts Associated with Reclamation

Year	Labor Employed In Mine Reclamation (Jobs)	Recreation Services Demand $ Million (1990)	Change in Housing Investment $ Million (1990)	Change in Demand for Retail Sector $ Million (1990)	Change in Demand for Personal Services $ Million (1990)
2000	0.00	0.00	0.00	0.00	0.00
2001	109	0.00	0.00	2.00	1.00
2002	109	0.00	0.00	2.00	1.00
2003	109	0.00	0.00	2.00	1.00
2004	109	0.00	0.00	2.00	1.00
2005	109	0.00	0.00	2.50	1.00
2006	82	0.35	25.00	2.50	1.00
2007	82	0.35	25.00	2.50	1.00
2008	82	0.35	25.00	2.50	1.00
2009	82	0.35	25.00	2.50	1.00
2010	82	0.35	25.00	2.50	1.00
2011	7.5	0.35	0.00	3.00	1.00
2012	7.5	0.35	0.00	3.00	1.00
2013	7.5	0.35	0.00	3.00	1.00
2014	7.5	0.35	0.00	3.00	1.00
2015	7.5	0.35	0.00	3.00	1.00
2016	7.5	0.50	0.00	3.00	1.00
2017	7.5	0.50	0.00	3.00	1.00
2018	7.5	0.50	0.00	3.00	1.00
2019	7.5	0.50	0.00	3.00	1.00
2020	7.5	0.50	0.00	3.00	1.00

Table 5: Direct Plus Indirect Impacts Associated with Reclamation

Year	Change in Output $ Million (1990)	Change in Earnings $ Million (1990)	Change in Indirect Business Tax Revenues $ Million (1990)	Change in Employment Jobs
2000	0.00	0.00	0.00	0
2001	23.21	3.38	2.00	219
2002	46.43	6.76	3.99	438
2003	69.64	10.14	5.99	658
2004	92.85	13.52	7.99	877
2005	116.07	16.91	9.98	1096
2006	115.13	16.74	9.99	1086
2007	114.18	16.37	9.97	1076
2008	113.24	15.86	9.93	1066
2009	112.30	15.22	9.87	1056
2010	111.36	16.06	10.02	1046
2011	92.28	14.34	8.47	952
2012	73.21	12.62	6.91	859
2013	54.13	10.91	5.36	765
2014	35.05	9.19	3.81	672
2015	15.97	7.47	2.25	578
2016	13.98	7.50	2.04	585
2017	11.98	7.52	1.83	591
2018	9.98	7.55	1.62	598
2019	7.98	7.57	1.41	604
2020	5.98	7.59	1.20	611
NPV @ 4%	873.95	148.68	79.74	N/A
NPV @ 8%	639.27	103.98	57.57	N/A

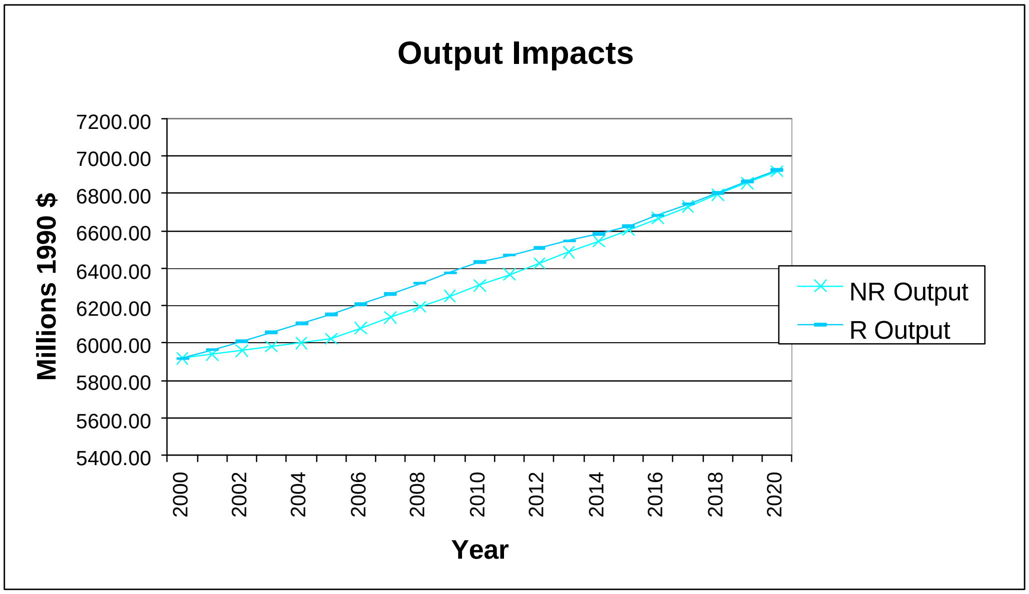

Figure 1

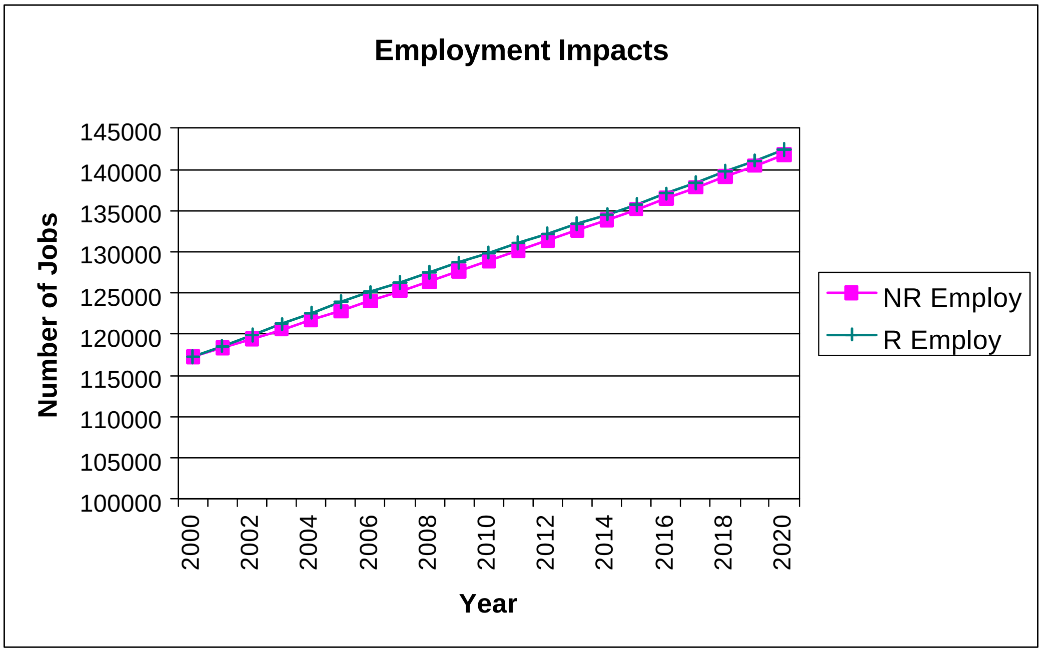

Figure 2

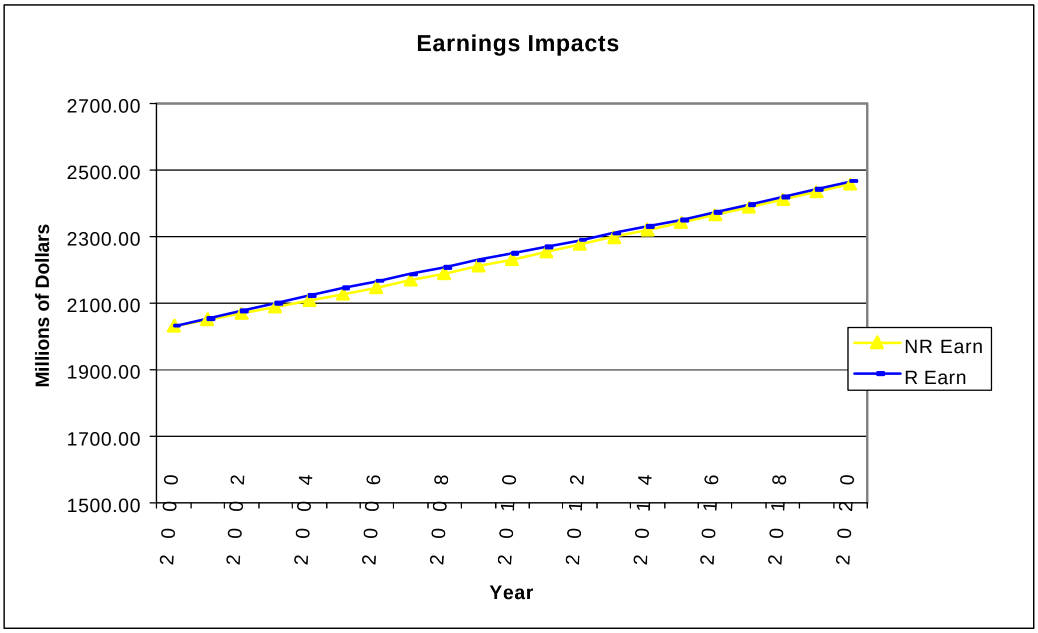

Figure 3

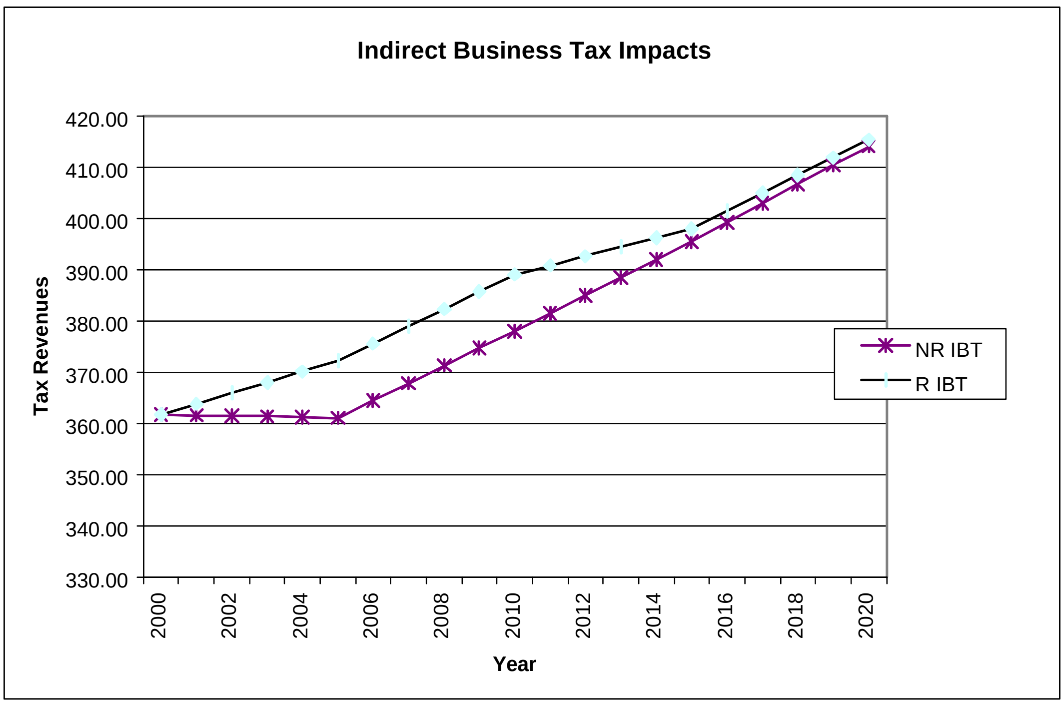

Figure 4

B. Non-Market Benefits

1. Approach

The objective of this scoping section is to identify the set of possible nonmarket environmental benefits of Molycorp mine reclamation, and to give some evidence of the likely magnitude of some these benefits. To review, a full benefit-cost analysis would first measure the change in environmental impacts between two reclamation scenarios (e.g., Full Reclamation and Closure Plan, with self-sustaining, functioning ecosystems, versus some minimal case). Then, given this set of identified physical changes the analysts would design a set of nonmarket valuation studies to measure the associated nonmarket environmental benefits. Less preferred, the analysts might pursue a benefits transfer approach where the identified changes at the study site match closely with that of previous nonmarket valuation studies.[12] Given available resources, the limited objectives here are to identify the types of likely ecosystem service and hazard avoidance benefits from mine reclamation at the Molycorp Mine near Questa, New Mexico, and then provide some likely evidence of the magnitude of their nonmarket values. The perspective taken is that of a Full Reclamation and Closure Plan versus essentially a no reclamation case.

In attempting to do a broad scoping study of the environmental benefits of mine reclamation there are two possible approaches (1) an aggregate or all-in-one approach, which gave one per household estimate for the full set of environmental benefits; and (2) a disaggregate or piece-by-piece approach. In the former, one would attempt to find one or more studies that valued a similar complex of environmental benefits for a similar site, and then convert the per unit value (annual or total, individual or household) into a total present value estimate. In the

[12] For a mine reclamation and damage case, located in the Phillipines see Bennagen, 1997.

latter, recognizing the significant overlap in the different benefit categories in Appendix III, one would select a set of effects that might be expected to be largely independent, and then aggregate them using available benefits transfer estimates to generate a total present value estimate. The primary difficulty in the former is finding a match for the Molycorp Mine site, given the relatively scarce literature that has attempted to value the composite environmental benefits of mine reclamation. The difficulty in the latter is building a credible aggregation scheme.

Turning to the piece-by-piece approach, we focus on aggregating estimates from three categories of environmental benefits that are likely to be relatively independent; (1) Recreational Fishing; (2) Ecological and Aesthetic Values from River Restoration; and (3) Changes in Property Values due to Disamenities from Air and Water pollution. We look at each of these in turn, and then aggregate the resulting scoping estimates to generate a composite estimate.

2. Recreational Fishing

The Full Reclamation and Closure Plan would be expected to generate significant changes in recreational fishing values from improved instream flow regimes, water quality and riparian conditions in the Red River.[13] The current baseline is that recreational fishing has been effectively eliminated in this stretch of the Red River since inception of large-scale mining activities at the site in the mid-1960's. The affected stretch includes approximately six to eight miles of the Red River that run adjacent to the mine and associated tailings piles. Prior to mining, numerous oral histories document that the Red River was a “blue ribbon” quality trout fishery (Kuipers 2000). “For Fishermen the river is dead from the Molycorp Molybdenum Mine downstream 10 miles to the Red River Hatchery near the town of Questa. Mining activities over

[13] It is expected that Full Reclamation and Closure Plan would include water quality treatment and a river restoration fund (see Kuipers, J. R. (2000). Full Reclamation and Closure Plan for Molycorp Questa Mine, New Mexico. Bozeman, Center for Science in Public Participation.).

the last 20 years have disrupted the ecological balance of the river….With its beautiful riffles and pools, cottonwoods, willows, and excellent hatches of caddis, mayflies and stoneflies, this once was the best section of river for dry fly-fishing" (Beacham, 1991) The potential for recreational fishing on the stretch of the Red River from the mine to the fish hatchery is enormous. John Rainey, owner of and guide for the Los Rios Anglers: Guides, Outfitters, Flyshop in Taos, New Mexico, says that restoring the Red River to the quality it once was would have a huge impact on his business: "Right now we fish less than 18 miles of river in New Mexico. If the 6-8 miles below the mine were restored that would constitute a huge increase in the miles we use for our guided fishing tours – it would be a incredible benefit to our business" [14] Fly fishing is a fast growing and lucrative industry the Enchanted Circle area. Los Rios Anglers take over1,000 people fishing every year and bring in an average of $240 per person. This figure represents guiding services only and does not include equipment rental and other purchases. The potential for growth in this industry is illustrated by the fact that Los Rios has experienced an average of 11% growth per year over the past 5 years. Id. There are three other flyshops/guiding shops in the Enchanted Circle- one each in Red River, Eagles Nest and Angel Fire. Each of these businesses would most likely experience an increase in revenues. With fly fishing not only do you have the person purchasing the guided trips but they more often than not bring along their whole families to the local area who spend money at local businesses and museums while the person purchasing the guided experience is fishing. Phil Caston, a guide with Los Rios believes the potential economic benefits to be great: "the economic impact of mine reclamation on the fishing industry and the local economy would be great. We would see economic benefits in the

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[14] Personal communication with John Rainey, owner and guide of Los Rio Anglers: Guides, Outfitters, Flyshop at his shop 226-C Pueblo Rd. Taos, New Mexico 87571. on 8/7/01.

form of license fees, overnight stays, meals, guided trips, and equipment." [15] There would be positive impacts of reclamation on businesses as far south as Santa Fe and Albuquerque. Manuel Monasterio, the owner and guide of The Reel Life, a flyshop and guide service based in Santa Fe and Albuquerque also believes that reclamation on the Red River would improve his business: "without a doubt restoration on the Red would positively affect our business. We would have the opportunity to provide more guided trips and it would spread out the fishing across the region."[16] The theory is if the section of the Red River between the mine and hatchery were fishable the stress on other northern New Mexico streams would be reduced by spreading out the fishing over a greater area. There is also potential for reclamation in the Red River to improve fishing in the Rio Grande. This could have substantial positive economic impacts throughout the state. If the water quality in the Red River were improved, it is likely that more of the fish that come from the Rio Grande to spawn in the Red River would survive. "The impact to the Rio Grande would be dramatic, we would see a fresh influence of young fish that are now presently either not surviving or not being created in the first place because of habitat destruction." Id.

Assume that a six mile stretch of river generates one additional recreational trout fishing day every tenth of a mile for 100 days annually (3-4 month season). This would generate a total addition of 6,000 recreational trout fishing days annually (60 x 100 =6,000). Using a per-day

[15] Personal communication with Phil Caston, guide for Los Rio Anglers: Guides, Outfitters, Flyshop at the Los Rios shop at 226-C Pueblo Rd. Taos, New Mexico 87571 on 8/7/01.

[16] Personal communication with Manuel Monasterio, owner and guide of The Reel Life, a flyshop and guide service based in Santa Fe and Albuquerque.

estimate of consumer surplus of $77.63, this would generate a total annual gain in recreational fishing values of $465,780.00.[17] [18]

The per-day value of $77.63 for recreational trout fishing in the western U.S. is estimated from a recent review study conducted for the Division of Economics of the U.S. Fish and Wildlife Service (Black 1998). They reviewed more than 100 nonmarket valuation studies on recreational fishing in the U.S. conducted between 1965 and 1997. For recreational trout fishing on western US rivers, there were 70 different estimates of consumer surplus per fishing day, with a high of $762 and a low of $11; the mean value from the studies was approximately $70.00, with a median value was $45 (in $1997). Taking the mean and median value estimates and updating them using the Consumer Price Index into current dollars ($2001) produces a value of $77.63 for the mean and $49.91 for the median.

Next, assuming that under proper management and care this improvement was protected in perpetuity, and using an 8% discount rate, this would generate a total present value of approximately $5.8 million, and represents a lower bound estimate. Alternatively, using a 4% discount rate and using the same assumptions about angler days generated, this would generate a total present value of approximately $11.7 million. Finally, as an upper bound case, assume that

[17] By way of comparison, in a study evaluating potential recreational trout fishing losses on stretch of the Blackfoot River in Montana due to a proposed large-scale gold mining project, Rieman (1999) estimates a loss of 8,872 angler days. Reiman (1999) uses mean consumer surplus estimate of $91 per trip for residents and $117 for nonresidents, in 1988 dollars, as taken from Duffield (1988). It was also assumed that residents averaged 1.2 angling days per trip, and that nonresidents averaged 2.7 days per trip. Changing the per trip consumer surplus measures into per day measures, and then converting them into current (2001) dollars, produces estimates of $114.10 for residents and $65.20 for nonresidents. These two estimates provide the relative comparison to our mean estimate of $77.63.

[18] The 6,000 estimate is assumed to be a net increase in angler days. For example, in 1998, NM Game and Fish Department figures place angler days above and below the affected stretch at approximately 75,000 angler days NMDGF (1998). Statewide Angler Survey: 1997 and 1998, New Mexico Department of Game and Fish.. Thus, the 6,000 increase would represent an 8% increase in angler days due to the Full Reclamation and Closure Plan. However. projecting future use of a fully reclaimed river use by anglers is by definition problematic. Discussions with local anglers and guides gave us a range of estimates of per day averages of from1 angler to 20 anglers per mile; here, we use an estimate of 10 per mile.

recreational days increased from 6,000 to 8,640, then using the same net consumer surplus estimate and a 4% discount rate would generate a total present value of approximately $14.6 million.[19]

There are a variety of caveats for consideration. First, the effects of reclamation and river restoration on recreational fishing would likely have some less concentrated effect downstream (e.g., after the confluence of the Red River and Rio Grande). Those aren't evaluated here; i.e., they are assumed to be zero, or rather could be subsumed under the estimate of increased recreational fishing days made above. Second, by choosing the value estimate of $77.63 (in current dollars, from previous value studies on recreational trout fishing on western U.S. rivers, we are using a fairly conservative estimate for consumer surplus.[20] If, consistent with the considerable oral history and unique location in Enchanted Circle, the Red River were to be restored to a truly "blue ribbon" trout fishery, then the per day net consumer surplus estimate would be much higher. Third, while not considered here, in addition to trout fishing, the river restoration might be expected to generate increases in a variety of additional activities (e.g., swimming, hiking along the river). Finally, as with the big game hunting values discussed, these recreational fishing values represent net economic surplus measures (i.e., benefits above costs). They are also nonmarket values, and thus do not represent economic impacts from expenditures

[19] A variety of dimensions could contribute. For example, if we assume that the fishing season extended to 120 days (4 months), a longer stretch of the River was affected by the Full Reclamation and Closure Plan (i.e., eight rather than six miles) and/or that density increased from one angler day every tenth of a mile to every twelfth of a mile, would all produce increased estimates of angler days. Changing density to one angler day every twelfth of a mile for six miles and using a 120 season produces the 8,640 estimate of increased angler days; this represents approximately an 11.5% increase in net angler days on the river (including the affected area, and the reaches above below).

[20] To put in perspective, fishing guide services in other nearby areas can cost anglers $100-150 per day or more.

on market goods, which, as discussed in the market benefit section of this paper, is very significant..

In summary, under different assumptions, a range of reasonable total present value estimates of <u>$5.8 -$16.8</u> million provides an indicator of the economic importance of this particular ecosystem service (recreational trout fishing).

3. <u>Ecological and Aesthetic Values for River Restoration and Improved Instream Flow Regimes</u>

Under the Full Reclamation and Closure Plan, river restoration and improved instream flow regimes, especially in the context of the arid Southwest, would be expected to generate a variety of aesthetic, ecological and recreational values. River restoration and improved instream flow regimes can generate <u>both</u> use value to recreationists (e.g., improved fishing and whitewater rafting in the six mile stretch of the Red River and downstream), and nonuse values for aesthetic and ecological reasons to individuals within the Questa/Taos area, and beyond (e.g., all New Mexican households who value environmental protection and in the Circle of Enchantment). In the previous section an estimate was generated for the value of recreational fishing. In this section we focus on generating an estimate for the latter category of value: nonuse values for ecological and aesthetic gains from river restoration and improved instream flow regimes.[21]

A series of recent nonmarket valuation studies have been published concerning the nonuse values of river restoration and protecting minimum instream flows in New Mexico Rivers (Berrens 1996; Berrens 1998). Using a dichotomous choice CV survey design, Berrens et al. (1996) provide a statistical estimate of approximately $90 ($1995) per NM household annually (for a five year period). Using a split sample treatment and a joint econometric

[21] For a recent review of the legal status and avenues for protecting river flows, without diversion, in New Mexico, see Fort, D. (2000). "Instream Flows in New Mexico." <u>Rivers</u> **7**(2): 155-163..

modeling approach, it was estimated that approximately $28 (of the $90) was apportioned to protecting minimum instream flows for 170 miles of the Middle Rio Grande (Berrens 1996). Converting these values into current dollars ($2001), provides annual NM household estimates of $33 for protecting minimum instream flows in the Middle Rio Grande, and $105 for all the major rivers in New Mexico.

The practical question is what portion of the remaining $72 ($105 - $33, in current dollars) might defensibly be apportioned to the stretch of the Red River rehabilitated by mine site reclamation? Assume that NM households value this six mile stretch of the Red River at the same per mile value as that generated for the Middle Rio Grande ($33/170 miles = 0.19411 cents per mile) a conservative estimator might be to assign $1.17 ($0.19411 x 6 miles) to the expected annual household value. Using this $1.17 estimate and multiplying by the approximately 500,000 NM households yields and total annual estimate of $585,000 annually. Assuming this value would be generated in perpetuity and an 8% discount rate provides a total NM household surplus present value of $7.3 million. Assuming a 4% discount rate provides a total NM household surplus present value of $14.6 million.

There are a number of points for consideration. Of the three categories of environmental benefits evaluated, this is the only one evaluating <u>nonuse</u> values, where households outside of the general area (and not direct users, such as anglers and hunters) would hold some value for full reclamation and closure of the mine site. Our scoping estimate is that the average NM household would be willing to pay $1.17 per year for such an environmental benefit.[22] As with any

[22] To put our estimate of $1.17 annual nonuse value per NM household in perspective, Farber and Griner (2000) estimate annual household nonuse values ranging from $1.58 to $61.56, for five years (converted into current dollars), for selected stream restoration from acid-mine degradation mining in the larger Western Pennsylvania watershed. For their analysis, they used a 1996 survey data set and a variant of the contingent valuation approach, known as conjoint analysis, which is commonly used in marketing research studies. The nonuse values were for Western Pennsylvania households that did not directly use or visit either of the two streams evaluated. Estimates varied depending on the econometric technique used to analyze the data, and the degree of restoration. While the

average, many household may hold no positive value for such a change, while others would be assumed to hold considerably higher values. Finally, since it is currently a state of New Mexico perspective that must be taken in any regulatory decision on reclamation at the site, we conservatively assume that such values would only accrue to NM households. Quite possibly, although not considered here, other households (e.g., in Southern Colorado) would positively value such a change as well.

In summary, under different assumptions, a range of reasonable estimates for the total present value of the nonuse benefits (ecological and aesthetic) of river restoration and improved instream flow regimes associated with reclamation of the mine site would be $7.3 - $14.6 million.

4. Changes in Property Value due to Air and Water Pollution

As shown in Appendix III, the Full Reclamation and Closure Plan would be expected to generate a variety of environmental benefits due to reduced air and ground water pollution and associated health hazard avoidance. We treat these various effects from air and water as a composite effect that is recognized by property owners. As such, there is a well established empirical literature linking various disamenities, contamination and health hazards (e.g., air and water pollution, and proximity to hazardous waste sites) to reductions in property values. These studies use a variety of approaches, but the most predominate one is the hedonic pricing method (HPM), which statistically decomposes variations in real estate sale prices to isolate the effect of the environmental factor(s), from other common determinants. A basic assumption of the HPM is that the environmental effects are capitalized into the current market values for the real estate

upper bound ($61.56) of the Farber and Griner (2000) is considerably above our estimate of $1.17, they assume annual payments for a period of 5 years, while we assume annual payments in perpetuity (households would continue to value the protected river).

(thus no further conversion into present values is necessary). It is assumed that current losses in property values would be recovered under the Full Reclamation and Closure Plan.

In searching for possible HPM results in similar settings, the complication in New Mexico is that like a small handful of other states (e.g., Texas) it is a non-disclosure state; that is, real estate sale prices are not publicly-disclosed information. However, for the purposes of this scoping study, we can attempt to infer the magnitude of likely effects as seen from reviews of previous HPM studies of various environmental factors, although because of its non-disclosure status none have been conducted in New Mexico.

Farber (1998) provides a full review of the available literature, and shows that property values losses from proximity to hazard waste and other polluted s and contaminated sites can often be substantial (although estimates vary widely). There is also evidence for a gradient effect, where more proximal properties receive the highest losses in value. While some stigma from environmental contamination may be permanent in some cases, there is also evidence of the ability of property values to recover after sites are fully cleaned up (e.g., Syms 1997).

In a recent environmental economics textbook, Chapman (2000) reviews several recent HPM studies that value residential property losses due to hazardous waste sites. As evidenced elsewhere, there is a gradient effect. Property value losses due to environmental pollutants decline with distance. For example, per household losses are estimated to be as high as $15,000 for properties within one-half mile, but less than $1,000 for properties five to six miles from a highly polluting site. Values will also vary across neighborhood types, and geographical and environmental settings (e.g., pollution in otherwise pristine or beautiful settings may generate larger losses than elsewhere).

In consideration of property value losses in the Molycorp mine reclamation case, the town of Questa is approximately three miles from the mine; however, the tailings site for the mine is directly adjacent to the town (i.e., highly proximal). Effects of the mining activity are also highly visible in the general area. Summarizing from various studies, Chapman (2000) shows hedonic pricing method (HPM) estimates of property losses of approximately between $10,000 and $12,000 for one mile from a hazardous waste site. This evidence is corroborated by Jenkins-Smith et al. (2001) who use a contingent valuation (CV) approach, based on survey of potential home buyers, to show the effect of information disclosure concerning the historical record of contamination in the proximity of a long-time hazardous waste site in Corpus Christi, TX. In the low-income proximal neighborhoods (e.g., with average housing values less than $50,000) they estimate a present value loss of $11,000 per home. Further, using a similar study approach for a hazardous waste site in Tacoma WA., Mundy and MacLean (1998) show losses of $10,000-$24,000 per housing unit.

While a detailed study of these impacts has yet to be initiated in the Questa area there is anecdotal evidence from the area indicating that this impact could be quite significant. In an anonymous interview, one local landowner complained that "our property was recently appraised for a lot less than it was before the mine." This property owner cited "ecological concern" as one of the reasons for depreciation of the property's value.

Current census estimates for housing in the census tract encompassing Questa and the surrounding vicinity (Questa CCD, Taos County, New Mexico) include 3,192 housing units and 1662 occupied units. Of the 1,530 vacant housing units, 1,153 are for seasonal, recreational or occasional use (vacation, etc.)

Conservatively, in a lower bound case, if it is assumed that the negative externality effect of various air and water pollutants on all 1,662 occupied housing units in the area was $10,000 per unit, and the loss to the 1,153 vacation/recreational homes was simply a tenth of that unit value ($1,000), this would imply a present value of approximately $17.8 million. Alternatively, in an upper bound case, assuming a negative externality effect of $12,000 per household for all currently occupied households (1,662), and the loss to the 1,153 vacation/recreational homes was one-half of that unit value ($6,000) would imply a combined present value of approximately $24.6 million.

The overall conservative assumption made here for both cases is that none of the remaining 377 unoccupied houses would accrue any restoration in value from the Full Reclamation and Closure Plan at the site. If pollution and/or mine site disamenities were a contributing factor in these units being unoccupied, then they may include some of the most severe cases of property value losses.

Thus, under different assumptions, the range of estimated total present value for eliminating the negative externality (disamenity and health effects) of air and water pollution on area housing values would be <u>$17.8 to 26.9 million</u>.

6. <u>Conclusions and Discussion</u>

In conclusion, using the dis-aggregate approach for scoping the nonmarket benefits of mine reclamation at the site, and evaluating only three categories of benefits, would produce an estimate of the total present value of ecosystem services and hazard avoidance of approximately **<u>$30.9 to $58.3 million</u>**. The midpoint value would be $45 million; however, we emphasize that this range is not a statistical confidence interval, but is better represented as a sensitivity analysis under different assumptions.

While the range of the estimated nonmarket environmental benefits is considerable, note that this is caused in large part by the choice of discount rate (4% or 8%) used to convert benefit streams into present values. The higher the discount rate chosen, the lower the present value of the future environmental benefits. Thus, as shown, the 4% rate is associated with higher value estimate of $62.1 million. There is an argument to be made that from the New Mexico State perspective, the consideration of social benefits (as done in this study for environmental benefits) should be made using a social discount rate.[23] [24] Social discount rates for project analysis are typically 4% or less (see the discussion in (Black 1998), and references therein). Assuming a lower discount rate, for example, Berrens et al. (1998a) report a value of 3% used in the U.S. Fish and Wildlife Service analysis of economic impacts of water management changes on the Colorado River, would produce a higher estimate of the environmental benefits of the Full Reclamation and Closure Plan.

Timing assumptions can also cause present value benefit and cost estimates to vary greatly. This scoping assessment adopts the perspective of the present value of environmental benefits foregone (if the Full Reclamation and Closure Plan was not implemented). To the extent that expected environmental benefits of the reclamation process have been unnecessarily delayed, e.g., by the company seeking a waiver, then these losses are already accumulating (and thus foregone values might be larger than estimated here). Realized benefits would of course be affected by the timing of actual implementation of habitat and environmental improvements. For example, delays may lower the present value of recreational days that occur later rather than

[23] The point being that a social discount rate may differ from a private discount rate used by a private commercial enterprise in project analysis. Public entities face different considerations, such as accounting for social or collective time preferences, opportunity costs and public risk assessments.

[24] Such a perspective might also argue for dropping the elk hunting category of environmental benefits, if the site remained in private ownership. Doing so still leaves a total present value estimate from the other three categories of environmental benefits evaluated of over $50 million.

sooner. Conversely, future scarcities (i.e., scarce recreational and aesthetic opportunities) can raise the per unit consumer surplus values assumed here for various environmental benefits.

As with any scoping study on nonmarket values, the numerous assumptions that must be made will be open to criticism. But this is also the case with any benefit-cost analysis, and certainly with the cost side of reclamation plans as well. An attempt has been made here to provide a set of reasonable and conservative assumptions, and to demonstrate the sensitivity of the result to various key assumptions (e.g., the discount rate used). Of course the final answer to any criticisms of a scoping study is to argue that original economic analyses should be conducted that are specific to the site (with and without the Full Reclamation and Closure Plan). The economic tools for such research analyses are certainly available, but themselves come at a cost.

The question then becomes where the burden of proof lies for providing such information and funding the necessary studies. When a private company, bound by state law to provide reclamation of a site back to a state of self-sustaining and functioning ecosystems, asks for a waiver largely on economic feasibility grounds (URS, 2001b), – i.e., their own costs – it is difficult to see how the affected parties (e.g., community groups) of the environmental pollution should bear the cost of collecting the necessary economic information.

The question of the burden of proof also relates to the final point of consideration. Much of the available evidence used here to construct the nonmarket value estimates of net consumer surplus are based on the perspective of an individual's willingness to pay (WTP) to acquire some positive change in the environment. By reversing the property right, one can also consider an individual's willingness to accept compensation (WTA) to give up the same change. For private goods (e.g., movie tickets), with lots of close substitutes, economic theory predicts that the two measures (WTP and WTA) should be roughly equivalent. And thus the issue of perspective and property rights is irrelevant. But in the case of public nonmarket goods without close substitutes, the two measures could differ widely, with WTP (which is income constrained) lower than WTA (which isn't) (Hanemann 1991). A wide variety of empirical studies for nonmarket environmental services have established that WTP estimates of consumer surplus are often at least two or three times lower than WTA estimates (see Bateman 1999). Further, the direct connection of this piece of economic theory to the case of the Molycorp mine site, is whether the public (i.e., the people of the state of New Mexico) have a claim to full reclamation and closure, as could be interpreted under current state law. If so, then the nonmarket values estimated here could significantly underestimate the true economic value of these environmental benefits. To the extent that the unique location of this site within New Mexico's Enchanted Circle has few if any good substitutes, then this argument is reinforced.

VII: Summary and Conclusions

Full reclamation of open pit mines, tailings piles, and associated infrastructure has the potential to generate enormous benefits for communities seeking to capitalize on the forces shaping the economic landscape of the modern West. Over the past century, the West's economic foundations have drastically changed. Extractive industries once accounted for over 85% of all jobs. Now that figure is 3%. Instead, western communities are far more dependant upon environmental amenities such as clean air, clean water, and healthy populations of fish and wildlife. Because of this, the legacy of unreclaimed mines-air and water pollution, degradation of scenery, and biologically dead rivers- may prove to be a hindrance to communities that wish to market themselves as high quality environments in which to live, work, and raise families.

Reclamation provides these communities with an opportunity to participate more fully in an economy dominated by sustainable land uses, high technology enterprises, recreation and tourism. While traditional extractive industries will always be an important component of western economies there is a growing understanding that these industries, and mining companies in particular, must adopt more sustainable practices such as full reclamation to be more compatible with an economy that places a high value on healthy ecological systems.

Mine reclamation can benefit local communities in many ways. Reclamation activities create numerous skilled, well paying jobs as well as substantial secondary income and wealth as the income earned by these workers is circulated throughout the local economy. Communities also receive benefits in the form of cleaner water and air and more abundant fish and wildlife as well as reductions in hazards that arise from floods, air pollution, and water pollution. There are numerous methodologies to quantify these benefits to local communities.

A benefit/cost analysis (BCA) should serve as a framework for quantifying all social benefits and all social costs associated with various reclamation alternatives. A social benefit/cost analysis would help regulators identify reclamation alternatives that generate positive net benefits for society as a whole. Methods for assessing reclamation costs are generally well understood, and not addressed in this paper. Instead, we focus on the benefits side of the equation.

Reclamation benefits can be divided into two broad categories: market and nonmarket. Market benefits can be analyzed by using a regionally specific input-output model that yields estimates of changes in output, earnings, taxes, and employment associated with any particular reclamation investment. Nonmarket benefits can be estimated through both revealed and stated preference models. In this paper, we applied an input-output model tailored to northern New Mexico and a benefits transfer technique to estimate some of the potential market and nonmarket benefits that could be generated by implementing a $200 million reclamation plan on the Molycorp mine site.

The Molycorp molybdenum mine is located near the village of Questa, a small community in northern New Mexico. Molycorp provides an excellent case study of potential reclamation benefits since its location-in northern New Mexico's "Enchanted Circle"-exemplifies the economic forces at work throughout the western U.S. In addition, New Mexico statutes governing mine reclamation are among the most progressive in the nation, and include numerous requirements for protecting and restoring beneficial economic uses of the land and waters affected by mines as well as requirements for economic analysis of mine permitting decisions.

Mining has occurred at the Molycorp site since 1923. The resulting impact to the surrounding environment and the adjacent Red River, a tributary to the Rio Grande, has been devastating. Approximately 2,000 acres of mixed conifer forest, ponderosa pine forest, pinyon-juniper woodland, sage flats and grasslands have been displaced by the mining operation. Surface and groundwater in the Red River have been severely contaminated by acid mine drainage, heavy metals and sedimentation. New Mexico's Surface Water Quality Bureau has labeled a section of the Red River below the mine as "biologically dead".

Questa's economy has long been plagued by the instability of the molybdenum market. Surrounding communities such as Taos, Angel Fire and Red River have been growing as quality of life and physical attractiveness are becoming the most important factors in business location decisions and as a result of increased tourism. Questa has been less able to capitalize on these opportunities due to ecological damage caused by the both the mine and real and perceived threats from the mine to human health and the environment. Because of this, reclamation at the Molycorp mine site has the potential to drastically improve the local economy.

Market benefits of implementing a full reclamation plan could be substantial. Under a $200 million reclamation scenario, through regional multiplier effects, reclamation would support an average of 772 jobs over a 20 year period. Direct and indirect benefits - in the form of output, earnings, indirect business taxes, and employment – could range between $640- $874 million.

Nonmarket benefits are also likely to be quite substantial. Benefits in the ecosystem service categories of recreational fishing, ecological and aesthetic river values, and changes in property value were assessed, although we recognize these may only represent a fraction of all of the benefits associated with restoring forests, woodlands, grasslands, rivers and streams in the area. The potential economic benefits to recreational trout fishing are $5.8-$16.8 million. The estimated economic benefits associated with enhanced ecological and aesthetic river values are $7.3-$14.6 million. The benefits of eliminating negative property value impacts from nearby air and water pollution could be $17.8 - $26.9 million. Total nonmarket benefits of reclamation could range from $30.9 to $58.3 million.

In conclusion, a regionally specific input-output model and a dis-aggregate benefit transfer approach yielded benefit estimates for a $200 million reclamation investment at Molycorp in the order of $670.9 – $932.3 million over the next 20 years. Given the size of these figures, public regulators must carefully examine both costs and benefits of reclamation in making decisions over the appropriate level of reclamation to require. While the benefits quantified here are rough estimates, their magnitude should provide the impetus for a more rigorous examination of mine reclamation benefits not only at Molycorp, but at similar sites throughout the nation.

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