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JACKPILE-PAGUATE

Uranium Mine Reclamation Project

ENVIRONMENTAL IMPACT STATEMENT

February 1985

US DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT
ALBUQUERQUE DISTRICT OFFICE

BUREAU OF INDIAN AFFAIRS
ALBUQUERQUE AREA OFFICE

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Environmental Impact Statement

FOR THE

Jackpile-Paguate Uranium Mine Reclamation Project

LAGUNA INDIAN RESERVATION

CIBOLA COUNTY, NEW MEXICO

U.S. DEPARTMENT OF THE INTERIOR

Bureau of Land Management
Albuquerque District Office
Rio Puerco Resource Area

Charles W. Luscher
State Director, New Mexico

Bureau of Indian Affairs
Albuquerque Area Office

Vincent Little
Area Director

ABSTRACT: The Department of the Interior (DOI) proposes to approve a reclamation plan for the Jackpile-Paguate uranium mine. The mine is located on three leases of Laguna Indian Tribal land in Cibola County, west-central New Mexico. The mine was operated by Anaconda Minerals Company, a division of Atlantic Richfield Company, from 1953 through early 1982. The No Action Alternative and three reclamation proposals developed by Anaconda, DOI (with two options) and the Pueblo of Laguna are analyzed in this document. The affected environment consists of 2,656 acres of open pits, waste dumps and associated facilities. Under the No Action Alternative, the minesite would remain environmentally unsuitable for any productive land use except for mining. The reclamation proposals would, to varying degrees, restore the minesite to productive land use (primarily livestock grazing), reduce radiological and physical hazards, blend the visual characteristics of the minesite with the surrounding lands, and provide employment. Reclamation cost estimates range from $54.2 to $57.4 million. Measures to mitigate environmental impacts have been incorporated into each reclamation proposal.

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Type Of Action: (X) Administrative ( ) Legislative

Comments have been requested from: See Chapter 4

Date Filed with EPA: MAR 5 1985

Comments on this EIS are due by: OCT 4 1985

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North
Gavilan Mesa
Rio Paguate
Jackpile Pit
Housing
Rio Moquino
North
Paguate
Pit
New
Shop
South
Paguate
Pit
P-10
Village
of
Paguate
Rio Paguate
SP-20
State Highway 279

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SUMMARY

Introduction

This Environmental Impact Statement (EIS) analyzes the environmental consequences of four alternatives for reclaiming the Jackpile-Paguate uranium mine. The mine is located on three tribal leases within the Laguna Indian Reservation, about 40 miles west of Albuquerque, New Mexico. The leaseholder, Anaconda Minerals Company, mined from 1953 to 1982. Out of a total of 7,868 leased acres, 2,656 acres were disturbed by mining. This disturbance includes three open pits, 32 waste dumps, 23 protore (sub-grade ore) stockpiles, four topsoil stockpiles and 66 acres of buildings and roads.

The lease terms and Federal regulations give the Department of the Interior (DOI) the authority to require reclamation of the minesite. The two main DOI agencies involved in this project are the Bureau of Land Management (BLM) and the Bureau of Indian Affairs (BIA). The BLM acts as the overall technical adviser while the BIA is responsible for the surface aspects of reclamation.

The public scoping process was used to focus on the major issues to be considered in this EIS. The two major issues identified were ensuring human health and safety and reducing radioactive releases.

There are no Federal or State regulations or standards for reclaiming uranium mines so a range of alternatives are evaluated in this document. These alternatives are: 1) No Action; 2) Anaconda's Proposal; 3) the DOI Proposal (with Monitor and Drainage Options); and 4) the Laguna Proposal. No Preferred Alternative has been identified in this Draft EIS.

Description of the Alternatives

No Action Alternative

For this EIS, the No Action Alternative would mean that no reclamation work would be performed. Anaconda would continue their security program to prevent unauthorized entry and they would continue to operate an environmental monitoring program in perpetuity. This alternative is not considered reasonable for this project due to the need to protect public health and safety.

Anaconda Proposal

Under Anaconda's Proposal, the open pits would be backfilled to at least three feet above Anaconda's projected ground water recovery levels. All highwalls would be scaled to remove loose material. The rim of Gavilan Mesa (Jackpile pit highwall) would be cut back by blasting or mechanical means and the base of the highwall would be buttressed with waste and overburden. Waste dump slopes would be reduced to between 2:1 and 3:1; most slopes would be terraced. (The disposition of excess material from waste dump resloping has not been described by Anaconda, but presumably some would be added to the pits to raise the level of backfill.) Jackpile Sandstone exposed by resloping would be covered with four feet of overburden and one foot of topsoil. Facilities would either be removed or cleaned up and left intact. All disturbed areas (pit bottoms, waste dumps, old roads, etc.) would be topsoiled and seeded. Reclamation would be considered complete when the weighted average for basal cover and production on revegetated sites equalled or exceeded 70 percent of that found on comparable reference sites. The post-reclamation monitoring period would be three years.

DOI Proposal

Because of concerns over the environmental impacts of either ponded water or salt build-up in the open pits, DOI has identified two options for treatment of the pit bottoms: 1) a Monitor Option which would backfill the pits with protore, excess material from waste dump resloping and soil cover. Due to the excess material (approximately 19 million cubic yards), the estimated backfill elevations of the pit floors could be 40 to 70 feet higher than Anaconda's proposed minimum. The pits would remain as closed basins, in which case the potential build-up of salt and saline water in the soils of the pit bottoms would be monitored. If soil problems are observed, additional backfill and revegetation would be required from Anaconda. The duration of the monitoring period would be sufficient to determine the stable future water table conditions; and 2) a Drainage Option which would restore the natural mode of overland runoff from the pit areas. Backfill volumes and elevations would be approximately the same as for the Monitor Option, but none of the pits would be left as closed basins. Open channels would be constructed with a slope equal to or flatter than local natural watercourses to convey runoff from the pit areas to the Rio Paguate. This would avoid ponded water or undrained saline soils on the reclaimed minesite.

For both options, other aspects of reclamation would be the same. Highwall stability techniques would essentially be the same as Anaconda's Proposal. With few exceptions, waste dump slopes would be reduced to 3:1, with no terracing. Treatment of Jackpile Sandstone and minesite facilities would be the same as Anaconda's Proposal. All disturbed areas would be topsoiled and seeded. Reclamation would be considered complete when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover and production of undisturbed reference areas. The post-reclamation monitoring period would be a minimum of 5 years.

Laguna Proposal

Under this proposal, South Paguate pit would be backfilled to its original contour. Due to the uncertainty of future ground water recovery levels, Jackpile and North Paguate pits would be backfilled 7 feet above the DOI Proposal. The North Paguate highwall would be buttressed to the crest and the buttress material would be sloped 3:1. Treatment of Gavilan Mesa, waste dump slopes, Jackpile Sandstone and minesite facilities would essentially be the same as the DOI Proposal. All disturbed areas would be topsoiled and seeded. Reclamation would be considered complete when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover and production of undisturbed reference areas. The post-reclamation monitoring period would be 10 years.

Environmental Consequences of the Alternatives

No Action Alternative

No blasting would be required.

Mineral resources in the P15/17, NJ-45 and P-13 underground areas would remain accessible. Normal erosion would cause significant losses of all protore outside the pits. Gavilan Mesa would eventually collapse and bury the protore buttress at its base.

The North and South Paguate pit highwalls would be stable. Gavilan Mesa is only marginally stable and would eventually fail.

All 32 waste dumps would eventually experience mass failure resulting in blocked drainages, alteration of stream courses, increased stream sediment loads and decreased surface water quality.

Ground above the P-10 decline could experience sudden and significant subsidence. Unsealed underground openings would present physical and radiological hazards.

For the population within a 50-mile radius of the minesite, modeling predicts from 95 to 243 additional radiation-induced cancer deaths over a 90-year period.

There would be a perpetual surface water loss of 200 acre-feet per year. Water quality in the rivers would decrease over time due to erosion of protore piles and waste dumps. Water ponded in the open pits would have elevated levels of virtually all constituents.

Ground water would double in conductivity as it flowed through mine materials. Up to 50 acres of saline ponds would exist in the pit bottoms.

Arroyo headcutting would eventually erode into the bases of I, Y, Y2 and FD-3 dumps resulting in increased sediment loads to the rivers.

Paguate Reservoir would continue to receive sediment at a rate of 22 acre-feet per year.

The Rios Paguate and Moquino could migrate laterally and erode the adjoining waste dumps causing increased sediment load and possibly increased levels of total dissolved solids (TDS), heavy metals and radioactive elements in the rivers.

Mean waste dump erosion would be 79.4 tons per acre per year resulting in increased sediment load to the rivers and a deterioration of surface water quality.

Total Suspended Particulate (TSP) levels could exceed Federal and State standards for short periods. This would present an aesthetic problem and possibly a health risk since radioactive particulates could be eroded from the exposed protore piles.

Soil erosion rates would be high. Meager and scattered vegetative re-establishment would continue by secondary succession on habitable sites. Many disturbed areas would remain permanently barren. Wildlife populations would be low.

There would be no impacts to cultural resources. Access would remain limited.

Visual resource quality would remain poor.

Socioeconomic conditions would remain as they are.

Anaconda Proposal

Approximately 0.5 million cubic yards of material would be removed by blasting; no specifications to mitigate the effects of blasting are proposed.

All mine entries would be sealed and their resources would become inaccessible. All protore would be placed in the open pits and would not be lost to erosion. Gavilan Mesa would eventually collapse and bury the protore buttress at its base.

All highwalls would be scaled to remove loose rock. The North and South Paguate pit highwalls would be stable. Modifications to Gavilan Mesa would make it only slightly more stable than under the No Action Alternative and it would fail.

Thirteen waste dumps would fail and 12 could fail. Environmental consequences would be the same as the No Action Alternative.

All underground openings would be sealed thus eliminating the subsidence and radiological hazards.

After reclamation, lung cancer deaths would be 10 percent of the No Action Alternative. All other cancer deaths would be reduced to less than 0.1 percent of the No Action Alternative.

There would be a one-time loss of 3,000 to 4,000 acre-feet of water which would percolate into the pit backfill. Evapotranspiration from the pit bottoms would remove about 200 acre-feet per year. Waste dump reclamation would reduce erosion which, in turn, would decrease TDS and heavy metal concentrations in the rivers. Up to 200 acres of intermittent ponds in the pit bottoms would be saline and unproductive for livestock use. Ground water would show a temporary increase in TDS and heavy metals. As the ground water reverts to a reducing state this leaching effect would decrease. Pit bottoms would retain a lens of shallow salt water.

Headcuts would be armored to slow erosion, but the armoring would become ineffective due to siltation and bypassing and erosion would continue.

Sedimentation of Paguate Reservoir would be reduced by reclamation.

All waste dumps would be moved back 200 feet from the rivers to provide a buffer against lateral migration and thus prevent contamination of surface waters by waste material.

Mean total waste dump erosion would be 26 tons per acre per year (a 61 percent reduction from the No Action Alternative).

TSP levels would be within Federal and State standards. Since all radiological material would be covered there would be no radiological health impacts.

Soil erosion rates would be reduced. Vegetative cover would lead to increases in wildlife populations. However, revegetated sites with only 70 percent of the basal cover and production of native reference areas would be less productive than natural sites and less capable of supporting populations of native and domestic herbivores.

Improved access to cultural sites could lead to increased vandalism as well as providing easier access for religious purposes.

Visual resource quality would be enhanced compared to the No Action Alternative.

Reclamation would temporarily increase employment and income.

Energy usage would be 292,000 kilowatt hours and 5.4 million gallons of fuel. Reclamation costs are estimated to be $54.2 million, requiring 201 man years of labor. There could be 30.2 equipment use accidents.

DOI Proposal (Monitor and Drainage Options)

For the Monitor Option, approximately 0.5 million cubic yards of material would be blasted; for the Drainage Option approximately 0.6 million cubic yards would be removed by blasting. Specifications are proposed to mitigate the effects of blasting.

Impacts on mineral resources would be the same as Anaconda's Proposal except that extra highwall stabilization techniques would lessen the chance of Gavilan Mesa collapsing on the protore buttress.

All highwalls would be scaled. The top 10 feet of any soil on the North and South Paguate highwall crests would be cut back to a 3:1 slope to prevent piping. The South Paguate pit highwall would be fenced to limit access to the crest. Recontouring Gavilan Mesa would increase its safety factor and lessen the chance of mass failure.

FD-2, I and Y2 dumps would probably be stable. All other dumps would be stable.

All underground openings, including the P-10 decline, would be treated the same as Anaconda's Proposal and would result in the same impacts.

Radiological health impacts would be the same as Anaconda's Proposal.

There would be a one-time loss of 3,000 to 4,000 acre-feet of water which would percolate into the pit backfill. Gentler waste dump slopes would reduce erosion 50 percent compared to Anaconda's Proposal resulting in a corresponding decrease in TDS and heavy metal concentrations in the rivers. For the Monitor Option, any ponded water would be eliminated by remedial action; ponds would not exist under the Drainage Option. For the Monitor Option, ground water quality would be better than under Anaconda's Proposal due to reduced evapotranspiration from the pit bottoms. The Drainage Option would further reduce the likelihood of evapotranspiration from waterlogged soils.

An improved, no-maintenance armoring system would be used to stabilize all headcuts.

Sedimentation of Paguate Reservoir would be reduced by reclamation.

The impacts of stream erosion on waste dumps would be the same as Anaconda's Proposal.

For both options, mean total waste dump erosion would be 13 tons per acre per year (an 82 percent reduction from the No Action Alternative and a 50 percent reduction from Anaconda's Proposal). For the Drainage Option, sediment would be generated from approximately two square miles of externally draining pits.

TSP levels would be in the same range as for Anaconda's Proposal.

Vegetative cover would be at least 90 percent of that on surrounding natural land. Reclaimed plant communities would therefore be more comparable with natural communities in terms of vegetative diversity and production, soil retention and carrying capacity for native and domestic herbivores.

Impacts to cultural resources would be the same as Anaconda's Proposal.

Visual resource quality would be enhanced over Anaconda's Proposal.

Impacts on employment and income would be the same as Anaconda's Proposal.

Energy usage would be 290,000 kilowatt hours and 5.3 to 5.5 million gallons of fuel. Reclamation costs are estimated to be $55.6 million, requiring 198 (Monitor Option) and 203 (Drainage Option) man years of labor. Equipment use accidents are estimated to be 29.8 for the Monitor Option and 30.5 for the Drainage Option.

Laguna Proposal

Most impacts would be the same as DOI's Proposal. The primary differences are noted below.

All protore would be placed in the pits above the ground water recovery levels for future recovery.

The South Paguate pit would be completely backfilled, eliminating the highwall and all associated impacts. The North Paguate pit highwall would be buttressed to its crest, eliminating the highwall and all associated impacts.

Visual resource quality would be the best of all proposals because of the backfilling of the South Paguate pit.

Reclamation costs are estimated to be $57.4 million, requiring 204 man years of labor. There could be 30.7 equipment use accidents.

Chapter 1
description of the alternatives

INTRODUCTION

History and Background

The Jackpile-Paguate uranium mine is located on the Laguna Indian Reservation, 40 miles west of Albuquerque, New Mexico (Map 1-1). The mine was operated by Anaconda Minerals Company, a division of the Atlantic Richfield Company. Mining operations were conducted continuously from 1953 through early 1982. The mine was closed because of depressed uranium market conditions, and studies are underway to determine how best to permanently reclaim it.

Mining operations were conducted under three uranium mining leases between Anaconda and the Pueblo of Laguna (Map 1-2). The leases cover approximately 7,868 acres, as shown in Table 1-1 below:

TABLE 1-1

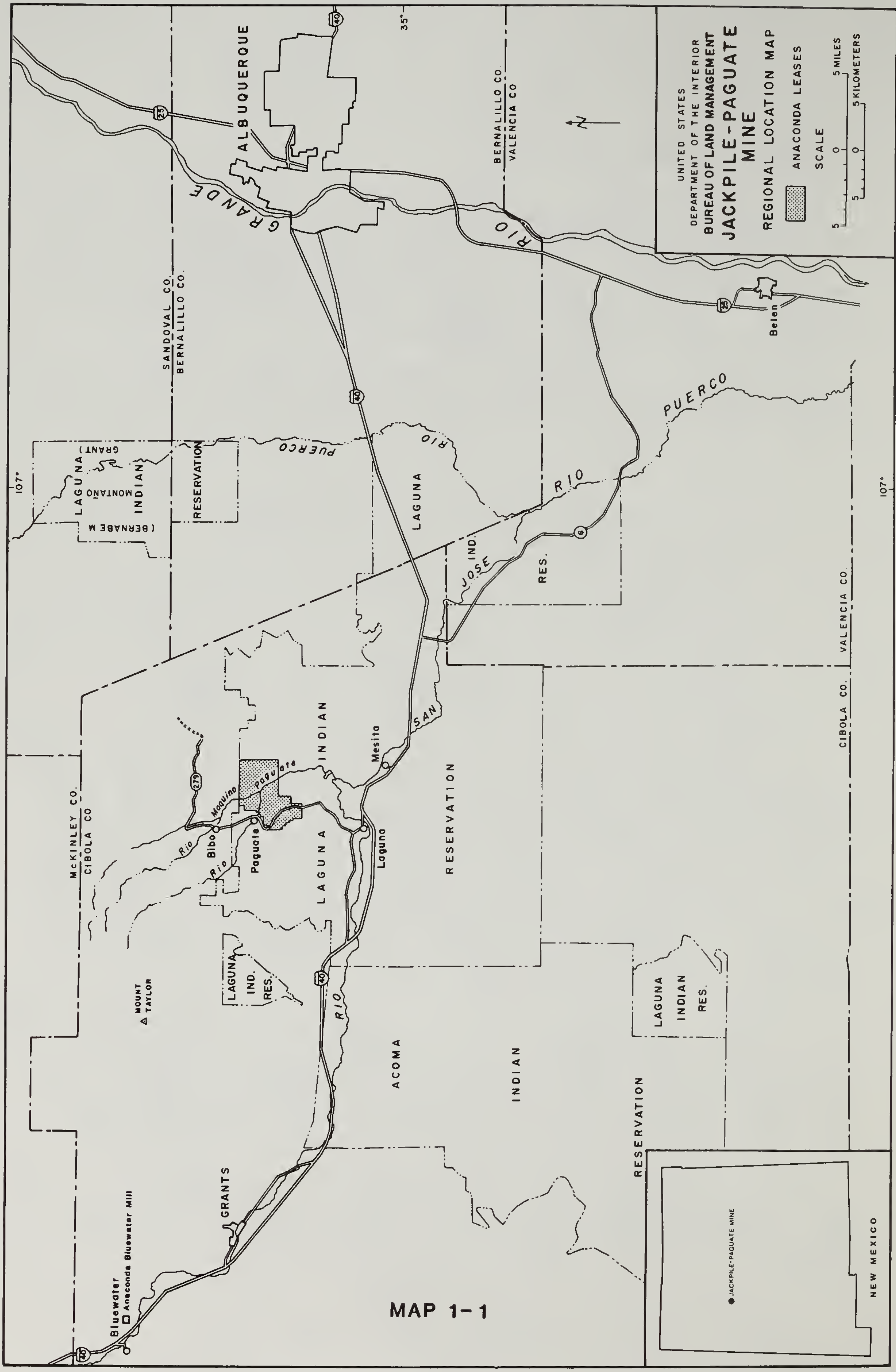
JACKPILE-PAGUATE URANIUM MINE LEASES

Lease Number	Date Signed	Size (Acres)
Jackpile	May 7, 1952	4,988
4	July 24, 1963	2,560
8	July 6, 1976	320
Total		7,868

Mining operations were conducted from three open pits and nine underground mines. Open pit mining was conducted predominantly with large front-end loaders and haul trucks. The overburden, consisting of topsoil, alluvium, shale and sandstone was blasted or ripped, removed from the open pits, and placed in waste dumps. The uranium ore was segregated according to grade and stockpiled for shipment to the mill. In the later years of mining, material conducive to plant growth was stockpiled for future reclamation, and some overburden and ore-associated waste was placed in the mined-out areas of the pits as backfill.

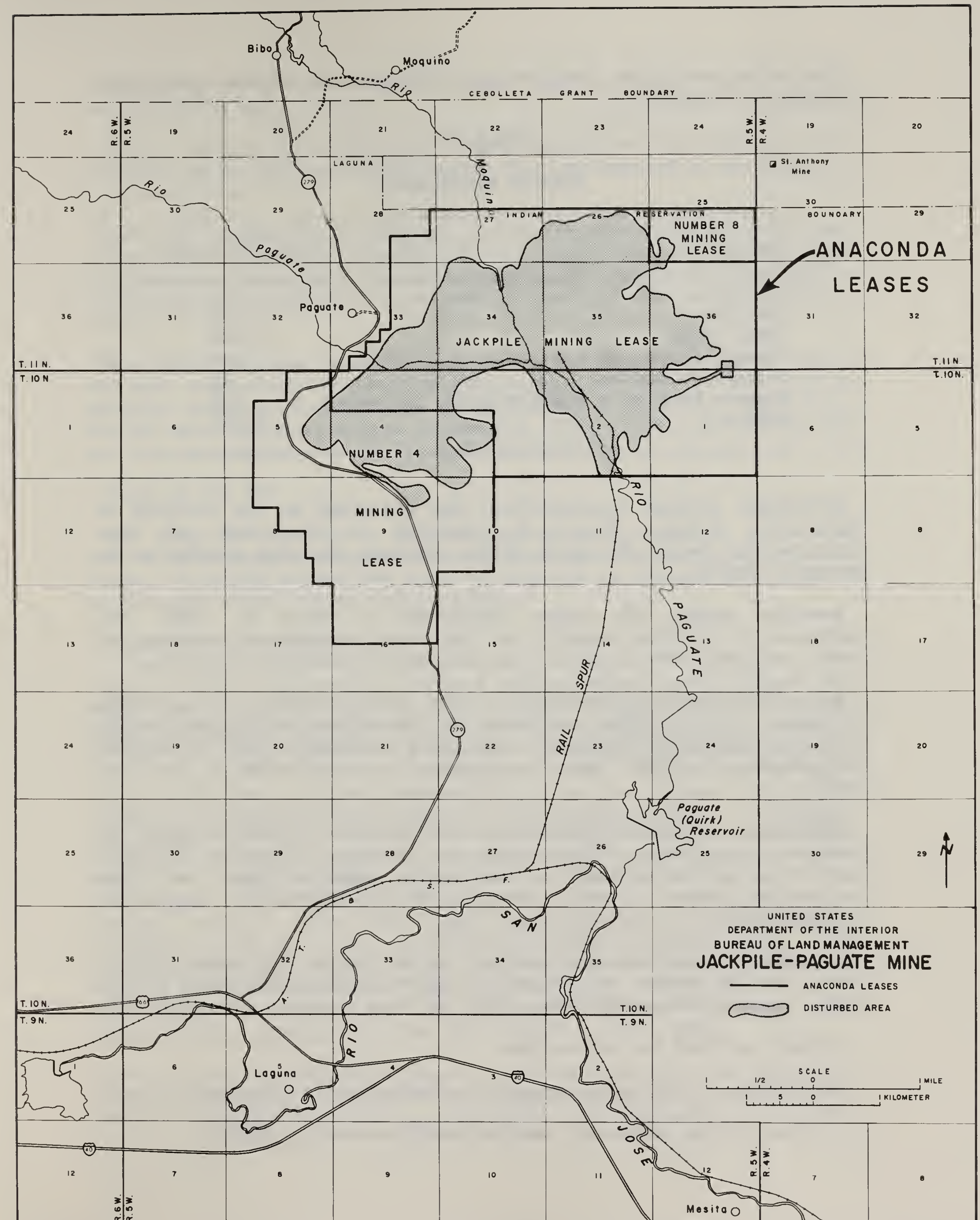
Underground mining was conducted by driving adits, or declines, to the ore zone. Drifts were driven through the ore zone, and the ore removed by modified room and pillar methods. Ventilation holes were drilled to maintain a fresh supply of air. Mine water was collected in sumps and pumped to ponds in the open pits. Waste rock was placed in waste dumps, and the ore was stockpiled for shipment to the mill.

During the 29 years of mining, approximately 400 million tons of earth were moved within the mine area, and about 25 million tons of ore were transported from the site via the Santa Fe Railroad to Anaconda's Bluewater Mill, 40 miles west of the mine (Map 1-1).



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
JACKPILE-PAGUATE MINE
REGIONAL LOCATION MAP
ANACONDA LEASES
SCALE
5 MILES
5 KILOMETERS
ALBUQUERQUE
RIO GRANDE
Belen
RIO PUERCO
35°
107°
SANDOVAL CO.
BERNALILLO CO.
VALENCIA CO.
CIBOLA CO.
McKINLEY CO.
LAGUNA INDIAN RESERVATION
(BERNABE M MONTAÑO GRANT)
LAGUNA IND. RES.
LAGUNA INDIAN RES.
ACOMA INDIAN RESERVATION
RIO SAN JOSE
Mesita
Laguna
Paguate
Bibo
Rio Moquino
Rio Paguate
MOUNT TAYLOR
GRANTS
Bluewater
Anaconda Bluewater Mill
NEW MEXICO
JACKPILE-PAGUATE MINE

MAP 1-1



Bibo
Moquino
CEBOLLETA GRANT BOUNDARY
LAGUNA INDIAN RESERVATION BOUNDARY
St. Anthony Mine
NUMBER 8 MINING LEASE
ANACONDA LEASES
Paguate
JACKPILE MINING LEASE
NUMBER 4 MINING LEASE
Rio Paguate
Rio Moquino
RAIL SPUR
Paguate (Quirk) Reservoir
A. T. & S. F.
RIO SAN JOSE
Laguna
Mesita
T. 11 N.
T. 10 N.
T. 9 N.
R. 6 W.
R. 5 W.
R. 4 W.
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
JACKPILE-PAGUATE MINE
ANACONDA LEASES
DISTURBED AREA
SCALE
1 MILE
1 KILOMETER

MAP 1-2

The mining operations resulted in 2,656 acres of surface disturbance as shown in Table 1-2.

TABLE 1-2

SURFACE DISTURBANCE

Features	Acres Disturbed
Open Pits	1,015
Waste Dumps	1,266
Protore Stockpiles	103
Topsoil Stockpiles	32
Support Facilities & Depleted Ore Stockpiles	240
TOTAL:	2,656

Additional acreage (unquantified) was disturbed by the drilling of exploration holes. Visual A, pocketed in the back of this Environmental Impact Statement (EIS), displays the mine complex as it presently exists.

Anaconda ceased all mining operations on March 31, 1982, but continues to provide security at the site to prevent unauthorized entry, and continues to operate an environmental monitoring program.

Anaconda advised the Department of the Interior (DOI) and the Pueblo of Laguna in April 1980 that open pit operations would terminate in February 1981 and subsequently submitted a reclamation plan to the DOI on September 11, 1980. Anaconda submitted a revised plan on March 16, 1982.

Anaconda's submission consists of a reclamation plan, reports by technical consultants and responses to questions raised by the DOI. More detailed information on Anaconda's plan, as well as other reclamation proposals, are presented under the Alternatives section of this chapter.

Anaconda's leases are administered by the Bureau of Indian Affairs (BIA), and the mining and reclamation operations are supervised by the Bureau of Land Management (BLM). Both of these agencies are within DOI.

Purpose and Need for Reclamation

Reclamation of the Jackpile-Paguate uranium mine is necessary because:

1. The site is presently a public health and safety hazard;

2. Additional and more serious hazards would develop if the site is not reclaimed; and

3. The mining lease terms and Federal regulations (25 CFR Parts 211 and 216, and 43 CFR Part 3570) require that reclamation be performed by the leaseholder.

This EIS assesses and compares the environmental impacts of three reclamation alternatives, including proposals developed by Anaconda, the Pueblo of Laguna and the DOI. The proposed action for this EIS is the review and approval of a reclamation plan for the Jackpile-Paguate uranium mine.

The lease terms and regulations give the DOI the authority to select the most appropriate reclamation procedures, but they do not contain specific goals or standards to guide the DOI's decision. Therefore, the DOI must consider various reclamation alternatives, and choose the one that is considered to be the most appropriate.

Scope of the EIS

The scope of this EIS is the reclamation (restoration to productive use) of the Jackpile-Paguate uranium mine and the affected adjacent areas. It is not within the scope of this EIS to discuss past impacts to the environment during mining activity.

Federal Trust Responsibility

Indian tribes and pueblos enjoy a unique status under Federal law based upon what has been characterized as a "guardian-ward" status. Morton v. Mancari, 417 U.S. 535,551 (1974); Cherokee Nation v. Georgia, 30 U.S. (5 Pet.), (1831). This is a judicially created fiduciary status that is loosely characterized by saying that the Secretary of the Interior has a "trust responsibility" to the Indians. Chambers, Judicial Enforcement of the Federal Trust Responsibility, 27 Stanford Law Review 1213, 1214 (1975). The trust responsibility arises out of statutes, treaties, executive orders and those situations where the Bureau of Indian Affairs (BIA) holds title to Indian land and administers it "in trust" for particular tribes. United States v. Mitchell, 445 U.S. 535 (1980); Cape Fox Corporation v. United States, No. 664-801 (Ct. Cl. filed December 27, 1983), Chambers, supra. The trust responsibility is a limited one that arises from and is limited by, the authorizing statute, treaty, or executive order, and it varies according to the particular relationship being examined. See North Slope Borough v. Andrus, 642 Fed. 589, 611 (D.C. Cir. 1980).

Due to the governing regulations and the Secretary of the Interior's trust responsibility to Indians (and in this action specifically to the Pueblo of Laguna), the DOI is responsible for determining the proper level of reclamation for the Jackpile-Paguate uranium mine.

Authorizing Actions

The BLM and BIA share joint responsibility for a decision on approval of a reclamation plan for the Jackpile-Paguate uranium mine. However, each agency has specific responsibilities with regard to reclamation as outlined below.

The BLM is responsible for authorizing the commencement and approving the completion of the Jackpile-Paguate uranium mine reclamation. The authorities for this action are the terms of the mining leases that require compliance with applicable Federal regulations. Specifically, they include the following:

1. 25 CFR Part 211, Leasing of Tribal Lands for Mining (formerly 25 CFR Part 171);

2. 25 CFR Part 216, Surface Exploration, Mining and Reclamation of Lands (formerly 25 CFR Part 177); and

3. 43 CFR Part 3570, Operating Regulations for Exploration, Development and Production (formerly 30 CFR Part 231).

The BLM is also responsible for authorizing any necessary changes in the ongoing reclamation operations and for preparing any corresponding environmental documentation that would be required.

The BIA is responsible for determining that the surface aspects of mine reclamation, including revegetation, have been completed in accordance with the Secretary's trust responsibility as well as established requirements. In conjunction with this determination, the BIA is responsible for authorizing partial or total release of any bonding requirements, and partial or total surrender of the involved mining leases. The authorities for these actions are various terms of the mining leases and the provisions of 25 CFR Parts 211 and 216.

Due to the effective dates of the three mining leases and applicable Federal regulations, disagreement exists between the involved parties about the applicability of some of these regulations to certain leases. Debate has also occurred about the interpretation of various lease terms. It is not intended that this EIS resolve any such disagreement or debate. This section of the EIS merely identifies the Federal regulations that relate to one or more of the mining leases, and indicates that the lease terms and those regulations assign certain responsibilities to the BLM and the BIA.

Interrelationships With Other Projects

The only related project planned is the realignment of State Highway 279 through the mine area. This project is dependent on State legislative appropriation. The realignment is scheduled to take place prior to or during reclamation. This project is not precluded by any of the alternatives addressed in this EIS nor would the realignment preclude implementation of any of the reclamation proposals. The impacts of the realignment will be evaluated in a separate environmental assessment.

ISSUES AND CONCERNS

During the initial stages of the EIS process, public meetings were held to determine the issues of greatest concern related to the mine reclamation project and possible reclamation measures. This process is called "scoping". The DOI reviewed all the comments raised during these meetings and selected those major issues to be addressed in this EIS. The criteria DOI used for selecting major issues were whether the concerns expressed were substantive, and whether the issues fell within the scope of this EIS as stated on p. 1-5. Issues that failed to meet both criteria were dropped from further evaluation. Issues which met the criteria were used to develop reclamation objectives which in turn would be used to evaluate alternatives. (A more detailed discussion of scoping activities is contained in Chapter 4 - Consultation and Coordination.)

Issues Dropped From Further Evaluation

1. Investigate the possible psychological effects that the mining operations and mine closure had on the Laguna people. Rejected as not within the scope of this EIS.

The present socioeconomic conditions of the Laguna people and the socioeconomic impacts of the reclamation operations are discussed in this document. However, investigating the possible psychological effects resulting from mining is not within the scope of this EIS.

2. Investigate the possible health impacts that mining operations had on former miners and residents of Paguate Village. Rejected as not within the scope of this EIS.

The predicted health impacts to the workers performing reclamation and post-reclamation impacts to the Laguna people are discussed in this document. However, investigating the possible health impacts of past mining operations is not within the scope of this EIS.

3. Determine if blasting during mining operations caused structural damage to the homes in Paguate Village. Rejected as not within the scope of this EIS.

This EIS assesses only those blasting impacts that could occur during reclamation. Determining if damages occurred during mining operations and assessing responsibility for mitigation lies outside the scope of this EIS and constitutes an unresolved liability issue.

4. Determine if past mining operations substantially contributed to the siltation of Paguate Reservoir. Rejected as not within the scope of this EIS.

The present condition of Paguate Reservoir and the impacts of reclamation on the reservoir are discussed in this EIS. However, determining if past mining operations significantly shortened the useful life span of Paguate Reservoir by causing increased sediment load, and assessing responsibility for mitigation lies outside the scope of this EIS. As with blast damage, the DOI considers this to be an unresolved liability issue.

5. Protection of the remaining on-site uranium resources (protore and unmined deposits) and existing mine workings for future production. Rejected as not within the scope of this EIS.

Projection of economic conditions suitable for recovery of the remaining reserves is speculative. A new mining project is not precluded in any of the reclamation proposals, but protecting the protore, unmined deposits and existing mine workings is outside the scope of this EIS.

6. Allow future residential and farming use of the minesite. Rejected as being contrary to the reclamation objective of ensuring human health and safety.

Either of these activities would require disturbing reclaimed areas to a significant degree and therefore have the potential for releasing previously covered radioactive materials into the biosphere.

7. Develop national standards for the reclamation of uranium mines. Rejected as not within the scope of this EIS.

Subtitle C of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, directed the U.S. Environmental Protection Agency to promulgate regulations for the management of hazardous wastes. These regulations were issued, but they exclude mining wastes. Evaluation of this site-specific project does not preclude Congress from acting to designate mining wastes as hazardous materials.

Issues Evaluated

1. Radiological doses and health impacts to workers involved in reclamation, persons visiting the minesite, residents of Paguate Village and to the general public.

2. Non-radiological minesite hazards such as possible collapse of the underground entries and workings, collapse of abandoned mine buildings and hazards due to unstable highwalls and waste dumps.

3. Engineering the reclaimed land forms to ensure their long-term integrity and blend the visual characteristics of the minesite with the surrounding landscape.

4. Contamination of surface waters with heavy metals and suspended solids.

5. Revegetation of the minesite to prevent erosion and facilitate post-reclamation land use (i.e., livestock grazing).

6. Backfilling or draining the open pits to prevent ponding of contaminated water.

7. Minimizing the concentration of airborne particulates during and after reclamation.

8. Protection of cultural, religious and archaeological sites within the minesite.

9. Socioeconomic impacts of reclamation on the Pueblo of Laguna.

10. Long-term environmental monitoring needs and procedures.

ALTERNATIVES ELIMINATED FROM DETAILED STUDY

The following is a list of the alternatives eliminated from detailed study, and a brief explanation as to why they were rejected:

1. Return the tailings from Anaconda's Bluewater uranium mill to the minesite. Rejected as not within the scope of this EIS.

The New Mexico Environmental Improvement Division and the U.S. Nuclear Regulatory Commission have jurisdiction over uranium mill sites in the State of New Mexico. The DOI does not have the authority to require Anaconda Minerals Company to return the mill tailings to the minesite.

2. Construct a wind or solar energy project at the mine or develop the site as an industrial park. Rejected as not within the scope of this EIS.

Such projects are not precluded in any of the alternatives addressed, but developing new industries for the Pueblo of Laguna is outside the scope of this EIS.

3. Completely backfill all open pits. Rejected as being not feasible and unnecessary.

The cost of backfilling all pits would exceed $200 million which is considered to be unreasonable. Also, studies thus far do not support that completely backfilling the pits is necessary.

4. Use the site as a source of gravel. Rejected as not within the scope of this EIS.

The alternatives addressed in this document neither make provisions for, nor preclude this use. Reserves of gravel are present throughout the area, and far exceed the expected demand. Reserves of gravel and fill also exist on the site, but extreme care should be taken in removing such material to assure that radiological material is not removed or uncovered.

5. Contain all solid wastes and liquids within the lease property. Rejected as technically impractical and inconsistent with the objective of restoring post-reclamation land use.

Managing the reclaimed mine for zero discharge of waste material using conventional control techniques (i.e., lining, capping and hydrodynamic control) would be extremely expensive, provide little environmental benefit over simpler methods and would require permanent maintenance. Such techniques would result in large areas of the mine being unsuitable for any other use.

ALTERNATIVES SELECTED FOR DETAILED STUDY

The scoping process indicated that reclamation of the Jackpile-Paguate uranium mine could be accomplished in several ways due to the interrelationships of various reclamation components (e.g., backfilling and resloping of waste dumps). However, since no specific standards exist for uranium mine reclamation, either in regulations or lease terms, reclamation objectives were developed to assist in determining the most appropriate reclamation measures for the Jackpile-Paguate uranium mine. The primary goal of these objectives is to reclaim and stabilize the minesite to restore productive use of the land and to ensure that adverse environmental impacts are reduced to the extent possible.

The reclamation proposals will be evaluated with the intent of achieving as many of the objectives as possible while realizing that no single reclamation proposal could meet all the objectives completely and that compromises would be required. Using post reclamation land use for livestock grazing as the common denominator and taking into account the major issues identified during the scoping process, the following reclamation objectives, in order of importance, were developed:

1. Ensure human health and safety.

2. Reduce the releases of radioactive elements and radionuclei to as low as reasonably achievable.

3. Ensure the integrity of all existing cultural, religious and archaeological sites.

4. Return the vegetative cover to a productive condition comparable to the surrounding area.

5. Provide for additional land uses that are compatible with other reclamation objectives and that are desired by the Pueblo of Laguna.

6. Eliminate the need for post-reclamation maintenance.

7. Blend the visual characteristics of the minesite with the surrounding terrain.

8. Employ the Laguna people in efforts that afford them opportunities to utilize their skills or train as appropriate.

Anaconda's Proposal and the Alternatives (except for the No Action Alternative) approach the reclamation objectives differently. The following is a brief summary of the reclamation alternatives analyzed in this EIS. A more complete description of these proposals is given in Tables 1-3 and 1-4.

No Action Alternative

For this EIS, the No Action Alternative would mean that no reclamation work would be performed. The area would be secured to prevent unauthorized entry and an environmental monitoring program would be operated. Additional requests by the Pueblo of Laguna to utilize certain facilities for storage could be accommodated, provided such use would be temporary and deemed safe.

This alternative is not feasible because the Secretary of the Interior cannot approve a plan which does not provide a reasonable measure of protection to public health and safety, and does not reduce environmental impacts to the extent possible. This alternative is included and analyzed only to provide a benchmark that would allow decisionmakers to compare the magnitude of environmental effects for a given range of alternatives.

Anaconda Proposal

Anaconda's reclamation plan was developed from company data, reports by Anaconda's technical consultants and in response to questions raised by the DOI.

The open pits would be backfilled to at least three feet above Anaconda's projected ground water recovery levels. All highwalls would be scaled to remove loose material. The rim of Gavilan Mesa would be cut back by blasting or mechanical means and the base of the highwall would be buttressed with waste and overburden. Waste dump slopes would be reduced to between 2:1 and 3:1; most slopes would be terraced. Jackpile Sandstone exposed by resloping would be covered with four feet of overburden and one foot of topsoil. Facilities would either be removed or cleaned up and left intact. All disturbed areas (pit bottoms, waste dumps, old roads, etc.) would be topsoiled and seeded. Reclamation would be considered complete when the weighted average for basal cover and production on revegetated sites equals or exceeds 70 percent of that found on comparable reference sites. The post-reclamation monitoring period would be a minimum of three years.

DOI Proposal (Monitor Option and Drainage Option)

This alternative was developed by the DOI. It is based on a series of technical reports, contracted studies and file data. Although similiar to Anaconda's Proposal in overall concept, it varies in important details.

Because of concerns over the environmental impacts of either ponded water or salt build-up in the open pits, DOI has identified two options for treatment of the pit bottoms: 1) a Monitor Option which would backfill the pits with protore, excess material from waste dump resloping and soil cover. Due to the excess material (approximately 19 million cubic yards), the estimated backfill elevations of the pit floors could be 40 to 70 feet higher than Anaconda's proposed minimum. The pits would remain as closed basins, in which case the potential build-up of salt and saline water in the soils of the pit bottoms would be monitored. If soil problems are observed, additional backfill and revegetation would be required from Anaconda. The monitoring period would be of sufficient duration to determine the stable future water table conditions; and 2) a Drainage Option which would restore the natural mode of overland runoff from the pit areas. Backfill volumes and elevations would be approximately the same as for the Monitor Option, but none of the pits would be left as closed basins. Open channels would be constructed with a gradient equal to or flatter than local natural watercourses to convey runoff from the pit areas to the Rio Paguate. This would avoid ponded water or undrained saline soils on the reclaimed minesite.

For both options, other aspects of reclamation would be the same. Highwall stability techniques would essentially be the same as Anaconda's Proposal. With few exceptions, waste dump slopes would be reduced to 3:1, with no terracing. Treatment of Jackpile Sandstone and minesite facilities would be the same as Anaconda's Proposal. All disturbed areas would be topsoiled and seeded. Reclamation would be considered complete when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover and production of undisturbed reference areas. The post-reclamation monitoring period would be a minimum of 5 years.

Laguna Proposal

This alternative was developed by the Pueblo of Laguna based on their desires and in consultation with their own technical consultants.

Under this proposal, South Paguate pit would be backfilled to its original contour; North Paguate and Jackpile pits would be backfilled 7 feet above the DOI's Proposal. The North Paguate highwall would be buttressed to the crest and the buttress material would be sloped 3:1. Treatment of Gavilan Mesa, waste dump slopes, Jackpile Sandstone and minesite facilities would essentially be the same as DOI's Proposal. All disturbed areas would be topsoiled and seeded. Reclamation would be considered complete when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover and production of undisturbed reference areas. The post-reclamation monitoring period would be a minimum of 10 years.

SUMMARY OF IMPACTS

Table 1-5 presents a summary and comparison of environmental impacts for the reclamation proposals outlined in Tables 1-3 and 1-4. For more detailed impact analysis, refer to Chapter 3 - Environmental Consequences.

TABLE 1-3

SUMMARY OF RECLAMATION ALTERNATIVES

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Monitor and Drainage Options)	Laguna Proposal
Pit Bottoms				
Backfill Levels	No Action	Backfill pit bottoms to at least 3 feet above projected ground water recovery levels as indicated below. A cross-sectional schematic diagram is shown in Appendix A. Pit / Proposed Minimum Backfill Levels[a] Jackpile: 5932 North Paguate: 5951 downgradient of cut-off[b]; 5983 upgradient of cut-off South Paguate: 5986-5988 South Paguate (SP 20): 6053 [a] Excess material generated by reclamation could raise these minimum backfill levels. [b] Refer to the Hydrology Section in Chapter 3 for explanation.	Backfill west end (PW 2/3 area) of North Paguate pit to elevation of 6045'. Other backfill levels could be 40 to 70 feet higher than Anaconda's proposed minimum with two options under consideration to prevent ponded water and/or salt build-up: 1) an option to monitor the future conditions of the pit bottoms and provide additional backfill, if necessary, and 2) an option to restore the natural mode of runoff by reshaping the pits to allow external drainage to the Rio Paguate. For both options, the higher backfill levels are a result of approximately 19 million cubic yards generated by waste dump re-sloping.	PW 2/3 area would be backfilled to the same elevation as DOI's Proposal. Backfill South Paguate pit to its original contour. Jackpile and North Paguate pits would be backfilled 7 feet higher than DOI's Proposal. A cross-sectional schematic diagram of backfill levels in Jackpile and North Paguate pits is shown in Appendix A.
Backfill Materials	No Action	Would consist of protore, waste dumps H and J, and excess material obtained from waste dump resloping and stream channel clearing. These materials would be covered with 4 feet of overburden and 1 foot of topsoil.	Same as Anaconda's Proposal. Materials excavated from drainage channels would also be used as back-fill.	Same as Anaconda's Proposal except that all protore would be positioned above predicted ground water recovery levels. Install a separate fence around the protore stockpile areas.

TABLE 1-3 (Cont'd)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Monitor and Drainage Options)	Laguna Proposal
Stabilization	No Action	Reduce all backfill slopes no greater than 3:1. Construct surface water control berms within pit bottoms to reduce erosion and retain soil moisture for plant growth. These areas would then undergo surface shaping, topsoil application and seeding as outlined in the vegetation segment of this table.	Same as Anaconda's Proposal, except pit bottoms would be contour furrowed.	Same as DOI's Proposal.
Post Reclamation Access	No Action	Livestock and vehicle access to the pit bottoms would be provided through the use of existing or newly created ramps.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
<u>Pit Highwalls</u>				
Jackpile Pit Highwall	No Action	Stabilize by scaling and buttressing. Amount of buttressing material would be 3.8 million tons of waste, or in excess of the amounts needed for ground water protection. The overall slope of the buttress would not exceed 3:1. Alternate method of stabilization may consist of removing top of highwall by either blasting or hauling to an angle that would exhibit required stability.	Buttressing would be the same as Anaconda's Proposal. Additional treatment would consist of using blasting and mechanical methods to recontour the west face of Gavilan Mesa so that sandstone units would have a near vertical angle and shale units would be at their natural angle of repose.	Same as DOI's Proposal. Additionally, monitor semi-annually any portion of Gavilan Mesa greater than 150 feet in height which has a safety factor less than 1.5. Those portions of the highwall exhibiting stability problems would be repaired as needed by scaling or other appropriate methods.
North Paguate Pit Highwall	No Action	Scale top of highwall to remove loose rock and debris.	Same as Anaconda's Proposal. In addition, the upper 10 feet of alluvial cover at the highwall crest would be sloped 3:1 to prevent slumping and piping.	Buttress North Paguate pit highwall to its crest and slope buttress material 3:1.
South Paguate Pit Highwall	No Action	Scale top of highwall to remove loose rock and debris.	Same as Anaconda's Proposal. In addition, the upper 10 feet of alluvial cover at the highwall crest would be sloped 3:1 to prevent slumping and piping. The south rim would also be fenced with 6-foot chain link.	South Paguate pit would be backfilled to its original contour which would probably eliminate all highwalls.

TABLE 1-3 (Cont'd)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Monitor and Drainage Options)	Laguna Proposal
Waste Dumps	No Action	Relocate waste dumps H and J to Jackpile pit as backfill material. Reduce overall slopes between 2:1 and 3:1. Dumps which have Jackpile Sandstone on their outer surface and any Jackpile Sandstone exposed during resloping would be covered with 4 feet of overburden and 1 foot of topsoil. Cover dumps that do not contain Jackpile Sandstone on their outer surface with 1 foot of topsoil. Install system of terraces, berms and rock-lined drainage structures to control erosion. Additional surface treatment is outlined in the vegetation segment of this table. Table 1-4 contains complete descriptions of modifications and treatments proposed for each waste dump. A cross-sectional schematic diagram is shown in Appendix B.	Treatment of waste dumps H and J and Jackpile Sandstone would be the same as Anaconda's Proposal. Reduce most dump slopes to 3:1 or less and contour furrow all dump slopes; exceptions are noted in Table 1-4. Install berms on all dump crests to control erosion. Slightly slope all dump tops away from their outer slopes. Contour dump slopes so their toes are convex to prevent formation of major gullies on slopes. Additional surface treatment is outlined in the vegetation segment of this table. Comparative modifications and treatments are presented in Table 1-4. A cross-sectional schematic diagram is shown in Appendix B.	Same as DOI's Proposal.
Protore Stock-Piles	No Action	Use all protore as backfill material in pit areas. Cover with 4 feet of overburden and 1 foot of topsoil.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal except that all protore would be positioned above predicted ground water recovery levels. Install a separate fence around the protore stockpile areas.
Site Stability and Drainage				
Stream Stability	No Action	Remove all protore and waste material lying within 200 feet of Rios Paguate and Moquino.	Same as Anaconda's Proposal. In addition, construct a permanent cement base or a flood-proof bridge on the Rio Moquino immediately above its confluence with Rio Paguate.	Same as DOI's Proposal.
Arroyo Headcutting	No Action	Armor arroyos south of waste dumps I, Y and Y2 to inhibit arroyo headcutting. Other headcuts encountered during reclamation would be stabilized by armoring.	Armor arroyos south of waste dumps I, Y and Y2, and the arroyo west of waste dump FD-3. Other headcuts encountered during reclamation would be stabilized by armoring. Stabilization design would differ from Anaconda's Proposal.	Same as DOI's Proposal.

TABLE 1-3 (Cont'd)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Monitor and Drainage Options)	Laguna Proposal
Blocked Drainages	No Action	Remove waste dump J and protore stockpiles SP-17BC and SP-6-B to unblock ephemeral drainage on south side of minesite. Two blocked drainages on north and south sides of Gavilan Mesa would remain blocked. Remainder of minesite, excluding open pits, would drain to Rios Paguate and Moquino.	Same as Anaconda's Proposal except pit areas would drain to the Rio Paguate under the Drainage Option.	Same as Anaconda's Proposal.
Surface Facilities/ Structures				
Lease No 1 (Jackpile Lease)	No Action	Remove all facilities including houses, offices, shops, sewage systems, the airstrip, parking areas and roads (except as noted under "Access Routes" below). Also remove all operational and maintenance equipment, including machinery and tools. Leave power lines and poles passing through Lease No. 1 and serving areas north of lease undisturbed; remove all others. Clear land surface (except pit highwalls and natural outcrops) of radiological material (e.g., Jackpile Sandstone) until gamma readings of twice background or less are achieved. Then grade and seed areas.	Same as Anaconda's Proposal. However, the Pueblo of Laguna has requested that certain facilities on Lease No. 1 remain. The Department could approve this request provided the facilities were structurally sound and radiologically safe.	Same as Anaconda's Proposal except the Pueblo has requested that the Geology building at the employee housing complex, Old Shop and the Open Pit offices remain. These facilities and associated parking areas would be cleared of radiological material. The Pueblo may request additional facilities to remain on Lease No. 1.
Lease No. 4	No Action	Leave all structures and facilities associated with P-10 Mine and New Shop, including all buildings, roads, parking lots, sewage systems, power lines and poles. Remove all operational and maintenance equipment, including tools, machinery, supplies and the P-10 conveyor. Clear all permanent structures and land surfaces (except pit highwalls and natural outcrops) of radiological material until gamma readings of twice background or less are achieved. Then grade and seed areas. Remove non-salvageable contaminated buildings and materials to pit for disposal.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.

TABLE 1-3 (Cont'd)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Monitor and Drainage Options)	Laguna Proposal
Access Routes	No Action	Clear 4 major roads within minesite of radiological material and leave after reclamation for post-mining use. These access routes include: 1) access road from P-10 and New Shop to State Highway 279; 2) main road through mine; 3) road that passes between housing area and North Oak Canyon Mesa and then proceeds to P-10; and 4) road to Jackpile Well No. 4. Remove all other roads (except on Lease No. 4), then grade and seed the areas.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Water Wells	No Action	Leave Jackpile Well No. 4, P-10 Well, New Shop Well and Old Shop Well, and 3 wells and their associated sheltering structures (near housing area). Remove pumps, riser pipe, wiring and water storage tanks. Also leave wells established for future monitoring purposes. Cap all wells to prevent dust, soil and other contaminants from entering well casing.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Rail Spur	No Action	Remove and salvage rail spur from Santa Fe Railroad main line to Jackpile Mine. Remove underlying ballast material and relocate to one of mine pits. Grade roadbed to conform with local relief and then seed it. Demolish Quirk loading dock and haul it to pit. Clear reclaimed roadbed and loading dock of radiological material (i.e., ore spillage) until gamma readings of twice background or less are achieved.	Same as Anaconda's Proposal except the Department could approve the Pueblo's request to leave the rail spur intact. This approval would be contingent upon the rail spur being radiologically safe.	Same as Anaconda's Proposal except the rail spur would be left intact and cleared of radiological material until gamma readings of twice background or less are achieved.
Drill Holes	No Action	Drill holes would be identified by field investigations and review of existing drilling records. Upon resumption of reclamation activities, upper 5 feet of holes would be plugged with concrete.	All drill holes would be plugged according to the State Engineer's requirements. A 5-foot surface concrete plug would also be placed in each hole. Any cased holes would have the casing cut off at the surface. In addition, areas around drill holes would be seeded. Any exploration roads not wanted by the Pueblo would be reclaimed.	Same as DOI's Proposal.

TABLE 1-3 (Cont'd)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Monitor and Drainage Options)	Laguna Proposal
Underground Modifications				
Ventilation Holes	No Action	Place 10-foot concrete surface plug in each vent hole. Secure plug by either steel pinning or belling out to prevent downward slippage. Contour and seed areas around vent holes.	Backfill vent holes with waste material (Dakota Sandstone and Mancos Shale) to within 10 feet of surface, and place 10-foot concrete surface plug. Secure plug by either steel pinning or belling out to prevent downward slippage. Contour and seed areas around vent holes.	Same as DOI's Proposal.
Adits and Declines	No Action	Construct concrete bulkhead approximately 680 feet below portal of P-10 decline. Backfill decline from bulkhead to ground surface with Dakota Sandstone and Mancos Shale. Place sufficient material over portal to allow for compaction and settling. Shape ground surface above buried portal then top-dress and seed. Bulkhead and backfill Alpine mine entry. Cover mine entries not previously plugged by backfilling.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Revegetation Methods				
Top dressing	No Action	Following final sloping and grading, top-dress areas to be planted with 1 foot of material composed primarily of Tres Hermanos Sandstone (stockpiled at three locations within minesite). In order to meet top dressing volume requirements, obtain additional material from topsoil borrow area comprising 44 acres. Following topsoil removal, contour disturbed borrow area, then fertilize, seed and mulch.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Surface Preparation	No Action	After applying top dressing, fertilize areas to be planted, followed by disking to depth of 8 to 12 inches. Complete surface preparation, where conditions dictate, with compactor roller or sheepsfoot roller to create shallow depressions for water collection, water retention and erosion control.	Same as Anaconda's Proposal except all areas would be contour furrowed.	Same as DOI's Proposal.

TABLE 1-3 (Cont'd)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Monitor and Drainage Options)	Laguna Proposal
Seeding and Seed Mixtures	No Action	In most situations, plant seed mixture with rangeland drill. Broadcast seeding combined with hydromulching may be used on inaccessible sites or if determined to be more feasible than drilling. For both methods, seed mixture would consist mainly of native plant species possessing qualities compatible with post-grazing use and adapted to local environment. Following drill seeding, apply straw mulch at about 2 tons per acre, and crimp into place with a notched disk.	Before seeding operations begin, fence entire minesite to prevent livestock grazing. Seeding methods and mixtures same as for Anaconda's Proposal.	Same as DOI's Proposal.
Revegetation Success	No Action	Plant establishment would be considered successful when weighted average for basal cover and production on all revegetated sites equalled or exceeded 70 percent of weighted average for basal cover and production on comparable reference sites on undisturbed lands within lease areas (but no sooner than 3 years following seeding). Prevent livestock grazing until 70 percent comparability values are met. At end of 3-year monitoring period, if unsuccessful trend is shown, retreatment may be necessary to achieve success criteria. Success criteria are discussed under Flora in Chapter 3.	Plant establishment would be considered successful when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover and production of undisturbed reference areas (but not sooner than 5 years following seeding). Prevent livestock grazing until 90 percent comparability values are met. Retreatment procedures would be the same as Anaconda's Proposal.	Same as DOI's Proposal except a minimum of 10 years would be required before determining if the success criteria were met.
Monitoring	Continue Anaconda's present monitoring program	Continue present monitoring program during reclamation period and for minimum of 3 years thereafter. Monitoring activities to be continued would include: meteorologic sampling, air particulate sampling, radon sampling (ambient), radon exhalation sampling, gamma survey, soil and vegetation sampling, water monitoring and subsidence.	Same as Anaconda's Proposal, except monitoring would continue for minimum of 5 years following reclamation. In addition, the monitoring program would be expanded to include: radon daughter levels (working levels) in any remaining mine buildings and ground water recovery levels/salt build-up in the open pits. The ground water monitoring period would be of sufficient duration to determine the stable future water table conditions.	Same as DOI's Proposal except monitoring would continue for minimum of 10 years following reclamation.

TABLE 1-3 (Concluded)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Monitor and Drainage Options)	Laguna Proposal
Security	Continue Anaconda's present security program to prevent unauthorized access.	Anaconda would continue to have full responsibility for mine access and security during reclamation and monitoring activities. However, security during monitoring phase would require cooperation from Pueblo of Laguna and BIA to prevent livestock grazing on revegetated sites.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Compliance	BLM and BIA would continue to ensure compliance with the present monitoring program and security measures.	BLM and BIA would monitor and inspect every aspect of reclamation activities to ensure compliance with all reclamation requirements.	Same as Anaconda's Proposal	Same as Anaconda's Proposal.
Reclamation Completion	N/A	Reclamation considered complete with occurrence of the following: 1. When weighted average for basal cover and production on all revegetated sites equalled or exceeded 70 percent of weighted average for basal cover and production on comparable reference sites (but not sooner than 3 years following seeding); or 2. If livestock grazing occurred on any revegetated area before the above weighted average success criteria were met.	Reclamation considered complete when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover and production of undisturbed reference areas (but not sooner than 5 years following seeding). In addition, gamma radiation levels must be no greater than twice background over the entire minesite. Outdoor radon - 222 concentrations must be no greater than 3pCi/1. Radon daughter levels (working levels) in any remaining surface facilities must not exceed 0.03 WL.	Same as DOI's Proposal except a minimum of 10 years would be required before determining if vegetative success criteria were met.
Post-Reclamation Land Uses	N/A	Livestock grazing. Specifically excluded are habitation, farming and construction of commercial or industrial facilities.	Livestock grazing. Specifically excluded are habitation and farming.	Livestock grazing, light manufacturing, office space, mining and major equipment storage. Specifically excluded are habitation and farming.

TABLE 1-4

WASTE DUMPS AT THE JACKPILE-PAGUATE URANIUM MINE
(existing conditions, proposed modifications and treatments)

Existing Conditions					Proposed Modifications and Treatments	
Dump(s)	Acres	Reclaimed to Date[a/]	Dump Composition	Present Slope (horizontal:vertical) -Mode Value-	Anaconda's Proposal[b/]	DOI Proposal (Monitor and Drainage Options) Laguna Proposal[c/]
A	23		Outer surface: mainly shales, mixed with some Tres Hermanos Sandstone (THS)	1.44:1	Slope 3:1	Same as Anaconda's Proposal
B	71		Outer surface: mainly shales mixed with some THS	1.50:1	Slope 3:1	Same as Anaconda's Proposal
C	21	X	Topsoil: 24 inches THS mixed with some shales; Under topsoil: THS mixed with shales	1.60:1	No change--most of dump slope covered by sloping of dump FD-2.	Same as Anaconda's Proposal, except any slopes not covered by FD-2 would be sloped 3:1.
D	14	X	Topsoil: 24 inches THS mixed with some shales; Under topsoil: THS mixed with shales	1.64:1	No change	Slope 3:1
E	12	X	Topsoil: 24 inches THS mixed with some shales; Under topsoil: THS mixed with shales	1.38:1	No change	Slope 3:1
F	73	X	Topsoil: 18-24 inches THS mixed with some shales; Under topsoil: mainly shale with some THS and Jackpile Sandstone (JSS)	1.50:1	No change	Slope 3:1
FD-1	168		Entire dump: primarily shales with JSS and some THS on west end	1.45:1	Dump moved back approx. 200 feet from arroyo. One terrace with 2:1 intermediate slopes; overall slopes from 2.3:1 to 3:1; 5-foot-high erosion-control berm placed between toe of dump and arroyo.	Dump moved back approx. 120 feet from arroyo. Boulder-size talus left at toe of dump to stabilize arroyo against headcutting; No terracing; slope 3:1.

TABLE 1-4 (Cont'd)

Existing Conditions					Proposed Modifications and Treatments	
Dump(s)	Acres	Reclaimed to Date[a/]	Dump Composition	Present Slope (horizontal:vertical) -Mode Value-	Anaconda's Proposal[b/]	DOI Proposal (Monitor and Drainage Options) Laguna Proposal[c/]
FD-2	25		Entire dump: shales and THS	1.48:1	Two terraces with 2:1 intermediate slopes; overall slope 2.3:1; top of dump lowered about 50 feet.	Same as Anaconda's Proposal due to dump's height and restricted room in surrounding terrain.
FD-3	10		Outer surface: JSS, some shales and THS on slopes	1.40:1	Dump moved back about 200 feet from arroyo. One terrace with 2:1 intermediate slopes; overall slopes from 2.3:1 to 3:1; 5-foot-high erosion-control berm placed between toe of dump and arroyo.	Dump moved back about 120 feet from arroyo. Boulder-size talus left at toe of dump to stabilize arroyo against headcutting. No terracing; slope 3:1.
G	49	X	Topsoil: 18-24 inches THS mixed with some shales; Under topsoil: shales mixed with JSS exposed on surface prior to covering	1.39:1	No change	Slope 3:1
H	7		Outer surface: JSS and some shales	1.43:1	Dump removed and backfilled into Jackpile pit--underlying area reclaimed.	Same as Anaconda's Proposal
I	57	X	Topsoil: 18-24 inches THS; Under topsoil: shales mixed with JSS exposed prior to covering	1.75:1	Approx. 36 acres of slope to be modified by using one terrace with 2:1 intermediate slopes. Overall slope 2.2:1; 21 acres would remain at present configuration of 1.5:1.	Slope east portion 3:1; slope south portion 2.5:1.
J	15	X	Topsoil: 18-24 inches alluvial material taken from floodplain area; Under topsoil: JSS	1.37:1	Dump removed and backfilled into Jackpile pit--underlying area reclaimed.	Same as Anaconda's Proposal
K	22	X	Topsoil: 24 inches THS; Under topsoil: mainly THS mixed with shales	1.66:1	No change	Slope 3:1

TABLE 1-4 (Cont'd)

Existing Conditions					Proposed Modifications and Treatments	
Dump(s)	Acres	Reclaimed to Date[a/]	Dump Composition	Present Slope (horizontal:vertical) -Mode Value-	Anaconda's Proposal[b/]	DOI Proposal (Monitor and Drainage Options) Laguna Proposal[c/]
L	40	X	Topsoil: 24 inches THS; Under topsoil: mainly shales mixed with THS	4.45:1	Approx. 18 acres left to reclaim. Slopes now at 1.5:1 would be sloped 3:1.	Same as Anaconda's Proposal
N	64		Outer surface: mixed shales and some THS	1.20:1	Dump moved back approx. 200 feet from Rio Moquino and sloped 2:1 (no terraces); 5-foot-high erosion-control berm placed between toe of dump and Rio Moquino.	Same as Anaconda's Proposal except dump sloped 3:1.
N2			Outer surface: mixed shales and some THS	1.66:1	Dump moved back approx. 200 feet from Rio Moquino and sloped 2:1 (no terraces); 5-foot-high erosion-control berm placed between toe of dump and Rio Moquino.	Same as Anaconda's Proposal except dump sloped 3:1.
O,P, P1,P2	35	X	Topsoil: 24 inches THS; Under topsoil: mainly THS with limited amounts of shale	1.30:1	No change	Slope 3:1
Q	52		Outer surface: JSS mixed with some shales	1.55:1	Slope 3:1	Same as Anaconda's Proposal
R	14		Outer surface: shales mixed with some JSS	2.35:1	Slope 3:1	Slope 3:1
S	96	X	Topsoil: 24 inches THS; Under topsoil: THS with some shales	1.5:1	Southern 26 acres seeded and sloped 3:1 and covered with 2 feet of topsoil; 60 acres would remain at present slope configuration of 1.5:1.	Same as Anaconda's Proposal except slopes now at 1.5:1 would be resloped 3:1.

TABLE 1-4 (Cont'd)

Existing Conditions					Proposed Modifications and Treatments	
Dump(s)	Acres	Reclaimed to Date[a/]	Dump Composition	Present Slope (horizontal:vertical) -Mode Value-	Anaconda's Proposal[b/]	DOI Proposal (Monitor and Drainage Options) Laguna Proposal[c/]
South Dump	175		Outer surface: shales and THS on slopes	1.40:1	Dump moved back a minimum of 150 feet from arroyo. Overall slopes between 2:1 and 3:1; some areas with one terrace.	Dump moved back a minimum of 150 feet from arroyo and sloped 3:1.
T	27	X	Topsoil: 18-24 inches THS; Under topsoil: JSS and some shales exposed prior to covering	1.45:1	Approx. 12 acres moved back about 200 feet from Rio Moquino. On 5 acres, slopes between 2:1 and 2.4:1. Some areas with one terrace; 5-foot-high erosion-control berm placed between toe of dump and Rio Moquino; 10 acres would remain at present slope configuration of 1.5:1.	Dump moved back 200 feet from the Rio Moquino and sloped 3:1.
T	5		Outer surface: JSS	1.45:1		
U	61		Outer surface: JSS and some shales on slopes	1.45:1	Dump moved back approx. 200 feet from Rio Moquino and sloped 2:1. Some parts of dump completely removed; south part with one terrace; 5-foot-high erosion-control berm placed between toe of dump and Rio Moquino.	Same as Anaconda's Proposal except dump sloped 3:1.
V	51		Outer surface: JSS, shales and some THS on slopes	1.40:1	One terrace with 2:1 intermediate slopes; overall slope 2.2:1.	Slope 3:1
W	7		Outer surface: THS and shales	1.46:1	No change due to rock cover on slopes.	Slope 3:1
X	9	X	Topsoil: 18-24 inches THS; Under topsoil: JSS and some shales	No exterior slopes	No change.	Same as Anaconda's Proposal

TABLE 1-4 (Concluded)

Existing Conditions					Proposed Modifications and Treatments	
Dump(s)	Acres	Reclaimed to Date[a/]	Dump Composition	Present Slope (horizontal:vertical) -Mode Value-	Anaconda's Proposal[b/]	DOI Proposal (Monitor and Drainage Options) Laguna Proposal[c/]
Y	30		Outer surface: JSS with some shales and THS	1.44:1	One terrace with 2:1 intermediate slopes; overall slope 2.3:1.	Slope 3:1
Y2	15	X	Topsoil: 18-24 inches of THS on top and none on slopes; Under topsoil: JSS and some shales exposed prior to covering	1.50:1	Two terraces with 2:1 intermediate slopes; overall slope 2.4:1.	Slope 2.5:1

Source: Dump composition data from Anaconda Minerals Company 1982c and 1984a; present slope data from BLM 1984.

Notes: a/ "Reclaimed to date" does not necessarily mean reclamation is complete. Previously reclaimed dumps proposed for additional treatment are indicated.

b/ Anaconda's Proposal includes:
- 5-foot-high erosion control berms placed on all dump crests and terraces.
- Dump tops contoured to channel runoff to open-chute rock-lined drainage structures (dumps A, FD-1, FD-2, FD-3, I, N, O, P1, S, South Dump, T, U, V, Y and Y2).
- Boulder-sized material placed on slopes as necessary to help stabilize them.

c/ DOI Proposal (Monitor and Drainage Options) and Laguna Proposal includes:
- 5-foot-high erosion control berms placed on all dump crests.
- All dump slopes would be contour furrowed.
- All dump tops sloped slightly away from their outer slopes.
- No drainage structures.
- All dump slopes contoured so that their toes are convex (to protect slopes from erosion).
- Boulder-sized material placed on slopes as necessary to help stabilize them.

TABLE 1-5

SUMMARY OF IMPACTS

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Both Options)	Laguna Proposal
Blasting During Reclamation	No blasting required.	Approximately 0.5 million cubic yards to be blasted. No blasting specifications proposed.	For the DOI Monitor Option, approximately 0.5 million cubic yards to be blasted. For the DOI Drainage Option, approximately 0.6 million cubic yards to be blasted. For both options, DOI has proposed specifications to control the effects of blasting.	Same as DOI's Monitor Option.
Mineral Resources	Resources in the P15/17, NJ-45 and P-13 underground areas would remain accessible over the short-term. However, over time the workings would deteriorate making them unsafe and inaccessible. Gavilan Mesa would eventually collapse and bury the protore buttress at its base. Over a period of decades, normal erosion would cause a significant loss of all protore located outside the pits.	All mine entries would be sealed, making the underground resources inaccessible. Gavilan Mesa would eventually collapse and bury the protore buttress at its base. All other protore would be placed in the open pits and would not be lost to erosion.	Impacts would be the same as Anaconda's proposal except that recontouring Gavilan Mesa would increase its stability and lessen the chance of it collapsing on the protore buttress.	Impacts would be the same as DOI's Proposal except that all protore would be placed in the pits above the groundwater recovery levels to facilitate future recovery.
Highwall Stability	North and South Paguate pit highwalls would be stable. However, sporadic rockfalls would occur. Gavilan Mesa is marginally stable and would eventually fail.	North and South Paguate pit highwalls would be stable. All highwalls would be scaled to reduce rockfalls. Proposed stabilization methods for Gavilan Mesa would be only partially successful and the highwall would eventually fail.	North and South Paguate pit highwalls would be stable. All highwalls would be scaled to reduce rockfalls. The top 10 feet of soil on the North and South Paguate highwall crests would be cut to a 3:1 slope to prevent piping. Fencing of the South Paguate highwall would limit access to the crest. Gavilan Mesa would be recontoured to increase its stability.	North Paguate highwall would be buttressed to its crest, eliminating any hazards. South Paguate pit would be backfilled to its original contour eliminating any hazards. Gavilan Mesa would be recontoured as in the DOI alternative.

TABLE 1-5 (Cont'd)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Both Options)	Laguna Proposal
Waste Dump Stability	All 32 waste dumps would eventually undergo mass failure, resulting in blocked drainages, alteration of stream courses, increased stream sediment loads and decreased surface water quality.	Based on calculated safety factors, 13 waste dumps would be unstable over the long-term and 12 waste dumps would be marginally to probably stable over the long-term. The remaining dumps would be stable. Mass failure of the dumps that are less than fully stable would result in the same environmental consequences as the No Action Alternative.	FD-2, I and Y2 dumps would be probably stable. All other waste dumps would be stable.	Same as DOI's Proposal.
Subsidence	Ground above the P-10 decline could experience sudden and significant subsidence.	The P-10 decline would be backfilled and sealed, eliminating the subsidence hazard.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Underground Openings	Unsealed underground openings would present physical and radiological hazards.	All openings would be sealed and all associated hazards eliminated.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Post-Reclamation Radiological Impacts	For the period 1982 through 2072, mathematical models predict from 95 (absolute risk model) to 243 (relative risk model) radiation - induced cancer deaths for the population within a 50-mile radius of the minesite. Approximately 135,000 natural cancer deaths are predicted for the same time period.	After reclamation, lung cancer deaths would be 10 percent of the No Action Alternative. All other cancer deaths would be reduced to less than 0.1 percent of the No Action Alternative.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Surface Water Quantity	Perpetual evaporative loss of 200 acre-feet per year from pit bottoms.	The evaporative loss would be the same as the No Action Alternative. One time loss of 3,000 to 4,000 acre-feet of water would saturate the pit backfill.	Evaporative loss is unlikely; one time loss of 3,000 to 4,000 acre-feet of water would saturate the pit backfill.	Same as DOI's Proposal.

TABLE 1-5 (Cont'd)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Both Options)	Laguna Proposal
Surface Water Quality	Water quality in the Rio Paguate would decrease over time due to erosion of protore piles and waste dumps. Water ponded in the open pits would have elevated levels of virtually all constituents.	All protore would be buried in the pits eliminating impacts to surface water quality. Up to 200 acres of intermittent ponds in the pit bottoms would be saline and unproductive for livestock use.	All protore would be buried as in Anaconda's Proposal. For the Monitor Option, any ponded water or saline soils would be eliminated by remedial action. For the Drainage Option, ponds or saline soils would not exist at all. In contrast with Anaconda's Proposal, the pit bottoms would be assured of productive use for livestock.	Same as DOI's Proposal except ponded water would only exist for a short time after heavy storms.
Ground Water Quality	Ground water would double in conductivity as it flowed through mine materials.	There would be a temporary increase in TDS and heavy metals. Eventually, ground water in the pits would revert to a reducing condition and limit the leaching of backfill material.	For both options, the leaching effects would be the same as Anaconda's Proposal. However, for the Monitor Option, ground water quality would be better than under Anaconda's Proposal due to reduced evapotranspiration from the pit bottoms. The Drainage Option would further reduce the likelihood of evapotranspiration from waterlogged soils.	Same as DOI's Monitor Option.
Recharge and Flow in the Pits	Approximately 50 acres of ponds would exist in the pit areas. Ponds would have elevated levels of salts, radionuclides and minor elements which could have deleterious health effects if ingested by wildlife, livestock or humans.	Ground water would locally converge in the pit bottoms where water would be evaporated and salts retained in the soil. (Backfill levels higher than Anaconda's proposed minimum would reduce the impacts of this recharge and flow pattern).	Recharge and flow would be similar to the natural pattern. The DOI Monitor Option would add backfill as needed to control ponding and saline soil. Under the Drainage Option, waters would not pond in pits and surface runoff would be directed to the Rio Paguate.	Same as DOI's Monitor Option.

TABLE 1-5 (Cont'd)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Both Options)	Laguna Proposal
Arroyo Headcutting	Headcuts south of I, Y and Y2 dumps would continue to erode, migrate upstream and eventually cut into the dumps. This would increase the sediment load and TDS concentration in the Rio Paguate. The headcut west of FD-3 dump would move upstream by piping-induced erosion and breach the road and dam.	Armoring of the headcuts south of I, Y and Y2 dumps would initially slow erosion, but eventually the armoring would become ineffective due to siltation and bypassing. Erosion would continue with the same impacts as the No Action Alternative.	An improved, no-maintenance armoring system would be used to assure the long-term stability of all headcuts.	Same as DOI's Proposal.
Sedimentation in Paguate Reservoir	Sedimentation would continue at a rate of about 22 acre-feet per year.	Reclamation measures would reduce the existing sedimentation rate. However, Paguate Reservoir would continue to be affected by natural sedimentation	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Stream Stabilization	The rivers could migrate laterally and remove significant amounts of protore or waste dump material from meander bends (bank caving). The Rio Moquino road crossing could be breached during high flows.	All waste dumps would be moved back 200 feet from the rivers, providing a buffer against lateral migration and bank caving. The road crossing could still be breached as in the No Action Alternative.	The potential for lateral migration and bank caving would be the same as Anaconda's Proposal. A permanent cement base or floodproof bridge across the Rio Moquino would stabilize the road crossing.	Same as DOI's Proposal.
Waste Dump Slope Erosion	High erosion rates of 79.4 tons per acre per year would continue to add waste material to the rivers resulting in decreased surface water quality.	Mean total erosion would be reduced to 26 tons per acre per year. However, steep slopes would still have a high potential for gully erosion.	For both options, mean total erosion would be 13 tons per acre per year. The 3:1 slopes would reduce the potential for gullying. Sediment generated from approximately two square miles would be released by the Drainage Option.	Same as DOI's Monitor Option.

TABLE 1-5 (Cont'd)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Both Options)	Laguna Proposal
Air Quality	TSP levels could exceed Federal or State standards for short periods. Besides creating an aesthetic problem, the particulates could include radioactive elements from the protore piles. This could create a health hazard.	All protore would be buried eliminating any radiological particulate health hazard. TSP levels are expected to be within Federal and State standards.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Soils	Erosion rates would be high and plant densities low. No topsoil borrow area would be needed.	Redistribution of soils and reclamation of the minesite would decrease erosion rates and increase vegetative cover. A 44-acre topsoil borrow area may be needed. Up to 200 acres of pit bottoms abandoned from productive use.	Same as Anaconda's Proposal except pit bottoms would not be abandoned.	Same as Anaconda's Proposal except pit bottoms would not be abandoned.
Flora	Meager and scattered vegetative re-establishment would continue by secondary succession on habitable sites. Many disturbed areas would remain permanently barren and unprotected from erosion.	Revegetated sites with only 70 percent of the basal cover and production of adjacent native reference areas would be less productive than natural sites, less capable of supporting populations of native and domestic herbivores, and more open to surface soil loss from erosional processes.	Gentler (3:1) slopes with contour furrows would significantly enhance the opportunities for plant community establishment. Vegetative parameters of density, basal and foliar cover, diversity and production on reclaimed sites would be at least 90 percent of that found on reference areas. Reclaimed plant communities would therefore be more comparable with natural communities in terms of vegetative diversity and production, soil retention and carrying capacity for native and domestic herbivores.	Same as DOI's Proposal.
Fauna	Wildlife habitat would be poor and wildlife populations would be low.	Habitat improvements would lead to an increase in wildlife populations.	A greater improvement in habitat would result from the improved revegetation. A corresponding increase in wildlife populations would result.	Same as DOI's Proposal.

TABLE 1-5 (Concluded)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Both Options)	Laguna Proposal
Cultural Resources	No Impact. Anaconda would continue to control access.	Access to cultural sites would be easier and less controlled. This would benefit those using sites for religious purposes, but also make it easier to vandalize the sites.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Visual Resources	Visual resource quality would remain poor.	Visual resource quality would be enhanced by reclamation.	Higher revegetation success criteria would enhance visual resource quality compared to Anaconda's Proposal.	Backfilling South Paguate pit to its original contour would enhance visual resource quality compared to DOI's Proposal.
Socioeconomic Conditions	Unemployment levels at the Pueblo of Laguna would remain high and associated social problems would persist.	Reclamation would provide temporary employment and income. However, as reclamation progresses and the work force is reduced, unemployment would resume and associated social problems would reappear.	Same as Anaconda's Proposal.	Same as Anaconda's Proposal.
Irreversible and Irretrievable Commitment of Resources	A perpetual evaporative loss of 200 acre-feet per year of surface water.	The evaporative loss would be the same as the No Action Alternative. A one-time loss of 3,000 to 4,000 acre-feet of water would resaturate pit backfill. Energy usage would be 292,000 kilowatt hours and 5.4 million gallons of fuel, respectively. Reclamation would require 201 man years of labor.	One-time loss of 3,000 to 4,000 acre-feet of water would resaturate pit backfill. Energy usage for the Monitor Option would be 290,000 kilowatt hours and 5.3 million gallons of fuel; for the Drainage Option 290,000 kilowatt hours and 5.5 million gallons of fuel. Reclamation would require 198 (Monitor Option) and 203 (Drainage Option) man years of labor.	Same as the DOI Drainage Option except reclamation would require 204 man years of labor.
Total Non-Radiological (equipment use) Accidents During Reclamation	0	30.2	29.8 (Monitor Option) 30.5 (Drainage Option)	30.7
Reclamation Cost Estimates	0	$54.2 million	$55.6 million (Both Options)	$57.4 million

RECLAMATION SCHEDULE

The reclamation schedule used for all alternatives is the schedule proposed by Anaconda Minerals Company (Figure 1-1). Based on this schedule, backfilling of the open pits would take about 34 months, placement of overburden about 27 months, placement of topsoil about 24 months, and revegetation about 24 months. The monitoring period would range from a minimum of 78 months (Anaconda Proposal) to a maximum of 162 months (Laguna Proposal). For the most part, reclamation operations would be conducted concurrently with each other.

Resloping of the waste dumps, modification of the highwalls, reclamation of the drill holes, P-10 decline, and vent holes, and if required, construction of the pit drainage channels would be done during the first 34 months (concurrent with backfilling of pits and placement of overburden). All other work (i.e., construction of the rock-lined drainages, disposal of buildings, etc.) would be done during the last 10 months. Total work time, excluding monitoring, is estimated to be 42 months.

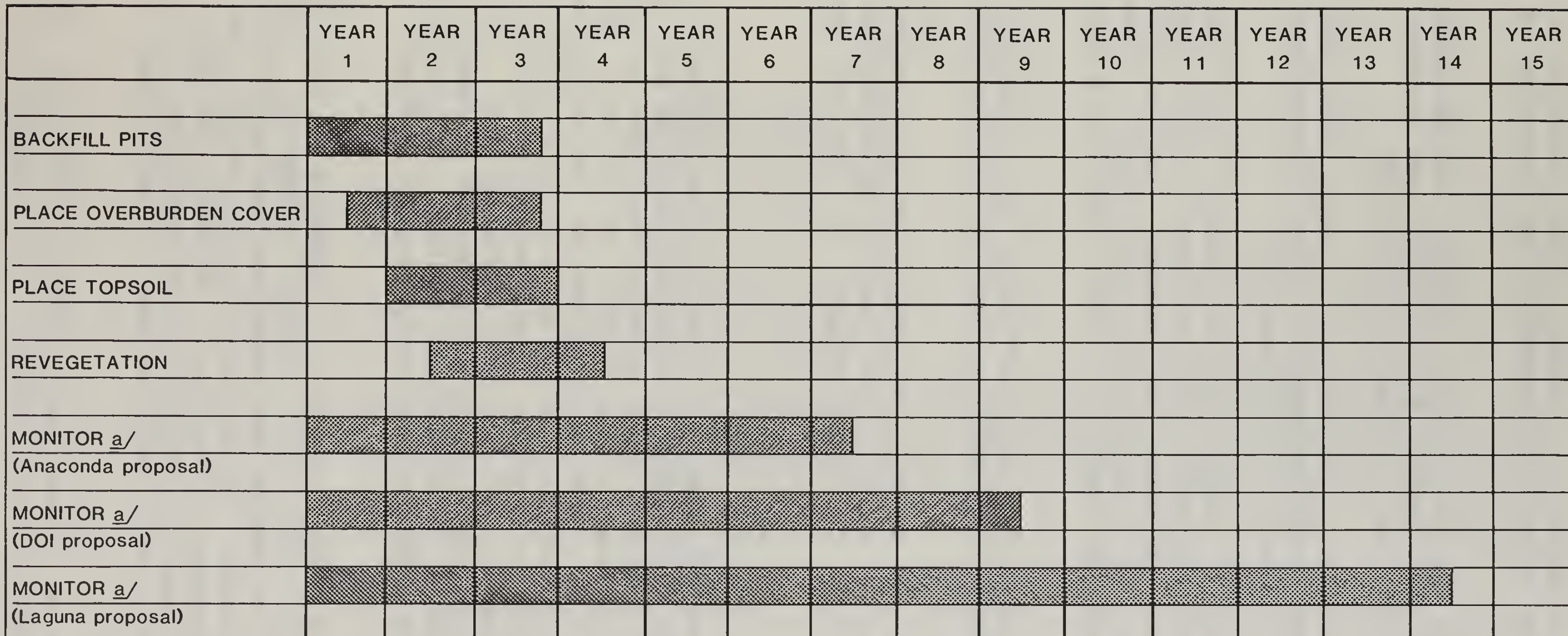
COST ANALYSIS SUMMARY

Before the cost analysis could be done, a detailed study of the quantities of material moved by and changes in topography caused by mining had to be made. The BLM's Denver Service Center conducted this study.

Aerial photographs were taken of the minesite and topographic maps were made. This gave the current (1984) topography. To compare this to the pre-mining topography, topographic maps were made from aerial photographs taken in 1952. The disturbed areas on the 1984 maps and the corresponding areas on the 1952 maps were digitized and placed into a computer program.

As part of the calculation of the backfill for the open pits, the proposed initial backfill elevations were digitized and compared to the 1984 topography. The volumes of the protore stockpiles, topsoil stockpiles and certain waste dumps were determined by comparing the pre-mining elevations from the digitized 1952 maps with the current elevations from the digitized 1984 maps. In cases where the piles were in the pits or where the pre-mining topography had been altered by mining prior to placement of the piles, the piles were assumed to have a flat bottom. The volume of material to be moved by the resloping of waste dumps under each alternative was calculated by constructing topographic maps for each dump showing how the slopes would look after resloping. These maps were then digitized and compared to the 1984 topography.

The next step was to take the volumetric data and determine the amount of reclamation work to be performed under each alternative. To begin with, all necessary initial backfill material was placed into the open pits. This material included all protore stockpiles, waste dumps H & J, shale for a water retention dike in North Paguate pit, the buttress for Gavilan Mesa highwall, and the 4-foot-thick layer of overburden.



Source: Modified from Anaconda Minerals Co. 1982.

NOTE: a/ Indicates the minimum monitoring periods as proposed under each reclamation alternative: Anaconda 3 yrs., DOI 5 yrs., and Laguna 10 yrs. following revegetation. The monitoring period may be extended for all reclamation proposals due to such factors as poor revegetation success, failure of waste dump stabilization measures, etc.

FIGURE 1–1

Jackpile – Paguate Mine Reclamation Schedule

Next, any excess material was placed in the pits. This included excess material that resulted from waste dump resloping and reshaping of Gavilan Mesa highwall.

Highwall stabilization costs took into account scaling, fencing, slope modifications for North and South Paguate pit highwalls, and treatment of Gavilan Mesa, as applicable to each reclamation alternative.

The material generated from the resloping of the waste dumps were placed as close to the source dumps as possible. Where this was not possible, this material was placed into the closest pit.

The amount of material needed to reclaim the P-10 decline, vent holes and any open drill holes was calculated. This consisted of waste dump material (excluding Jackpile Sandstone) and concrete for the P-10 bulkhead and surface plugs. The quantity of material needed for the rock-lined drainage structures and armoring of arroyo headcuts was also calculated.

Revegetation costs were calculated by determining the amount of topsoil, seed, mulch and fertilizer needed, as well as the associated equipment costs.

In summary, the major costs for the three reclamation proposals result from the material to be moved, ranging from about 50 to 60 million cubic yards. Table 1-6 shows the cost estimates for each of the reclamation alternatives.

MITIGATING MEASURES

Mitigating measures have been incorporated into each of the reclamation proposals addressed in this EIS. However, additional measures may be identified through the EIS process. These measures would then become stipulations to the final reclamation plan approved by the DOI. Any approved reclamation plan will require stipulations and monitoring to ensure compliance with reclamation measures and to minimize environmental impacts during reclamation. DOI personnel will be responsible for assuring that all reclamation criteria are met. This includes everything from verifying that the proper amount of backfill has been placed in the pits to collecting and reviewing radiological data. Details of the proposed DOI monitoring plan will be included in the final EIS.

It is important to note that monitoring would not eliminate all adverse environmental impacts which could occur during reclamation. For example, it is not possible to predict when total suspended particulate (TSP) levels would exceed limits. Monitoring would only indicate that limits had been exceeded sometime in the past. Therefore, mitigative measures for TSP would be based on observation not monitoring (e.g., during periods of high winds, water would be used to control dust as necessary).

Except for the monitoring of ground water recovery levels and the monitoring of site discharge water quality, all monitoring and

TABLE 1-6

RECLAMATION COST ESTIMATES
(all figures rounded)

Item	No Action Alternative	Anaconda Proposal	DOI Proposal (Monitor Option)	DOI Proposal (Drainage Option)	Laguna Proposal
Backfill of Pits	0	$15,200,000	$16,200,000[a/]	$16,300,000[b/]	$44,000,000[c/]
Pit Highwall Stabilization	0	$ 3,100,000	$ 3,300,000	$ 3,300,000	$ 3,300,000
Waste Dump Resloping	0	$30,300,000[d/]	$30,300,000[d/]	$30,300,000[d/]	$ 4,300,000
Erosion Control	0	$ 133,000	$ 363,000	$ 363,000	$ 363,000
Backfilling Drill Holes[e/]	0	$ 5,000	$ 9,000	$ 9,000	$ 9,000
Sealing Decline	0	$ 12,000	$ 12,000	$ 12,000	$ 12,000
Backfilling Vent Holes	0	$ 22,000	$ 27,000	$ 27,000	$ 27,000
Revegetation	0	$ 5,380,000	$ 5,380,000	$ 5,380,000	$ 5,380,000
TOTALS[f/]	0	$54,152,000	$55,591,000	$55,691,000	$57,391,000

Source: BLM 1985.

Notes: [a/] Includes costs of ground water monitoring.
[b/] Includes costs of drainage channels.
[c/] Includes costs of backfilling South Paguate pit to its original contour, and for backfilling Jackpile and North Paguate pits 7 feet above the DOI's Proposal.
[d/] The majority of excess material from resloping will be placed into the pits.
[e/] For an estimated 2,300 drill holes to reclaim.
[f/] Excludes costs for disposition of surface facilities (including railroad spur), monitoring, security and remedial action. The costs for these items could result in an increase of 5 to 10 percent above the total reclamation costs for each alternative.

compliance measures would be short-term. Although all reclamation and environmental components would meet the required goals and criteria immediately following reclamation, it is not possible to guarantee they would do so indefinitely. For example, over centuries waste dumps would erode, highwalls would topple and stream channels would migrate. One of the goals of any approved reclamation plan would be to minimize the need for institutional control. However, it is obvious that some form of long-term monitoring or custodial control and remedial action will be necessary to ensure that reclamation is not undone by natural forces. Repair of waste dump slopes, sealing of highwalls, adding extra backfill, etc., would be done as necessary with estimated costs not to exceed 10 percent of the total costs for each reclamation alternative.

For the present, DOI and the Pueblo of Laguna will be responsible for assuring that land use restrictions are followed, and for doing on-site surveillance and remedial action. Uranium mine wastes are not presently listed as hazardous wastes and are not controlled by any Federal or State agency. If uranium mine wastes do come under regulatory control in the future, custodial and remedial action responsibilities could transfer to another agency.

Chapter 2
affected environment

INTRODUCTION

This chapter describes the existing physical, biological and socioeconomic conditions in and adjacent to the Jackpile-Paguate uranium mine. The information in this chapter provides the basis for the assessment of impacts made in Chapter 3.

Map 1-2 in Chapter 1 shows the principal features of interest in and around the minesite. These features are also listed in Table 2-1. Table 2-2 defines terms that are used throughout this document. These definitions apply specifically to this EIS and should not be confused with other definitions for these terms.

MINING OPERATIONS

Operations at the Jackpile-Paguate uranium mine were conducted from three open pits and nine underground mines. Open-pit mining was conducted predominantly with large front-end loaders and haul trucks. The overburden, consisting of topsoil, alluvium, shale and sandstone was blasted or ripped, removed from the open pits, and placed in waste dumps. The uranium ore was segregated according to grade and stockpiled for shipment to the mill. In the later years of mining, material conducive to plant growth was stockpiled for future reclamation. Ore-associated waste and some overburden was also placed in the mined-out areas of the pits as backfill.

Underground mining was conducted by driving adits, or declines, to the ore zones. Drifts were driven through the ore zone, and the ore removed by modified room-and-pillar methods. Ventilation holes were drilled to maintain a fresh air supply. Mine water was collected in sumps and pumped to ponds in the open pits. Waste rock was placed in waste dumps, and the ore was stockpiled for shipment to the mill.

Surface Disturbance

During the 29 years of mining activity, approximately 2,656 acres of natural ground were disturbed by mine operations, as indicated in Table 2-3 and on Visual A.

Open Pits

The Jackpile, North Paguate and South Paguate open pits make up about 40 percent of the total disturbed acreage at the minesite (Figure 2-1). Approximately 101 million tons (63.6 million cubic yards) of backfill, composed principally of ore-associated waste with some overburden, have been returned to the pits. Due to irregular topography, the pits vary in maximum depth as follows: Jackpile 625-feet deep; North Paguate-200 feet deep; and South Paguate-325 feet deep.

The most prominent features within the excavated pits are the pit walls (also called highwalls), which are composed principally of shale with some intermixed sandstone beds. The overall slope angle of the pit walls ranges between 49 and 55 degrees (Figure 2-2).

TABLE 2-1

PRINCIPAL FEATURES OF INTEREST IN AREA OF JACKPILE-PAGUATE URANIUM MINE

Feature	Description
Anaconda Mining Leases	Three leases totaling approximately 7,868 acres.
NM Highway 279	Realignment is being proposed to eliminate a hazardous section of this State highway that presently passes around the mine. This realignment is not part of the overall reclamation project.
Paguate Reservoir[a/]	Constructed south of the mine area in 1940, now almost completely silted in.
Rail Spur	Constructed by Anaconda on a right-of-way across Pueblo of Laguna land.
Rio Paguate and Rio Moquino	Small perennial rivers that join within the minesite for an average combined discharge of 1.2 cubic feet per second.
Village of Laguna	Laguna Indian village with 1,565 residents located 7 miles from the mine.
Village of Paguate	Laguna Indian village with 1,435 residents located approximately 1,000 feet from the mine.

Note: [a/] Paguate Reservoir is sometimes referred to as Quirk or Mesita Reservoir.

TABLE 2-2

TERMS USED IN THIS EIS

General Term	Definition	Components
Jackpile Sandstone	The ore-bearing unit at the Jackpile-Paguate uranium mine	Barren waste [less than .002 percent uranium (U_3O_8)] Ore-associated waste (.002 to .019 percent U_3O_8) Protore (.02 to .059 percent U_3O_8--refer to Glossary)[a] Ore (greater than .06 precent U_3O_8)
Overburden	Any material that overlies the ore-bearing unit	Topsoil, Alluvium, Mancos Shale, Tres Hermanos Sandstone, Dakota Sandstone
Soil	Material used as plant-growth medium during revegetation	Topsoil, Alluvium, Pulverized Tres Hermanos Sandstone

Note: [a] This percentage range applies to this EIS only--refer to the Mineral Resources section of this chapter for an explanation.

TABLE 2-3

JACKPILE-PAGUATE URANIUM MINE DISTURBED AREA

Feature	Acres
Open Pits	
Jackpile	475
North Paguate	140
South Paguate	400
	1,015
Waste Dumps	
Jackpile area	718
North Paguate area	192
South Paguate area	356
	1,266
Protore Stockpiles	
Total mine area, excluding open pits	103
Topsoil Stockpiles	
TS-1	21
TS-2(A and B)	11
TS-3[a]	(19)
	32
Other Disturbed Areas	
Depleted ore stockpiles[b]	50
General area disturbance (includes buildings, parking lots)	66
Roads	88
Rail spur and miscellaneous areas	36
	240
TOTAL ACRES DISTURBED	2,656

Source: Anaconda Minerals Company 1982.

Notes: [a] Topsoil stockpile TS-3 is located on South Dump and therefore does not constitute additional acreage of disturbed natural ground.

[b] Refers to former stockpile areas in which the ore was either relocated to the open pits or shipped to the mill.

FIGURE 2-1 VIEW SOUTH THROUGH JACKPILE PIT

FIGURE 2-2 SOUTH PAGUATE PIT HIGHWALL

Water has collected in the lowest portions of the pits as a result of surface runoff, ground water recovery and water discharged from the underground operations (Figure 2-3). As of April 1984, water levels in the pits ranged between elevations of 5830' and 5959'.

FIGURE 2-3 PONDING IN NORTH PAGUATE PIT

Waste Dumps

The minesite contains 32 waste dumps that make up about 48 percent of the disturbed area (Figure 2-4). The dumps are composed of Tres Hermanos Sandstone, Mancos Shale, Dakota Sandstone, and both barren and ore-associated Jackpile Sandstone. Characteristics of the dumps are presented in Table 1-4 (Chapter 1).

Protore Stockpiles

Located outside and inside of the pits are 23 protore stockpiles (Figure 2-5 and Table 2-4). The protore that lies outside the pits covers approximately 100 acres and contains approximately 9.7 million cubic yards of material. Those stockpiles that lie inside the pits contain about 3.1 million cubic yards of material but do not constitute additional acreage of disturbed ground. The stockpiles are generally segregated according to grade, but some grade variation exists within each stockpile.

FIGURE 2-4 WASTE DUMPS ON NORTH SIDE OF MINE

FIGURE 2-5 PROTORE STOCKPILE SP-1

TABLE 2-4

PROTORE STOCKPILES AT THE JACKPILE-PAGUATE URANIUM MINE

Area	Stockpile Designation	Volume (cubic yards)
Jackpile Pit	J-1	618,500
	J-1A[a]	
	J-1-A	1,673,500
	JLG	
	SP-1	
	J-2	137,300
	SP-6-A	462,100
	SP-6-B	742,800
	SP-17BC	18,100
	17-E[a]	660,000
North Paguate Pit	1-B	1,866,100
	1-E[a]	154,500
	2-E	423,400
	10-Dike	100,500
	SP-1	620,400
	SP-1-C	483,300
	SP-2-C	2,044,600
	SP-2-D	395,900
South Paguate Pit	1-D[a]	
	PLG	648,700
	PLG-1	
	4-1	168,700
	SP-1-A	1,664,000
TOTALS	23 stockpiles	12,882,400

Source: Stockpile designations and locations Anaconda Minerals Company 1982; volumetric calculations BLM 1984.

Note: [a]Stockpiles located within pits themselves.

Topsoil Stockpiles

During the later years of mining, all Tres Hermanos Sandstone and alluvium encountered during surface mining was stockpiled for future reclamation operations. These stockpiles contain approximately 3.1 million cubic yards of material (BLM 1984).

Surface Facilities

The minesite contains various buildings, structures and surface facilities which cover approximately 66 acres (Figure 2-6). Most of the major buildings are constructed on cement slabs with steel frames and sheet metal siding. Many have heating, sewage, electric and drinking water systems. The condition of the buildings varies considerably, but many are in good condition. A list of these facilities located on leases No. 1 (Jackpile) and No. 4 is shown in Table 2-5.

FIGURE 2-6 P-10 MINE BUILDINGS

The minesite also contains a rail spur that connects the site to the main east-west line of the Santa Fe Railroad, 5 miles south. The spur was used to transport ore from the mine to Anaconda's Bluewater Mill near Grants, New Mexico.

TABLE 2-5

STRUCTURES AND FACILITIES LOCATED ON LEASES NOS. 1 AND 4

Lease/Feature	Coverage
Lease No. 1 (Jackpile)	
Buildings-Structures	
1. Geology building	4,000 sq. ft.
2. School building	1,500 sq. ft.
3. Miners' training center	2,730 sq. ft.
4. Guardhouse (2)	144 sq. ft. each
5. Explosives magazines (3)	100 sq. ft; 1,200 sq. ft.; 180 sq. ft.
6. Maintenance and repair shop	7,000 sq. ft.
7. Repair and electrician's shop	1,260 sq. ft.
8. Welding shop	1,600 sq. ft.
9. Warehouse	3,600 sq. ft.
10. Change house	480 sq. ft.
11. Restroom	320 sq. ft.
12. Safety room and change room	1,116 sq. ft.
13. Mine engineering and housing repair shop	5,000 sq. ft.
14. Fuel service area (mine office) a. 2 ea. gasoline pumps b. Gasoline storage tanks	
15. Fuel service area (Hamilton) a. 2 ea. fuel pumps b. 2 ea. underground fuel storage tanks	
16. Surface mining main office	1,116 sq. ft
17. Truck parking lot (includes 20 service stands and 2 small buildings)	
18. Boundary fencing	approx. 14,850 linear ft.
19. Road culverts over Rios Moquino and Paguate (6 ea.)	
20. Concrete crossing (ford) over Rio Paguate near main gate	
Housing	
1. 7 houses	approx. 1,650 sq. ft. each
11 houses	approx. 1,250 sq. ft. each
2. Recreational facilities (includes tennis/basketball courts, misc. playground equipment)	
Utilities	
1. 5 wells, cased with pumps	
a. Jackpile No. 1 - Peerless vertical turbine pumps, electrical service (not activated), building	
b. Jackpile No. 2 - Reda submersible pump, electrical service (not activated), building	
c. Jackpile No. 3 - submersible pump, electrical service (not activated), building	
d. Jackpile No. 4 - submersible pump, electrical service (not activated), building	
e. Jackpile No. 5 - Jensen straight pumpjack, electrical service (not activated), building	
2. Water Distribution Systems and Water Storage Tanks	
a. 600 gallon (1 ea.)	
b. 800 gallon (1 ea.)	
c. 1,000 gallon (1 ea.)	
d. 2,000 gallon (1 ea.)	
3. Housing Sewage Disposal System and Lagoons—2-cell sewage lagoon (fenced)	
4. Powerlines	
a. Poles	
b. Wire line	approx. 16,000 linear ft.
c. Transformers	
5. 3-Phase Substation at Engineering Office	

TABLE 2-5 (concluded)

Lease/Feature	Coverage
Lease No. 1 (Jackpile) (cont'd)	
Rail Spur	
Railroad spur from rail line (AT & SF) to mine-Materials: 90# rail, ties, hardware, ballast, turnouts and switches, bridge structure and culverts	approx. 5.4 miles long
Lease No. 4	
Buildings-Structures	
1. P-10 underground mine office	4,000 sq. ft.
2. P-10 change house	2,800 sq. ft.
3. P-10 equipment repair shop	1,850 sq. ft.
4. P-10 electric shop	1,900 sq. ft.
5. P-10 storage shed	150 sq. ft.
6. P-10 fenced storage yard	approx. 1.5 acres
7. Carpenter shop	2,520 sq. ft.
8. Paint shop	225 sq. ft.
9. Electric shop	2,520 sq. ft.
10. Welding shop	3,000 sq. ft.
11. Warehouse	10,800 sq. ft.
12. Rebuild shop	1,350 sq. ft.
13. Maintenance and repair shop	12,240 sq. ft.
14. Small storage shed	150 sq. ft.
15. Wash rack and associated buildings	306 sq. ft.
16. Garage	864 sq. ft.
17. Change house	936 sq. ft.
18. Conference hall and office	1,200 sq. ft.
19. Fuel service area, including:	
a. 2 gasoline pumps	
b. 1 diesel pump	
c. 3 fuel storage tanks	
20. Chain-link fenced shop storage yards (2)	approx. 1 to 1.5 acres ea.
21. Chain-link fenced warehouse storage yard (asphalt base)	approx. 1/4 acre
22. Guardhouse (2)	144 sq. ft each
23. Explosives magazine (2 ea.)	600 sq. ft.
24. Stock water tank (south of new shop well)	
Utilities	
1. 2 wells, cased with pumps	
a. P-10 well, submersible pump, electrical service, cover structure	
b. New shop well, submersible pump, electrical service, cover structure	
2. Water distribution systems and water storage tanks	
a. P-10 tank, approximately 1,000 gallon with support structure	
b. New shop tank, approximately 1,200 gallon with support structure	
3. Sewage disposal system and lagoons.	
a. P-10 with 3-cell lagoon (fenced)	
b. New shop system with 3-cell lagoon (fenced)	
4. Powerlines	
a. Poles	
b. Wire line	approx. 7,600 linear ft.
c. Transformers	

Source: Anaconda Minerals Co. 1984.

Note: All building areas are approximate.

Underground Disturbance

Mining was conducted in nine underground mines (Visual A). Five of these mines were permanently plugged and abandoned as part of normal mining operations. The remaining four were operating when overall mining operations were suspended, and each has been temporarily closed for safety (Figure 2-7). Table 2-6 briefly describes each mine.

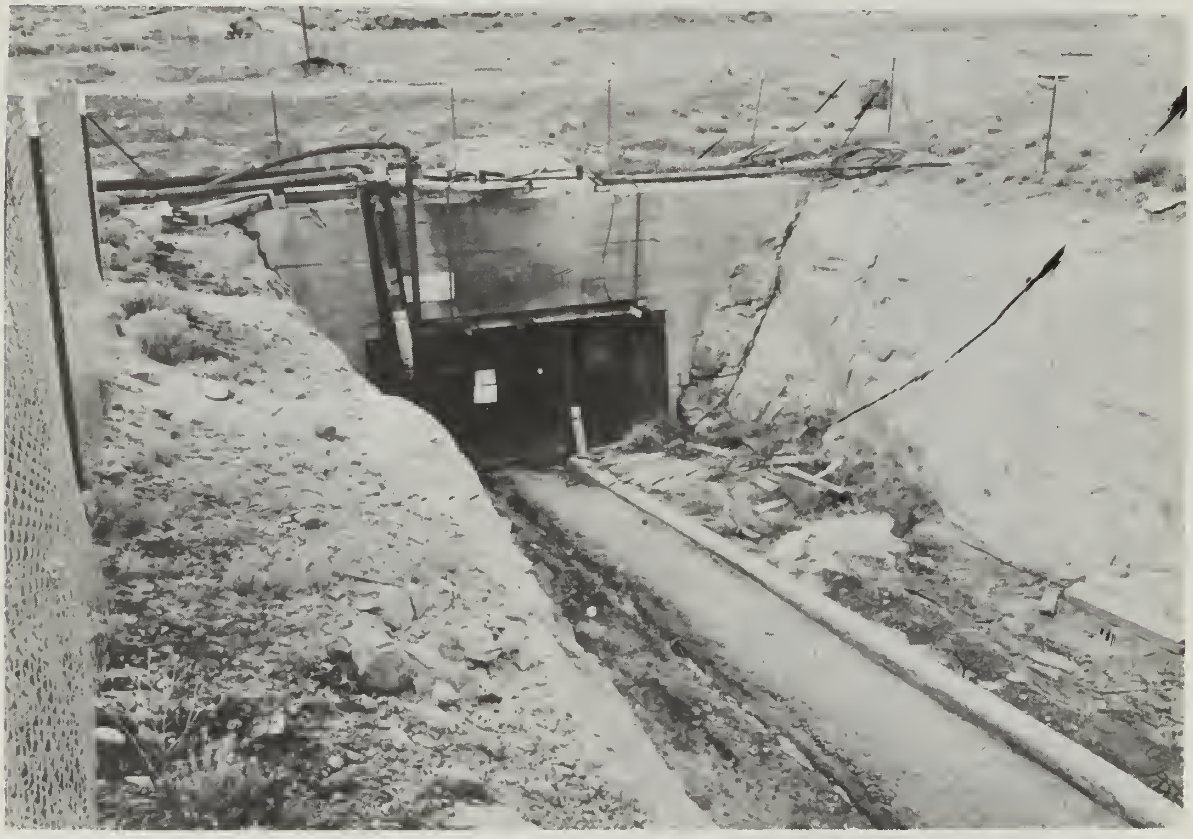


FIGURE 2-7 P-10 DECLINE -TEMPORARILY ABANDONED

Only the P-10 mine produced a substantial amount of water, and the water level has risen to render its workings inaccessible. The deposits at each of the mines, with the exception of NJ-45 and P-13, were mined as completely as the economics of the times would allow.

Previous Reclamation

Anaconda Minerals Co. began a limited reclamation program in 1976. The program consisted of returning most of the overburden removed during the stripping process to mined-out areas of the pits, clearing of stream channels, slope stabilization tests and revegetation of dumps. Each of these processes is described as follows.

TABLE 2-6

STATUS OF UNDERGROUND MINING OPERATIONS

Mine	Description	Status
Alpine	Small operation - access via 2 adits	Adits permanently plugged with waste
H-1	Small operation - access via 2 adits -3 vent holes - used as an undergroundminer's training school	Adits and vent holes permanently plugged with waste
NJ-45	Small operation begun in 1981 - access via 3 adits from Jackpile pit - 2 vent holes - approximately 1/3 of ore removed	Adits and vent holes temporarily covered - mine workings relatively stable and assumed to be inaccessible
P-7	Large operation - access via P-10 underground drifts - 6 vent holes - vertical emergency escapeway into South Paguate pit	Vent holes temporarily covered - mine workings filled with water and inaccessible
P-9-2	Large operation - access via 5 adits - 8 vent holes	Adits, majority of workings, and all but 1 vent hole mined through by advances of South Paguate pit - 1 vent hole open but covered
P-10	Large operation - access via 2,000-foot decline - 11 vent holes	Decline and vent holes temporarily covered - mine workings filled with water and inaccessible
P-13	Small operation begun in 1981 - access via 2 adits from South Paguate pit - ore body not fully opened - very small percentage of ore removed	Adits and mine workings flooded with water and inaccessible
P 15/17	Large operation approved for development but never begun	No operations conducted
PW 2/3	Small operation - access via 2 adits from North Paguate pit - 2 vent adits into pit	All adits permanently covered with backfill (highwall buttress)
Woodrow	Small operation - vertical shaft with 2 working areas to mine vertical breccia pipe deposit - mining completed in 1956	Shaft backfilled from bottom to top

Source: Anaconda Minerals Company 1982.

Backfilling

During the later years of mining, some overburden was placed into the mined-out portions of the pits. The southern portion of the Jackpile pit and the South Paguate pit received most of this material. Backfilling was also performed for two possible routes for the realignment of State Highway 279. There were no requirements to keep records on the radiological content of this material.

Stream Channel Modification

In an effort to begin clearing waste from the Rio Moquino's floodplain, approximately 500,000 tons of material from waste dump U on the east side of the river were removed during the last year of mining operations.

Slope Stabilization Tests

Limited tests were performed on the slope of waste dump I to evaluate the ability of biodegradable matting to inhibit erosion. Special reseeding techniques were performed on the slope of waste dump J. The matting and special reseeding techniques were unsuccessful.

Waste Dump Revegetation

The tops of 17 waste dumps were reclaimed between 1976 and 1979. The dumps were contoured to a slight slope, water spreading berms were constructed, large boulders were pushed into piles, 18 to 24 inches of soil were spread, and the dumps were seeded. This work was performed on 18 percent of the disturbed area with varying degrees of success. Further details are provided in the Flora section of this chapter.

Monitoring

Anaconda has performed a comprehensive environmental monitoring program since 1977. The program is summarized in Table 2-7.

GEOLOGY

Physiography

The Jackpile-Paguate minesite is located in mesa and canyon country typical of much of the southeastern Colorado Plateau physiographic province. It is situated in a broad valley of northwest-dipping, sandstone-capped benches pierced by numerous basaltic volcanic necks that rise up to 1,000 feet above the surrounding terrain. Principal landscape components in the area are:

1. Sparsely vegetated, sandstone-capped, flat mesa tops;

2. Steep mesa slopes characterized by approximately 30-degree shale slopes and nearly vertical sandstone slopes, with basal talus from numerous rock falls;

TABLE 2-7

ANACONDA'S ENVIRONMENTAL MONITORING PROGRAM

Item	Monitoring Frequency	Monitoring Parameters	Number of Stations Monitored
Subsidence	Quarterly[a]	Ground movement	89
Surface water	Monthly	29 chemical and radiological parameters[b]	6
Ground water	Monthly	29 chemical and radiological parameters[b]	3[c]
Particulates (radiological)	Monthly	U-natural, Ra-226, Po-210 and Th-230	4
Particulates (non-radiological)	Monthly	Total particulates	4
Gamma	Once after topsoil application	Gamma radiation	100-meter grid on each waste dump
Radon concentration	Monthly	Rn-222	4
Radon exhalation	Twice after topsoil application	Radon release per unit area	100-meter grid on each waste dump
Vegetation	Once	Th-230, Ra-226, Po-210, uranium and radon	Each reclaimed waste dump
Vegetation	Variable	Density, diversity and basal cover	Each revegetated area
Soils	Once	11 chemical and radiological parameters	One composite sample on each reclaimed waste dump
Meteorology	Continuous	Wind speed and direction, temperature and precipitation	1

Notes: [a] On June 9, 1983, subsidence monitoring of P-13 and P-15/17 was discontinued because these mine workings were never developed. At the same time, the monitoring frequency for the P-10 and PW-2/3 mines was reduced to semi-annual.

[b] pH, conductivity, TDS, HCO_3, Cl, SO_4, Na, K, Ca, Mg, NO_3, F, SiO_2, Mn, As, Ba, Cd, Cr, Pb, Hg, Se, Cu, Fe, Zn, Mo, Ni, V, U, Ra-226.

[c] Sampling of the Old Shop Well was discontinued in May 1983. Sampling of the New Shop and #4 wells was discontinued in August 1983. A new ground water monitoring program using nine wells was started in September 1983.

3. Vegetated valley floors cut by numerous arroyos entrenched in fine-grained alluvium; and

4. Densely vegetated, major stream beds.

Prominent landforms of the mine area are: Gavilan Mesa to the east, North and South Oak Canyon Mesas and Oak Canyon to the south, and Black Mesa and numerous deep canyons to the west. Within the lease boundary, elevations range from 5,820 to 6,910 feet.

Stratigraphy

Sedimentary rocks exposed in the area of the minesite range in age from Late Triassic to Late Cretaceous. In addition, Tertiary age diabase dikes and sills and volcanic flow rocks are exposed near the minesite. A generalized stratigraphic column is given in Figure 2-8.

At the minesite, all of the rock units above the lower Mancos Shale have been eroded. The stratigraphy of the mine includes the Morrison Formation, Dakota Sandstone, Mancos Shale, Tertiary igneous dikes and Quaternary alluvium.

The Morrison Formation, locally 600 feet thick, consists of (in ascending order) the Recapture Member, the Westwater Canyon Member and the Brushy Basin Member. The Brushy Basin Member, which is exposed at the minesite, is composed of mudstones up to 350 feet thick with numerous interbedded, thin sandstone lenses of restricted extent. The Jackpile Sandstone, a unit in the upper portion of the Brushy Basin Member and the uranium host rock, is a grayish-white, fine- to medium-grained friable sandstone, and is locally more than 200 feet thick (Kittle 1963).

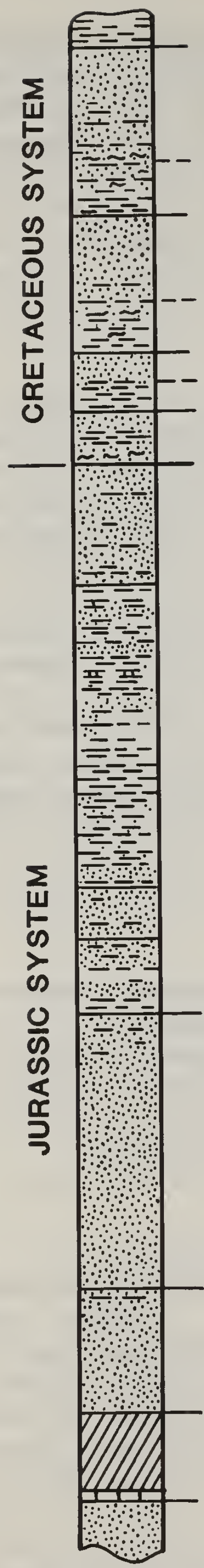
The Dakota Sandstone unconformably overlies the Jackpile Sandstone and consists of black carbonaceous shales and grey siltstones separated by up to four prominent, fine- to medium-grained, well-sorted and cemented sandstones averaging about 45 feet in thickness (Kittle 1963).

The lower part of the Mancos Shale is exposed near the minesite and consists of a massive shale with intervening sandstone beds that together total up to 350 feet in thickness. The sandstone units, called the Tres Hermanos sandstones, are typically fine- to medium-grained, thinly to (mostly) massively bedded horizons from 20 to 60 feet thick. The intervening shales are dark in color.

Quaternary alluvium ranges from 0 to 60 feet thick along the Rios Paguate and Moquino, and is over 100 feet thick along the Rio San Jose (Lyford 1977). The alluvium is composed mostly of silt and fine-to medium-grained sand.

Structure

The geologic structure at the Jackpile-Paguate uranium mine is relatively simple. Sedimentary rocks dip uniformly about 2 degrees to the northwest into the San Juan Basin. One fault (a minor northwest-



FORMATION	UNIT	THICKNESS (feet)
Mancos		
Dakota	Tres Hermanos	60–100
Mancos		40–60
Dakota	Tres Hermanos	60–100
Mancos		40–60
Dakota	Tres Hermanos	
Mancos		40
Dakota		50
Morrison	Jackpile Sandstone	0–220
	Brushy Basin	250–350
	Westwater Canyon	0–50
	Recapture	50–100
Bluff		275
Summerville		120
Todilto		75
Entrada		10

Vertical scale:
1 inch = 500 feet

LEGEND

Sandstone
Shale and Mudstone
Limestone
Anhydrite
Carbonaceous material

FIGURE 2–8
Generalized Stratigraphic Column of the Jackpile Mine Area

trending, normal fault) and two low-amplitude folds are present at the southwestern end of the Jackpile pit (Schlee and Moench 1963). Joints are present in all rocks in the area. Vertical joint sets in the Gavilan Mesa highwall are oriented N. 25 degrees E. and N. 35 degrees W. (Seegmiller 1979a). Vertical joint sets in the North and South Paguate pit areas are oriented N. 25 degrees E. and N. 72 degrees W. (Seegmiller 1979b). Joint spacing ranges from 5 to 15 feet in sandstones and less in shales.

Nature of the Ore Deposit

The Jackpile deposit mined in the Jackpile pit was an elongate, tabular ore body in the Jackpile Sandstone, approximately 1.5 miles long and 0.5 miles wide. Individual ore layers rarely exceeded 15 feet in thickness, but stacked layers totaled up to 50 feet (Moench 1963). The dominant ore minerals were coffinite, uraninite and numerous oxidized uranium minerals (Moench 1963).

The deposit mined in the North and South Paguate pits had a known length of over two miles and an average width of several hundred feet. The northern part of the deposit was in the upper one-third of the Jackpile Sandstone, while in the southern area, the lower two-thirds of the Jackpile Sandstone hosted the deposit. Both the Jackpile and Paguate deposits were formed as uranium minerals precipitated from ground water in the presence of carbonaceous material (Moench and Schlee 1967).

MINERAL RESOURCES

Under Federal regulations, details regarding Indian mineral leases (i.e., production data and royalty information) is confidential. The information contained in this section is presented in general terms to protect its confidentiality. Only the information necessary to provide the reader with an understanding of the importance of this issue is presented.

Remaining Uranium Deposits and Protore Stockpiles

Approximately 23 million tons of uranium resources remain at the minesite as stockpiled protore and unmined deposits. Protore is material that was stockpiled throughout the mining operation because it contains elevated but sub-economic uranium concentrations. (For discussion purposes in this EIS, the term "protore" also refers to the remaining Anaconda "ore" stockpiles. These ore stockpiles have been grouped with the protore stockpiles for discussion because they would be treated in the same manner during reclamation).

Approximately 21 million tons of protore, containing .02 to .059 percent uranium (U_3O_8), exist at the minesite. This material is located on the surface in 23 stockpiles dispersed throughout the mine, as shown in Visual A. The protore was generally segregated according to grade, but some variability in grade exists within each stockpile.

Approximately two million tons of unmined deposits containing .094 to .30 percent U_3O_8 remain at the site. These resources are located in 11 deposits, 3 of which contain 90 percent of the resources. These three deposits are the P15/17, the NJ-45 and the P-13 (Visual A).

The P15/17 deposit is located immediately south of the P-10 mine and was scheduled to be mined by underground methods until depressed uranium market conditions made mining uneconomical. Approximately 60 percent of the minesite's unmined resources are contained in this deposit. The deposit remains undeveloped.

The NJ-45 deposit is located under Gavilan Mesa, adjacent to the Jackpile pit. Anaconda constructed three adits and drove drifts to this deposit in 1981, but mined only a small portion of the resource.

The P-13 deposit is located east of the P-10 mine, adjacent to the South Paguate pit. Anaconda constructed two adits and drove two drifts to this deposit in 1981, but did not mine the resource. Operations at both the NJ-45 and P-13 mines were suspended when Anaconda closed the overall project.

NON-RADIOLOGICAL MINESITE HAZARDS

Non-radiological hazards at the Jackpile-Paguate minesite include: 1) unstable highwalls, 2) unstable waste dumps, 3) possible subsidence, and 4) underground openings. All of these present a potential physical hazard to humans and livestock as well as a long-term environmental hazard.

Slope Stability

Mine highwalls and waste dumps frequently present safety problems that require carefully designed mitigation procedures. These hazards include:

1. Rockfalls - Toppling and falling of loose sandstone blocks that occurs on all highwalls at the minesite.

2. Rotational failures - These landslides occur in loose rock or soil, and break along concave-upward curved surfaces.

3. Translational failures - These occur in hard rocks, and break along pre-existing zones of weakness i.e., faults or joints. (Note: slope failures may exhibit characteristics of several of these above types.)

Conclusions about slope stability are based on the slope safety factor, which is the ratio between the forces available to resist slope failure and the forces tending to cause this failure. This safety factor is calculated from the friction angle, cohesion and specific (unit) weight of the rock or waste material being analyzed. These properties are determined from field measurements and laboratory tests. The safety factor itself can be calculated using several different methods. Anaconda used the Hoek method while the DOI used the Morgenstern - Price method. The concensus is that these two methods give comparable results.

Generally, a safety factor less than 1.0 indicates instability, while a safety factor greater than 1.0 indicates relative stabilty under the conditions assumed. However, because of the many assumptions used in this EIS and because a margin of safety is needed, the following scale for safety factor and stability is used:

Safety Factor $\leq$ 1.0	Unstable
Safety Factor $>$ 1.0 but$<$1.2	Marginally stable
Safety Factor $\geq$ 1.2 but$<$1.5	Probably stable
Safety Factor $\geq$ 1.5	Stable

In calculating the safety factor, the effect of cohesion of earth materials is taken into account, because cohesion inhibits slope failure. Cohesion of materials decreases over time, and may approach zero, but past experience indicates that assuming zero cohesion underestimates slope stabilities. However, assuming maximum (laboratory-determined) cohesion leads to over-estimation of stability. Therefore, the following analyses assume cohesion of 50 percent of laboratory values.

Highwall Stability

The three major areas with highwalls at the mine are Jackpile pit (Gavilan Mesa), North Paguate pit and South Paguate pit (Visual A). Safety factors for them are given in Table 2-8. All three highwall areas are composed of Dakota Sandstone and Mancos Shale. Highwall slopes in the shale units are about 40 degrees, while the sandstone slopes are nearly vertical.

TABLE 2-8

SAFETY FACTORS FOR HIGHWALLS

Pit Highwall	Safety Factors	
	Anaconda[a]	DOI[b]
Jackpile (Gavilan Mesa)	1.40	1.15-1.26
North Paguate	1.63	1.58-1.63
South Paguate	1.87	1.29-3.05

Source: [a] Seegmiller 1981.
[b] Smith 1983.

The Gavilan Mesa highwall is the tallest at the mine; its crest measures just over 500 feet (Figure 2-9). Its slope angle ranges up to 74 degrees, with an overall angle of 49 degrees (Seegmiller 1981a.) This highwall has up to six benches 25 to 50 feet wide. Several tension cracks occur on the first bench below the crest of the highwall. Numerous overhanging and loose sandstone blocks are also present and are most common where several joints intersect with bedding planes and the cliff face. Under present conditions, sections of the Gavilan Mesa highwall are only marginally stable for the long-term. The most likely slope failure would be a rotational one. This type failure would involve most benches and result in a large volume of material falling to the toe of the highwall.

FIGURE 2-9 JACKPILE (GAVILAN MESA) PIT HIGHWALL WITH BUTTRESS MATERIAL AT BASE

Toward the end of mining operations, Anaconda placed waste material against the base of Gavilan Mesa to help stabilize the highwall. Additional buttress material is scheduled for placement when reclamation commences. The rim of the highwall is not fenced.

The North Paguate pit highwall has a maximum height of 200 feet and a slope angle that ranges up to 70 degrees; the maximum overall slope angle is 55 degrees (Seegmiller 1981a). This highwall has up to three benches 15 to 20 feet wide. It is considered stable for the long term. That portion of North Paguate pit highwall close to the Village of Paguate is fenced with six-foot chain link.

The South Paguate pit highwall reaches a maximum height of about 300 feet. The slope angle ranges up to 80 degrees, with the maximum overall slope angle being 50 degrees (Seegmiller 1981a). This highwall has up to five benches 5 to 25 feet wide. In places, the South Paguate pit highwall is capped by up to 150 feet of alluvium. Under present conditions, the highwall is probably stable over the the long-term. If a slope failure were to occur, it would most likely be a steep-angled rotational one involving the entire highwall. The rim of the highwall is not fenced.

Waste Dump Stability

Potential hazards resulting from waste dump instability at the mine include: rotational failures, base translational failures, foundation spreading and piping. These waste dump failures could expose radiological material and thus present a health and environmental hazard. The material properties of eight waste dumps have been analyzed to assess existing stabilities (safety factors), including rotational failures through the dump toes, and translational failures along the dump bases (Seegmiller 1980b). The eight waste dumps analyzed are those where the most severe stability problems could be expected. Safety factors for the eight dumps under rotational and base translational failure are given in Table 2-9. These safety factors are applicable only under short-term conditions (with cohesion present) and are not applicable to long-term stability (with diminishing cohesion). Saturation of a dump in the climate at the minesite is not considered likely, so conclusions about rotational failure assume dry conditions.

TABLE 2-9

SAFETY FACTORS FOR WASTE DUMPS

Dump	Rotational Failure (dry conditions)[a]	Base Translational Failure	
		Static[a]	Dynamic[b]
FD-2	1.5	.84	<1.1
I	2.1	29.00	>1.1
South Dump	1.6	29.00	<1.1
T	2.2	29.00	<1.1
U	3.0	29.00	<1.1
V	1.4	29.00	<1.1
Y	4.0	29.00	>1.1
Y_2	3.5	29.00	<1.1

Source: Seegmiller 1980b.

Notes: [a]Minimum safety factor of 1.5 or greater.
[b]Minimum safety factor of 1.1 or greater

The Seegmiller analysis (1980b) indicates that, under conditions assumed, all dumps are at least "probably stable" with regard to rotational failure, and that all dumps except FD-2 are stable in regard to base translational failure under static conditions. The analysis also indicates that the two most critical dumps, in terms of stability, are FD-2 and V dumps.

FD-2 is a 270-foot-high dump composed of shale and Tres Hermanos Sandstone (Figure 2-10). It lies on a steep slope on the south side of Gavilan Mesa. Tension cracks are present near the crest, and a buttress has been placed at the toe to correct stability problems. Although Seegmiller calculated a safety factor of 1.5 (rotational failure under dry conditions), this dump appears to be just marginally stable. If one assumes no cohesion, FD-2 is unstable with regard to rotational failure. If the dump were to fail, a slump would probably displace the upper one-third to one-half of the dump, with the displaced material sliding to the base of the mesa.

V dump, approximately 215 feet high and composed mostly of Jackpile Sandstone, is located near the Rio Moquino (Figure 2-11). The southwest side of this dump shows slide scars near the dump toe. Seegmiller's analysis shows this dump to be stable under short-term conditions (cohesion present), but under zero cohesion conditions, this dump has a safety factor against rotational failure of 1.0, i.e., it is unstable.

Slopes sometimes fail when the materials underlying them cannot hold up the weight of overlying materials. This is called failure by foundation spreading. This has not been a problem at the Jackpile-Paguate mine in the past, and is not expected to be a problem except at FD-2 dump, where fissures in materials underlying the base of the dump suggest foundation spreading.

Piping is a process in which surface water flows downward through unconsolidated material, eroding the material to form a hollow tube or pipe. Piping on waste dump tops is common, especially where water ponds against erosion control berms. Piping causes geologic hazards at the minesite in two ways:

1. Areas around large, deep pipes are unstable, leading to a greater likelihood of human or livestock accidents.

2. Piping at dump crests has initiated large gullies at D,I,T,V and South dumps. These gullies are sources of rockfalls, small earth slides and high-velocity concentrated runoff.

Subsidence

Information on existing ground subsidence above the underground mine workings is presented in Table 2-10. As of December 31, 1983, a maximum of 3.37 inches of subsidence has occurred at one station over the 1500 area of the P-10/7 mine (Anaconda 1984).

Seegmiller (1981b, c, d) studied several possible problem areas at the mine. These are the A and B stopes of the Alpine mine, the 1400B stope of the P-10/7 mine and the A and B stopes of the PW 2/3 mine. Seegmiller's estimates of subsidence at these sites are shown in Table 2-11. The data indicate that all areas, except for the area above the

FIGURE 2-10 FD-2 DUMP ON EAST SIDE OF GAVILAN MESA

FIGURE 2-11 V DUMP SHOWING ACTIVE EROSION

TABLE 2-10

SUBSIDENCE DATA ON UNDERGROUND MINES - JACKPILE-PAGUATE MINESITE

Mine	Depth (Feet)	Mining Height (Feet)	Overlying Strata[a/]	Ground Surface	Subsidence Monitoring Grid	Subsidence
Alpine	70	9 to 12	JSS, DS	Undisturbed	None	None observed
H-1	140 to 200	8 to 13	JSS, DS, MS	Undisturbed	None	None observed
NJ-45	35 to 320	10	JSS, DS, MS	Disturbed - pit and highwall	None	None observed
P-9-2	140 to 160	9 to 20	JSS, DS, MS	Undisturbed	None	None observed
P-10/7 (and P-13)	200 to 600	9 to 45	JSS, DS, MS COLL	Mostly disturbed	81 stations at Hwy 279 (estab. 1976)	Range: -0.02 to -3.37 inches
PW 2/3	40 to 140	9 to 15	JSS, DS, MS	Disturbed - pit	8 stations (estab. 1978)	Range: -0.1 to -0.4 inches
Woodrow	Up to 200	-- [b/]	Backfill	Disturbed	None	None observed

Sources: Seegmiller 1981d, Anaconda Minerals Company 1984.

Notes: [a/] JSS=Jackpile Sandstone; DS = Dakota Sandstone; MS = Mancos Shale; COLL = Colluvium.
[b/] -- = Unknown.

P-10 mine decline, are in a "low risk" category with regard to subsidence. The P-10 decline could be subject to subsidence of significant magnitude and rate. This is because, from the surface to 680 feet down the decline, the ratio of overburden to mining height is less than 10:1. (As a general rule, mine voids with values of this ratio of less than 10:1 may be unstable without support.)

TABLE 2-11

PREDICTED MAGNITUDE AND RATE OF SUBSIDENCE OVER POSSIBLE PROBLEM STOPES AT UNDERGROUND MINES

Mine Area	Probable Subsidence	Probable Rate
Alpine Mine, A stope	6"	Very Slow
Alpine Mine, B stope	4"	Very Slow
PW 2/3, A stope	6"	Very Slow
PW 2/3, B stope	12"	Very Slow
P-10/7, 1400B stope	1"	Zero to Very Slow

Source: Seegmiller 1981b,c,d.

Underground Openings

The Alpine mine was accessed by two adits that have been sealed by backfilling with 5 to 10 feet of waste material. No bulkheads were placed in either adit. The area surrounding the adits has been backfilled to above the portals.

The H-1 mine was accessed by two adits, one of which has been backfilled 20 feet inward from the portal. The other adit is sealed by waste material only at the portal. The three ventilation shafts have been backfilled from bottom to surface and are covered by a 5-foot-high surface mound.

The NJ-45 mine was accessed by four adits, three of which accessed the workings, while only the portal of the fourth adit was constructed. Ventilation was supplied by two 42-inch ventilation shafts. All mine workings are still open.

The P-9-2 mine was accessed by five adits and ventilated by eight 42-inch ventilation shafts. Open-pit operations progressed through the mine workings and seven of the ventilation shafts. The remaining ventilation shaft is still open. The mined areas have been backfilled above the level of the remaining underground workings.

The P-10/7 mine was accessed by one decline and an emergency escapeway that leads into the South Paguate pit. It was ventilated by seventeen 42-inch ventilation shafts. All mine entries are still open.

The P-13 mine was accessed by two adits that are still open. However, this mine has flooded naturally.

The PW 2/3 mine was accessed by four adits, the portals of which have been backfilled. Subsequent backfilling has covered three of the portals.

The Woodrow mine was accessed by a 225-foot deep shaft. The shaft has since been backfilled to the surface.

RADIATION

Introduction

This section describes the existing radiological environment in and around the Jackpile-Paguate uranium mine. A primer on radiology, including the terminology used in this EIS, is given in Appendix C. Readers unfamiliar with this subject matter should read Appendix C before proceeding with this section and the corresponding impacts section in Chapter 3 of this EIS.

Standards

No standards exist for the release of radiation and radioactive materials from uranium mining operations, nor do standards exist for post-reclamation radiation levels. Standards have been developed by the Federal government for active uranium mills, inactive uranium mills, public drinking water systems and point-source discharges of water (Table 2-12). These standards were developed to fit very specific circumstances and are not legally applicable to surface uranium mining operations. However, the standards to provide a useful comparison by showing the levels of radiation and radioactive materials that are considered acceptable for other types of operations. In the case of uranium mills, for example, the conditions are often somewhat similar to those around a surface mine, and many of the standards for mills may become practical guidelines for mine reclamation.

Sources of Radiation at the Minesite

Uranium and all members of its decay chain are present everywhere in low concentrations in air, soil and water. However, special geologic and hydrologic conditions at the minesite have allowed uranium from the ground water to be deposited in much higher concentrations than background levels in the ore deposits.

The decay of some of the uranium in the ore at the minesite has led to the presence of all members of uranium decay series in the deposits. Because this decay has been occurring over a very long period of time, it has reached a state of "secular equilibrium," i.e., the radioactivity of each member of the decay chain is the same as that of the uranium-238, the parent.

During mining operations, the ore with the highest concentration of uranium was removed, thereby decreasing somewhat the total amount of

TABLE 2-12

FEDERAL RADIATION STANDARDS

Source of Standard	Subject	Standard[a/] Item	Limit
Nuclear Regulatory Commission (10 CFR 20.105 and 20.106)	Permissible levels of radiation in unrestricted areas[b/]	Annual whole body dose to an individual	0.5 rem (equivalent to 57 microroentgens per hour)
		Radon-222	3 pCi/l (individual)[c/] or 1 pCi/l (population)
Environmental Protection Agency (40 CFR 141.15)	Maximum levels for radium-226, radium-228 and gross alpha particle activity in community water systems	Combined radium-226 and radium-228	5 pCi/l
		Gross alpha (including radium-226 but excluding radon and uranium)	15 pCi/l
(40 CFR 192)	Health and environmental protection standards for uranium mill tailings	Radon-222 release from uranium by-product materials	20 pCi/m^2·s[b/]
		Radon-222 concentrations at the boundary of a disposal site	0.5 pCi/l
		Radium-226 in land averaged over 100 square meters	5 pCi/g (over the first 15 centimeters of soil below the surface)[c/]
			15 pCi/g (averaged over 15-centimeter-thick layers of soil more than 15 centimeters below the surface)
		Radon daughter and gamma levels inside buildings at abandoned mill sites	.03 WL and 20 μR/h[c/]
(40 CFR 440.52)	Concentration of pollutants discharged in drainage from uranium mines, either open-pit or underground (<u>in situ</u> leach mines excluded)	Radium-226 (dissolved)	10 pCi/l (daily maximum) 3 pCi/l (30-day average)
		Radium-226 (total)	30 pCi/l (daily maximum) 10 pCi/l (30-day average)
		Uranium	4 mg/l (daily maximum)[c/] 2 mg/l (30-day average)

Notes: [a/]Air standards are above background; water standards include background.
[b/]10 CFR 40.13 specifically excludes "... unrefined and unprocessed ore..." (i.e., mines and mining).
[c/]Units of measurement: pCi/l = picocuries per liter; pCi/m^2·s = picocuries per square meter per second; pCi/g = picocuries per gram; WL = working level; μR/h = microroentgens per hour; mg/l = milligrams per liter.

radiation produced at the site. However, the mining operation increased the rate at which the radiation was released into the immediate vicinity of the site by bringing the radioactive ore to the surface (i.e., by removing the shielding of the overburden) and by altering the ore's chemical and physical properties. The sources of radiation at the site (other than normal background) are protore, ore-associated waste and the unmined portions of the uranium ore deposit. The uranium (U-238) and radium (Ra-226) levels in these materials are listed in Table 2-13.

The protore at the minesite consists of approximately 13 million cubic yards of rock containing 0.02 to 0.059 percent uranium oxide (U_3O_8). The protore is located in 23 stockpiles inside and outside of the open pits. [In mining, the concentration of all uranium isotopes (U-234, U-235, U-238) present in a certain amount of rock is expressed as if the isotopes existed as an equivalent amount of uranium oxide (U_3O_8). This U_3O_8 equivalent is expressed as a percentage by weight.]

The ore-associated waste consists of an unknown quantity of rock containing 0.002 to 0.02 percent U_3O_8. Records were not required on the exact uranium content, nor on the deposition sites of the ore-associated waste. This waste was mixed indiscriminately with the overburden and placed in the 32 waste dumps on the site, or was used as backfill material. It is estimated that 50 million tons of ore-associated waste remain at the site, but this number might be in error by a substantial amount.

The site also contains about 2 million tons of unmined uranium resources containing 0.094 to 0.3 percent U_3O_8 and an unknown amount of resources below 0.094 percent. These resources have not been disturbed by mining operations and contribute little to the amount of radiation released from the site because they are shielded by the overburden.

The radium and uranium contents of various surface materials in and around the minesite are summarized in Table 2-13. The minesite has an average of 70 picocuries per gram of radium-226 and uranium-238. These values are about 47 times higher than the average background levels and about 14 times higher than the U.S. Environmental Protection Agency's mill tailings standard (40 CFR 192).

The protore piles contain concentrations up to 165 picocuries per gram for both radium-226 and uranium-238. Small localized pockets may exceed 600 picocuries per gram for these elements.

Radiation Exposure Pathways and Existing Levels of Radiation

The principal potential pathways for human exposure to radiation from the minesite are as follows:

1. Direct Gamma Radiation--Direct exposure to radiation emitted by the radioactive material on the surface of the ground at the site. Exposure is to the whole body, but applies only to people at the minesite itself. (Direct exposure to beta radiation is also a

TABLE 2-13

URANIUM AND RADIUM IN SURFACE MATERIALS
(picocuries per gram)

Material/Standard	U-238	Ra-226
U.S. soil average	0.6	-
San Juan Basin soil average	1.18	0.75
Minesite average (Jackpile Sandstone)	70	70[a]
Minesite maximum (south part of Jackpile pit)	270	270[a]
Topsoil stockpile average	1.5	
Topsoil borrow area	1.5	
Overburden (Mancos Shale, Tres Hermanos Sandstone, Dakota Sandstone)	1.5	
Jackpile Sandstone		
Barren waste	less than 5	less than 5[a]
Ore-associated waste	5 to 55	5 to 55[a]
Protore	greater than 55	greater than 55[a]
EPA Mill Tailings Standard[b] (40 CFR 192)	-	5

Source: Momeni, et al. 1983.

Notes: [a]Estimated values based on the assumption that both elements are in secular equilibrium in the Jackpile Sandstone.
[b]Refer to Table 2-12.

potential exposure pathway, but the health impacts from direct gamma exposure far exceed those of beta radiation. All measures taken to reduce direct external gamma radiation would also reduce external beta radiation. Therefore, direct external beta radiation is not analyzed any further in this document.)

2. Ambient Radon--Inhalation of radon-222 and its radioactive decay products (progeny) from the continuous decay of radium-226 in the protore and ore-associated waste; exposure is primarily to a portion of the lungs from radon-222 progeny.

3. Particulates--Inhalation of windblown particles containing radioactive elements; exposure is to the lungs from the progeny of the uranium-238 decay chain.

4. Water--Consumption of surface or ground waters containing radioactive elements; exposure is primarily to the bone and stomach from all progeny of the uranium-238 decay chain.

5. Ingestion--Consumption of meat and vegetables contaminated with radioactive elements.

Any of the exposure pathways mentioned above would be created by radioactive material that has been removed from the site by water erosion, spillage along ore haul routes or purposely taken from the site.

Direct Gamma Radiation

Gamma rays are continuously emitted from the radioactive decay of many elements contained at the minesite in protore and ore-associated waste. The principal gamma emitters are decay products of uranium-238, mainly bismuth-214 and lead-214.

Gamma rays cannot penetrate long distances through dense material. For example, one foot of compacted earth shields about 90 percent of the gamma radiation (Ford, Bacon & Davis Utah, Inc. 1977). Therefore, only the gamma rays that are produced at or very near the ground surface enter the atmosphere. In the atmosphere, gamma rays may travel up to 500 yards before they are absorbed by the air; therefore, people must be within 500 yards of the gamma-emitting source to be exposed. The closer ā person is to the source, the greater the dose received.

Exposure to gamma rays can be very hazardous because gamma can penetrate the human body and expose all organs. The potential damage to these organs from ionizing radiation is discussed in Appendix C. The Nuclear Regulatory Commission (10 CFR 20.105) limits gamma exposure in unrestricted areas to no more than 0.5 rem per year [0.5 rem/year = 57 microroentgens per hour (μR/h)] over background. As previously mentioned, this standard does not apply to uranium mines. However, it does put the following discussion of gamma levels in perspective.

An aerial survey was conducted at the minesite and the surrounding areas to determine the levels of gamma radiation being emitted from the site and vicinity, to discover if winds had spread radioactive material offsite, and to locate any spills. This aerial survey was used to determine background gamma radiation levels to be used as a basis for reclamation evaluation. The survey was performed in July and August, 1981, by the Energy Measurements Group of EG&G (Jobst 1982). Corrections were made in the data for the altitude of the helicopter, terrestrial radiation, and cosmic radiation, to obtain an exposure rate at 3 feet above the ground due to gamma sources in the soil. The results of the survey are shown on Maps 2-1 and 2-2.

The background gamma exposure rate is 13 μR/h; most of the area outside of the minesite, including the Village of Paguate, is at background levels. This indicates no measurable spread of radioactive materials (particulates) by winds has occurred.

Those areas that have exposure rates above background values are shown on Maps 2-1 and 2-2. Slightly elevated (14 to 18 μR/h) levels were measured in all major drainages above and below the minesite. A followup ground survey showed the high exposure rates in these areas are primarily due to spillage of ore and to natural outcrops of uranium-bearing rock. Conditions at areas 1, 3, 4, 7 and 8 on Map 2-1 resulted from the mining operations. More detail for each of these high exposure areas is provided in Table 2-14.

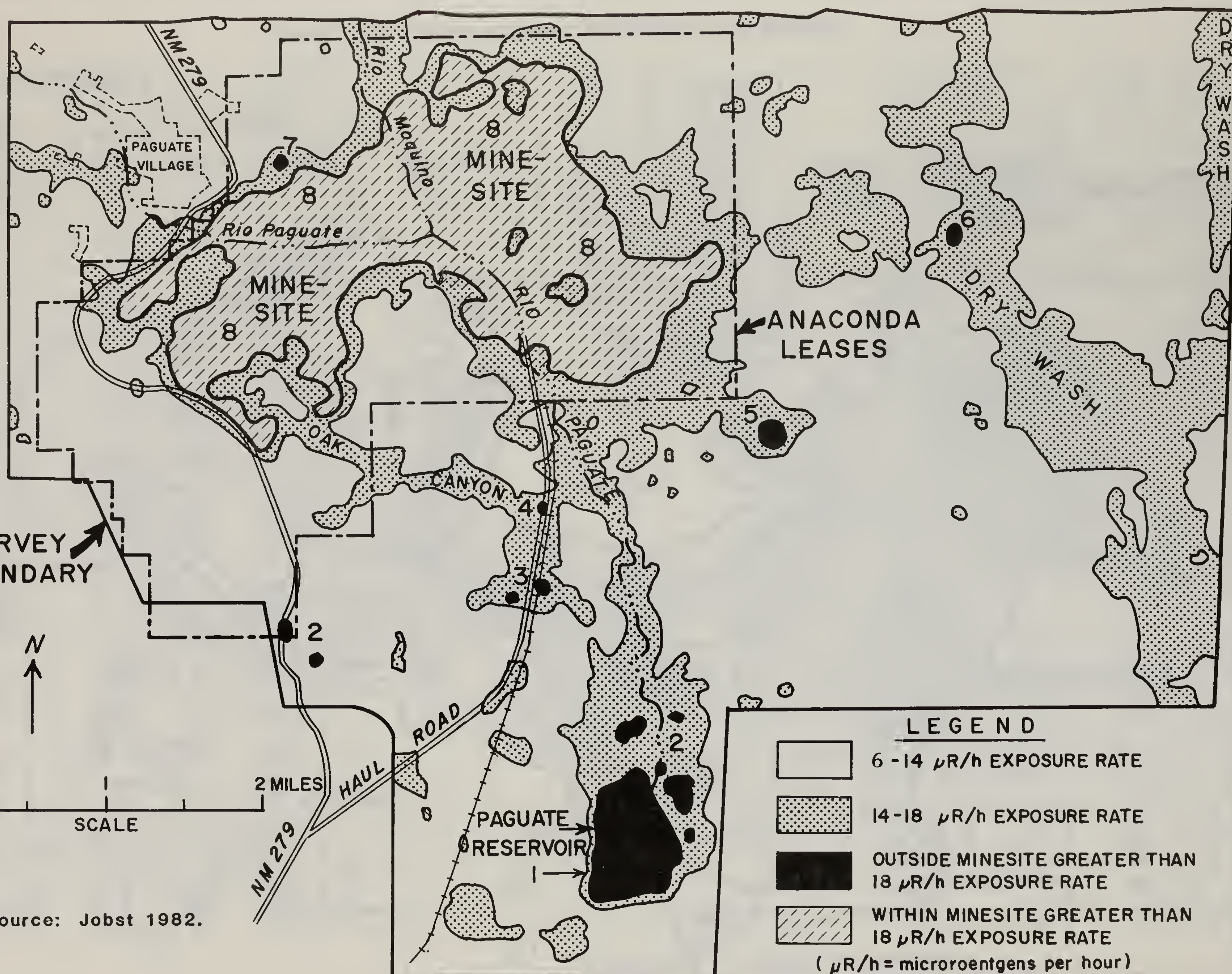
TABLE 2-14

EXPLANATION OF HIGH GAMMA EXPOSURE AREAS

Area Number[a]	Exposure Rate (μR/h)[b]	Source of Elevated Exposure Rates
1	18-29	Sediments in Paguate (Quirk) Reservoir. Partially the result of erosion from the minesite and partially the result of erosion from undisturbed areas.
2	18-23	Natural outcrop of uranium-bearing rock
3	18-29	Ore spillage along rail spur
4	18-29	Ore spillage along rail spur
5	18-23	Natural outcrop of uranium-bearing rock
6	18-23	Natural exposure of uranium-bearing sediments
7	18-23	Location of Anaconda's hydraulic mining test
8	18-480	Jackpile-Paguate minesite

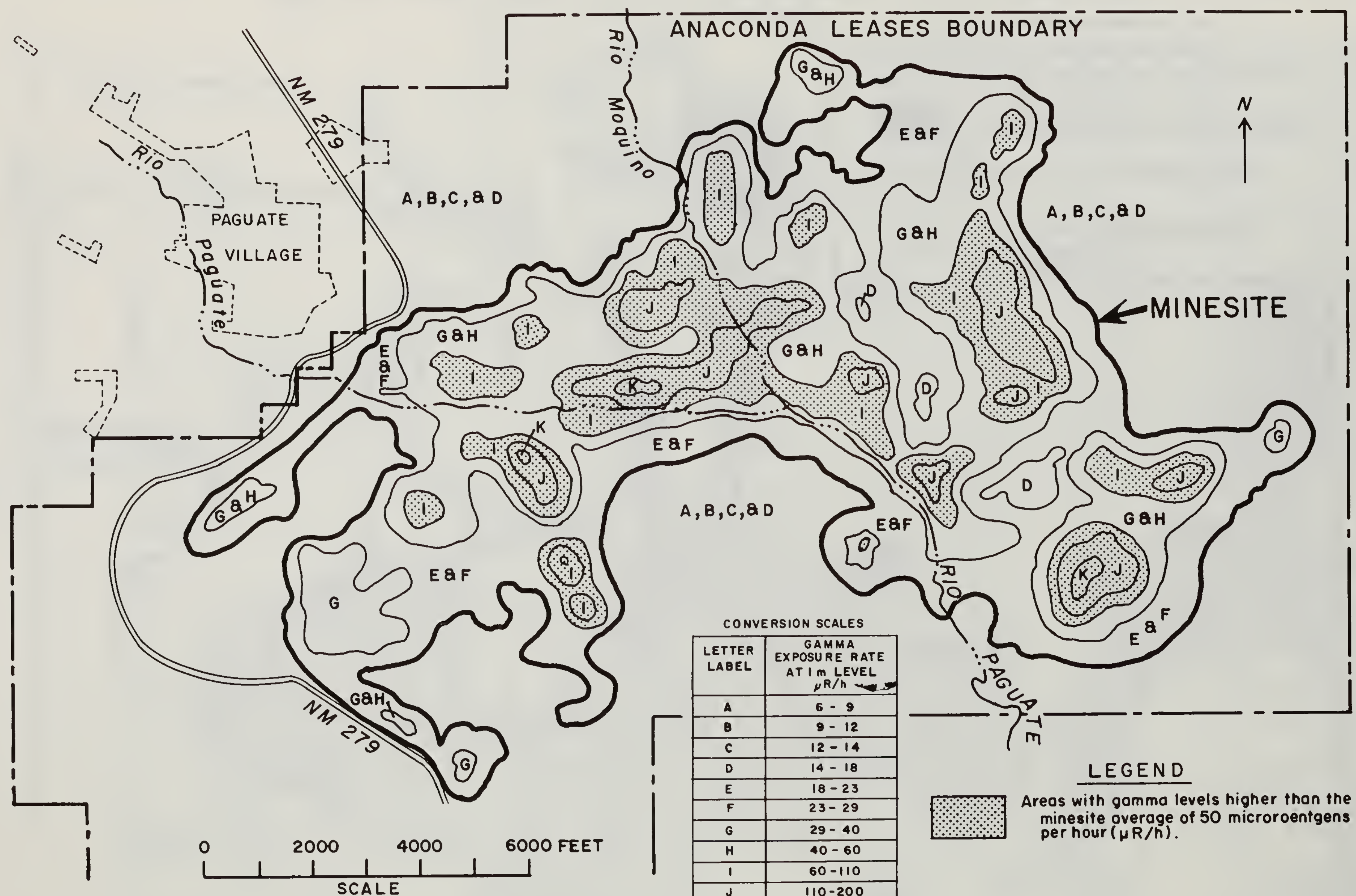
Source: Jobst 1982.

Notes: [a] Area numbers are the locations shown on Map 2-1.
[b] μR/h = microroentgens per hour.



Source: Jobst 1982.

MAP 2-1 Aerial Gamma Survey of the Minesite and Surrounding Area



CONVERSION SCALES

LETTER LABEL	GAMMA EXPOSURE RATE AT 1 m LEVEL μR/h
A	6 - 9
B	9 - 12
C	12 - 14
D	14 - 18
E	18 - 23
F	23 - 29
G	29 - 40
H	40 - 60
I	60 - 110
J	110 - 200
K	200 - 480

Source: Jobst 1982.

MAP 2-2 Aerial Gamma Survey of the Minesite

The exposure rates within the minesite are shown on Map 2-2. The maximum exposure rate of 480 μR/h is approximately 37 times the background level of 13 μR/h, while the average exposure rate of 50 μR/h is approximately 4 times background. The protore piles have the highest exposure rates. Areas that have been covered with soil, such as dumps C through G, have exposure rates at or below 18 μR/h.

Paguate (Quirk) Reservoir was studied to determine the concentration of radioactive elements in the sediment. A surface gamma survey consisting of 1,500 data points was conducted in and around the reservoir (Eberline Instrument Corp. 1981). Also conducted was a subsurface gamma survey consisting of 47 drillholes (a maximum of 30 feet deep) and 7 trenches (a maximum of 5 feet deep) in the reservoir. The gamma exposure rates and the percentage of the reservoir area exhibiting these exposure rates are given in Table 2-15.

TABLE 2-15

GAMMA EXPOSURE RATES AT PAGUATE RESERVOIR
(microroentgens per hour)

Exposure Rate	Percentage of Reservoir
Less than 10	22
11-20	47
21-30	27
Greater than 30[a]	4

Source: Eberline Instrument Corporation 1981.
Note: [a] The maximum rate measured was 47 microroentgens per hour.

Slightly more than 31 percent of the reservoir exhibits exposure rates above background values, with the maximum rate measured being about 2.5 times background. The airborne gamma survey (previously discussed) showed the background exposure rate for the stream channels in the area to be 14 to 18 μR/h.

Six villages on the Laguna Reservation (including Paguate and Laguna) and three villages near the reservation were surveyed for gamma radiation by the U.S. Environmental Protection Agency (EPA) on September 6, 1980 (EPA letter of January 25, 1983). A truck-mounted gamma scanner was driven through each village to locate radiological anomalies.

Twenty-five such anomalies were found. A follow-up survey of them was performed the week of February 9, 1981, using pressurized ion chambers or scintillometers. Often, the source of the anomaly was found to be a single rock, which was removed. Only three locations were found to have gamma exposure rates above 16 μR/h. These three had rates of 32, 37 and 600 μR/h. The source of each was found to be rock or soil located outside of buildings, and all sources were removed. Therefore, no anomalies above 16 μR/h (slightly above background values) remain, and no health hazards exist.

Data are not available on the radiological levels in the buildings on the minesite, but levels of gamma radiation are expected to be high due to spillage of ore in and around the buildings.

Ambient Radon

The exposure of the public to radon (Rn-222) and its decay products represents one of the greatest potential health risks from the mine. Rn-222 is produced continuously by the radioactive decay of the radium (Ra-226) present in the protore and ore-associated waste. Rn-222 is an inert gas that diffuses through the protore and waste into the atmosphere, where it can be dispersed by winds. Rn-222 has a half-life of 3.82 days, so a given amount may travel some distance in the atmosphere before it completely decays.

The mining operations decreased the total amount of Rn-222 that would be released from the minesite by removing the high-grade ores; however, these same operations have also increased the rate at which Rn-222 is released into the atmosphere by uncovering the ore zone and placing the protore and waste on the surface. Before mining, most of this material was deeply buried, and much of the Rn-222 changed to its solid decay products before it could diffuse through the rock and enter the atmosphere. Because the protore and waste have been placed uncovered on the surface, a higher percentage of the Rn-222 enters the atmosphere before it decays.

The total radon release rate from the minesite is calculated to be 5,588 curies (Ci) per year (Momeni, et al. 1983). Of this amount, 3,915 Ci (70 percent) come from the protore, 1,396 Ci (25 percent) from the ore-associated waste, and 280 Ci (5 percent) from material containing less than 5 picocuries uranium-238 per gram.

Data on ambient radon concentrations measured at four locations at the minesite since February 1979 are summarized in Table 2-16. The average of all concentrations was 2 1/2 times background levels, and the maximum concentration measured was 7 times background. Radon concentrations typically show considerable variability because they are affected by local atmospheric stability conditions and ground moisture.

During June, 1976, the U.S. Environmental Protection Agency performed ambient radon surveys in the vicinity of the Laguna Reservation (Eadie, et al. 1979). The average radon concentration of locations near or at the minesite and those away from the minesite were 1.13 picocuries per liter (pCi/l) and 0.53 pCi/l respectively (Map 2-3, Tables 2-17 and 2-18).

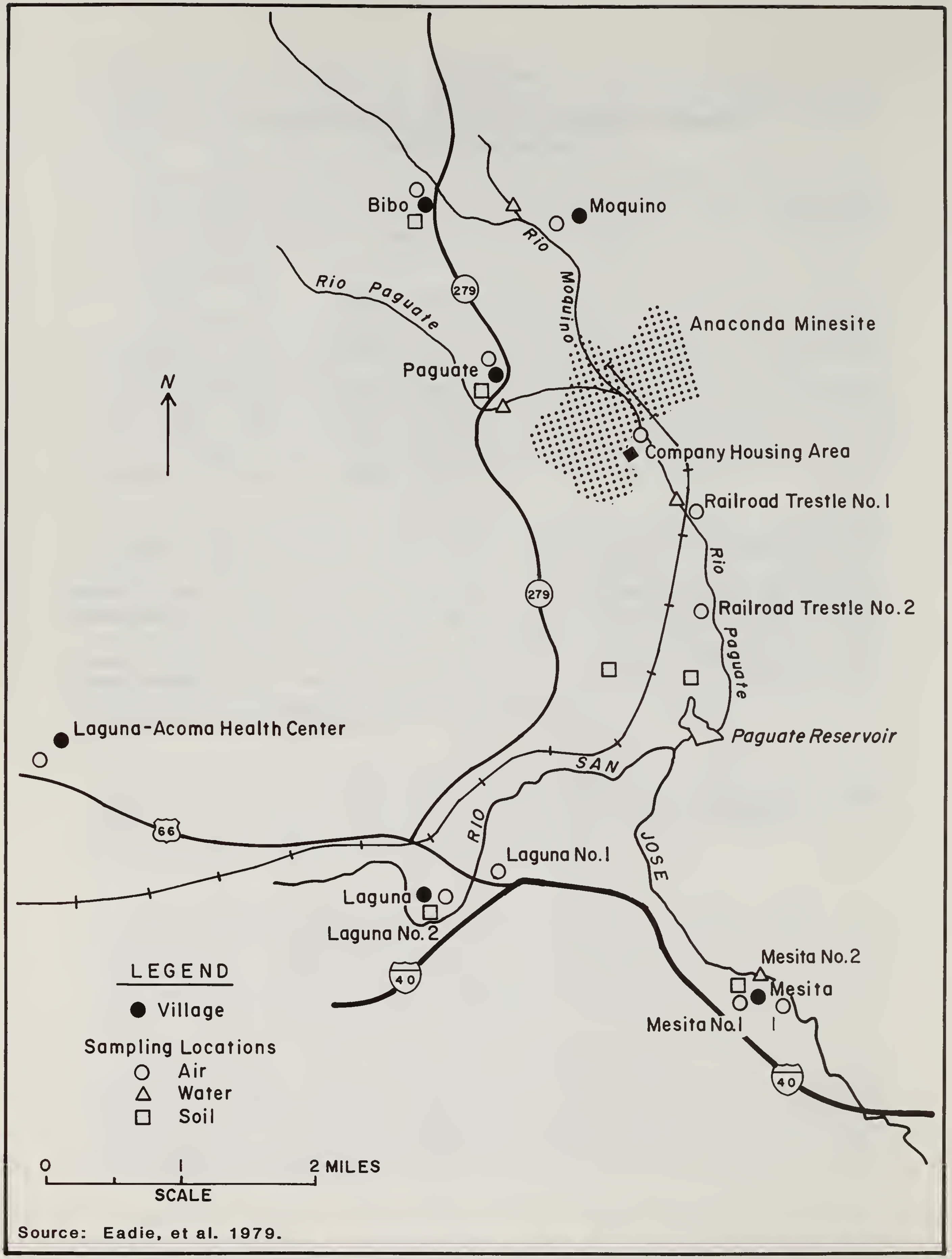
TABLE 2-16

RADON-222 CONCENTRATIONS AT MONITORING LOCATIONS
(picocuries per liter)

Monitoring Location	Range	Average
Dump F	0.01 - 3.68	1.35
Mine Vent	0.1 - 3.68	1.47
West Gate	0.06 - 2.17	0.96
Well #4	0.01 - 2.78	1.31
Average	0.01 - 3.68	1.27
Typical background[a]		0.50
EPA Mill Tailings Standard[b] (40 CFR 192)		0.50 (above background)
NRC Standard[b] (10 CFR 20)		3.0 (above background)

Source: Anaconda Minerals Company 1982.

Notes: [a]As listed in Eadie, et al. 1979.
[b]Refer to Table 2-12.



MAP 2-3 Radiological Sampling Locations in the vicinity of the Jackpile Mine

TABLE 2-17

AMBIENT OUTDOOR RADON-222 CONCENTRATIONS DURING JUNE 1976
(locations at or near the minesite)[a]
(picocuries per liter)

Location	Concentrations Maximum[b]	Minimum[b]	Average[c]
Company Housing Area	1.8 ± 0.23	0.25 ± 0.10	1.1 ± 0.34
Railroad Trestle No. 1 (below Co. Housing Area)	2.1 ± 0.26	Less than 0.12	0.99 ± 0.54
Railroad Trestle No. 2—1 mile south of Railroad Trestle No. 1	2.7 ± 0.24	0.44 ± 0.05	1.3 ± 0.50

Source: Eadie, et al. 1979.

Notes: [a] These locations are shown on Map 2-3.
[b] Result ± two-sigma counting error terms.
[c] Average result ± two-standard error terms (i.e., standard deviation of the sample population divided by the square root of the number of samples).

TABLE 2-18

AMBIENT OUTDOOR RADON-222 CONCENTRATIONS DURING JUNE 1976
(locations away from the minesite)[a]
(picocuries per liter)

Location	Concentrations		
	Maximum[b]	Minimum[b]	Average[c]
Laguna No. 1 - (Old Laguna)	1.3 ± 0.18	0.20 ± 0.10	0.51 ± 0.28
Laguna No. 2 - (Training Building)	1.5 ± 0.39	0.14 ± 0.07	0.51 ± 0.29
Laguna-Acoma Health Center	1.6 ± 0.19	0.22 ± 0.11	0.63 ± 0.36
Bibo (Wellhouse)	1.4 ± 0.29	Less than 0.12	0.50 ± 0.23
Mesita No. 1 (Industrial Plant)	0.89 ± 0.33	0.18 ± 0.05	0.47 ± 0.31
Mesita No. 2 (Community Building)	1.7 ± 0.22	Less than 0.12	0.55 ± 0.49
Moquino (Private Residence)	1.4 ± 0.23	Less than 0.12	0.54 ± 0.31
Paguate (Community Building)	0.75 ± 0.06	Less than 0.12	0.42 ± 0.14

Source: Eadie, et al. 1979.

Notes: [a]These locations are shown on Map 2-3.
[b]Result ± two-sigma counting error terms.
[c]Average result ± two-standard error terms (i.e., standard deviation of the sample population divided by the square root of the number of samples).

Radon levels in most of the mine buildings are not expected to be higher than in the ambient atmosphere (1.27 picocuries per liter) because most buildings are not tightly constructed. Radon levels in the tightly constructed buildings such as the employee housing, geology building, and offices are expected to be higher because these buildings have reduced radon leakage.

Radon exhalation (the rate at which radon is released from a given area of ground) was measured at four waste dumps that have been covered with soil. This data is summarized in Table 2-19. The average exhalation rate measured was 2.6 times higher than background. Radon exhalations at six locations on the Laguna Reservation as measured by the EPA (Eadie, et al. 1979) averaged 0.5 picocuries per square meter per second (refer to Table 2-20).

TABLE 2-19

RADON EXHALATION[a] AT THE JACKPILE-PAGUATE URANIUM MINESITE
(picocuries per square meter per second)

Site	Exhalation Rate
Dump F	1.10
Dump G	4.15
Dump L	2.57
Dump K	2.70
Average	2.63
Typical background	1
EPA Mill Tailings Standard[b] (40 CFR 192)	20

Source: Anaconda Minerals Company 1982.

Notes: [a] Data taken between October 1, 1980, and December 31, 1981, by Anaconda Minerals Company.
[b] Refer to Table 2-12.

Particulates

Radioactive elements such as uranium-238, radium-226 and thorium-230 can attach to dust particles in the air and thereby pose an inhalation hazard to humans. After being inhaled, these particles may deposit in the respiratory tract and decay, releasing alpha, beta, or gamma radiation (or a combination of these).

TABLE 2-20

RADON EXHALATION ON THE LAGUNA RESERVATION
(picocuries per square meter per second)

Site	Exhalation Rate
Railroad Trestle	0.09
Old Laguna Ball Field	0.07
Jackpile Dump	
Old	0.4
New	0.6
Laguna Training Center	0.2
Paguate	0.3
Average	0.5
EPA Mill Tailings Standard[a] (40 CFR 192)	20

Source: Eadie, et al. 1979.

Note: [a]Refer to Table 2-12.

Table 2-21 shows the results of an EPA study of airborne radioactive particulate concentrations outside the minesite (Eadie, et al. 1979). Table 2-22 shows the results of Anaconda's own particulate survey for four locations within the minesite (Anaconda Minerals Co. 1982). The concentrations within the minesite are about ten times higher than those outside the minesite. In all cases, however, the concentrations are far below the recommended Nuclear Regulatory Commission standards (10 CFR 20.106).

TABLE 2-21

AREA AIRBORNE CONCENTRATION OF RADIOACTIVE PARTICULATES
(picocuries per cubic meter)

Location	Uranium (U-238)	Thorium (Th-230)	Radium (Ra-226)
Near Minesite[a]			
Bibo	0.00040	0.000320	0.00019
Mesita	0.00032	0.000180	0.00037
Old Laguna	0.00029	0.000085	0.00017
Average	0.00034	0.000200	0.00024
Offsite[b]			
Grants, NM	0.00120	0.001700	0.00075
Chicago, Ill.	0.00012	0.000045	--
New York State	0.00040	--	--
New York City	0.00008	--	--
NCRP-45 Background[a]	0.00012	0.000045	0.00010
Standards[a]			
Soluble	3.0	0.08	3.0
Insoluble	5.0	0.30	2.0

Sources: [a]Eadie, et al. 1979.
[b]Momeni, et al. 1983.

Water

The concentrations of uranium (U-234, U-235 and U-238) and of radium (Ra-226), gross alpha, and beta activity in samples of water from four wells on the Laguna Indian Reservation are listed in Table 2-23. The average concentrations for these wells are 0.3 picocuries per liter (pCi/l) Ra-226, 0.4 pCi/l U-234 , 0.1 pCi/l U-235, and 0.6 pCi/l U-238. These concentrations are within drinking water standards and are typical of values reported for public water supplies in the United States. In a recent work, Kriege and Hahne (1982) surveyed Ra-226

TABLE 2-22

MINESITE AVERAGE AIRBORNE CONCENTRATION OF RADIOACTIVE PARTICULATES
October 1980-December 1981
(picocuries per cubic meter)

Location	Uranium-Natural[a/] (U-Nat)	Thorium (Th-230)	Radium (Ra-226)
Dump F	0.0016	0.0024	0.0014
Mine Vent	0.0092	0.0023	0.001
West Gate	0.0044	0.0023	0.0012
Well No. 4	0.0110	0.0024	0.0012

Source: Anaconda Minerals Company 1982.

Note: [a/] Uranium-natural is not the same as uranium-238 in Table 2-21. Standards for uranium-natural are 5 picocuries per cubic meter (soluble and insoluble).

TABLE 2-23

RADIOACTIVE ELEMENTS IN GROUND WATER FROM FOUR WELLS ON THE LAGUNA INDIAN RESERVATION[a]

Well	Element	Concentration (pCi/l ± SE) [b]
Mesita No. 1 (BIA)	Gross alpha	5 ± 6
	Gross beta	5 ± 5
	Ra-226	0.2 ± 0.1
	U-234	1.3 ± 0.8
	U-235	0.4 ± 0.4
	U-238	1.3 ± 1.0
N.Y. No. 1	Gross alpha	3 ± 5
	Gross beta	7 ± 5
	Ra-226	0.3 ± 0.1
	U-234	0.5 ± 0.3
	U-235	0.0 ± 0.2
	U-238	0.9 ± 0.4
Well No. 1 Paguate	Gross alpha	3 ± 5
	Gross beta	3 ± 5
	Ra-226	0.4 ± 0.1
	U-234	0.1 ± 0.2
	U-235	0.1 ± 0.1
	U-238	0.1 ± 0.2
Well No. 2 Paguate	Gross alpha	0 ± 7
	Gross beta	2 ± 4
	Ra-226	0.2 ± 0.2
	U-234	-0.3 ± 0.5
	U-235	0.0 ± 0.2
	U-238	0.0 ± 0.2

Source: Momeni, et al. 1983.

Notes: [a] The EPA's national standards for community water systems are 15 picocuries per liter for gross alpha and 5 picocuries per liter for radium (40 CFR Parts 100 to 399). The NRC's maximum permissible concentrations (above background) in unrestricted areas are 4×10^4 picocuries per liter for U-238, and 3×10^4 picocuries per liter for U-234 and U-235 (10 CFR Parts 0 to 199).
[b] Picocuries per liter ± SE (standard error of measurement).

concentrations in community water supplies in 625 towns in Iowa. The range of average Ra-226 concentrations was 0.1 to 48 pCi/1. In an earlier study (Hursh 1953), the range of Ra-226 concentrations across the nation was found to be from 0.09 pCi/1 in raw water and 0.08 pCi/1 in tap water in Los Angeles, California, to 65.4 pCi/1 in raw water and 57.9 pCi/1 in tap water in Joliet, Illinois.

Surface waters are not regularly used for human consumption in the Paguate-Laguna area; however, part of surface water passing through the minesite collects downstream in Paguate Reservoir. Water from this reservoir is drunk by livestock, so a potential pathway exists for indirect exposure.

Table 2-24 shows the concentrations of radioactive elements in the Rios Moquino and Paguate. Radium concentrations increase about 10 times as the rivers flow through the minesite, while uranium concentrations increase almost 30 times. In both cases, these increased concentrations are still far below the drinking water standards. The increased river concentrations show up in Paguate Reservoir, although the radium concentration in the reservoir is only about a third the level of the radium in the river at the south boundary of the minesite.

TABLE 2-24

RADIUM AND URANIUM IN SURFACE WATERS IN AND NEAR THE MINESITE

Location	Ra-226[a/]	Natural Uranium[b/]
Rio Paguate (upstream)	0.35	0.006
Rio Moquino (upstream)	0.28	0.008
Ford Crossing (downstream)	3.73	0.239
Paguate Reservoir	1.03	0.236

Source: Momeni, et al. 1983.

Notes: [a/]Measured in picocuries per liter.
[b/]Measured in milligrams per liter.

As described in the Hydrology section of this chapter, four major ponds have formed at the minesite as the result of ground water seepage into the pits. All ponds have elevated levels of radium-226, from 1.6 to 9 times the drinking water limit of 5 pCi/1. However, uranium concentrations are below the New Mexico ground water limit of 5 milligrams per liter. (No federal drinking water standard exists for uranium.) The concentration of radium-226 in the ponds increased 170 percent in a recent 15 month period. The increasing levels of radioactive constituents are probably due to concentration by evaporation.

Ingestion

Radiation doses by ingestion normally result from consumption of food and/or water contaminated with radionuclides. The water pathway has already been discussed; this discussion is limited to food pathways.

Pueblo of Laguna families or groups of families have small farming operations or gardens to supply produce for personal use. Sheep and cattle are also raised for food.

No radiological analysis of meat from locally raised animals has been done. However, the U.S. Environmental Protection Agency (Eadie, et al. 1979) has collected and analyzed samples of cucumbers and onions (Table 2-25).

Previously reported analyses of vegetables from elsewhere in the United States indicate a radium-226 content of less than 0.002 picocuries per gram (pCi/g -- Hallden, et al. 1963). Welford and Baird (1967) report a total uranium content for vegetables of roughly 0.00053 pCi/g. The radioactive content of the cucumbers from the EPA's study is essentially comparable to these reported "typical background" values, with the exception of radium-226. The uranium content of onions was high compared to the values reported by Welford and Baird (1967).

Studies of radioactivity in rangeland vegetation in the Thoreau-Crownpoint area, New Mexico, have found radium-226 levels as high as 0.74 pCi/g and thorium-230 levels up to 0.50 pCi/g (Mobil Oil Corp. 1980). As with radioactive particulates (refer to the previous section of this chapter), this increased radioactivity level may be a natural phenomenon caused by the presence of ore-bearing formations or by the many years of mining activities in the San Juan Basin.

Vegetative sampling of reclaimed dumps within the minesite have shown radium-226 levels ranging from 0.16 to 1.59 pCi/g, uranium (natural) levels from 0.76 to 7.13 μg/gm and thorium-230 levels from 0.43 to 2.56 pCi/g. Refer to the Flora section of this chapter for a complete analysis of radiological constituents in vegetative material on reclaimed waste dumps.

HYDROLOGY

Surface and ground water quality data have been summarized in this EIS. Complete data is available for review at the BLM Albuquerque District Office, Rio Puerco Resource Area.

Surface Water

Rios Paguate and Moquino

The minesite and surrounding areas are drained by the Rios Paguate and Moquino, which begin on the slopes of Mount Taylor northwest of the minesite (Map 1-1, Chapter 1). The Rio Paguate is joined by the Rio Moquino near the center of the minesite (Figure 2-12). Below this

TABLE 2-25

RADIOACTIVITY IN VEGETABLES FROM THE LAGUNA RESERVATION[a]

Element	Cucumber	Onion
Radium-226	0.11 ± 0.011	0.047 ± 0.0083
Uranium-234	0.00018 ± 0.000032	0.026 ± 0.002
Uranium-235	Less than 0.000011	0.0011 ± 0.00034
Uranium-238	0.00013 ± 0.000027	0.027 ± 0.0021
Thorium-230	0.0032 ± 0.00049	0.035 ± 0.0052
Thorium-232	0.00042 ± 0.000091	0.039 ± 0.0057

Source: Eadie, et al. 1979.

Notes: [a]Concentration ± two-sigma counting error, in picocuries per gram.

confluence, the Rio Paguate flows southeasterly into Paguate Reservoir before joining the Rio San Jose 5 miles below the minesite. The Rio San Jose flows into the Rio Puerco, a major tributary to the Rio Grande, about 25 miles southeast of Laguna. The Rio Paguate watershed above the mine includes 107 square miles of drainage area, 68 percent of which is drained by the Rio Moquino. In and above the minesite, both rivers flow on alluvium that is at least 20 feet to more than 60 feet thick.

FIGURE 2-12 CONFLUENCE OF RIOS PAGUATE AND MOQUINO

The Rio Paguate has been rechanneled for more than 2,000 feet downstream from its entrance to the minesite. Channel characteristics (sinuosity and gradient--refer to the Glossary) of the relocated stretch are the same as those of the premining Rio Paguate.

The Rio Moquino has been extensively modified over a 4,000-foot segment immediately above its confluence with the Rio Paguate. Waste material has been dumped into the original channel on both sides, straightening the course of the meandering stream. Premining channel characteristics of sinuosity and gradient were 1.9 and .007, respectively, while those of the present Rio Moquino are 1.1 and .01, respectively.

The mean daily discharge of the Rio Paguate at the south end of the mine is 1.2 cubic feet per second (cfs), about half of which is supplied by surface discharge of ground water (base flow). Both the Rios Paguate and Moquino lose water from the points where they enter the mine to near their confluence. This loss is probably a response to dewatering of the mine. In the area of the confluence, both streams gain water from ground water discharge. Measurements at various times have shown that the streams gain between 43 and 135 gallons per minute (gpm) as they run through the minesite, while at other times they show a net loss of 83 gpm (Hydro-Search 1981). At the minesite, both streams usually flow all year (perennially); however, below the minesite, the Rio Paguate becomes intermittently dry (it is ephemeral).

Flow in the Rios Paguate and Moquino is generally moderate from January to March, elevated in March and April, low during the summer months, and moderate from October through December. Short-term peak flows occur in the summer in response to thunderstorms. The highest flow recorded on the Rio Paguate was estimated to be 2,300 cfs (USDI, Geological Survey 1976). Flood estimates of peak discharges at the southern mine boundary are 1,520 cfs for a 5-year flood; 6,290 cfs for a 100-year flood; and 10,500 cfs for a 500-year flood.

The chemical quality of the Rios Paguate and Moquino generally degrades as the rivers flow from their sources toward the Rio San Jose. This degradation is due to the geologic materials traversed by the streams, and to the influences of man. Data on premining water quality is nonexistent.

Water in the Rio Moquino is a sodium-calcium-magnesium-sulfate type (i.e., it is dominated by these constituents), and has a total dissolved solids (TDS) content of about 2,500 milligrams per liter (mg/l). Water in the Rio Paguate above the Rio Moquino is a magnesium-bicarbonate type, with TDS content of about 600 mg/l. Below the confluence of the streams, the water in the Rio Paguate is of the same type as in the Rio Moquino, with TDS of about 1,600 mg/l. Measured pH values of Rios Paguate and Moquino waters within the minesite range from 7.4 to 8.5 (Hydro-Search 1981).

Ponding in Open Pits

Because the Jackpile Sandstone is a major bedrock aquifer in the area, its excavation in the open pits during mining has resulted in significant ground water seepage into the pits. A large spring on the Rio Paguate side of the North Paguate Pit is flowing at about 100 gallons per minute into the pit. During mining operations, this water was used for dust suppression on roads, so the ponds were small. However, since mining has ceased, the water level in the pits has been increasing, and water depths averaging 18 feet deep have been recorded within the major ponds that have formed in each of the three pits. The surface water drainage area for water collecting in the pits is about 2 square miles. About two-thirds of the pond water is derived from ground water seepage, and one-third from runoff. The pits presently contain 36 acres of water surface and store about 455 acre-feet of water volume. The salt load collected in the pits is about 130 tons annually.

The quality of water in open ponds in the pits is poor. Water quality analyses were taken over a 3-year period (end of 1974 to end of 1977) from the P-10 and Rabbit Ear holding ponds (Hydro-Search 1979). These two ponds have since been drained; however, their analysis gave an indication of pit water conditions.

The P-10 pond contained water pumped from underground mine workings in the Jackpile Sandstone. As could be expected, the water was of the same type as Jackpile aquifer water and was chemically indistinguishable from the ground water.

The Rabbit Ear pond contained water pumped from pit seepages. This water was of much poorer quality than the ground water, due in part to concentration by evaporation. It was a sodium-sulfate-type water that increased in concentration over the 3-year period.

Total dissolved solids ranged from 1,500 to 4,900 milligrams per liter (mg/l), with sulfate values from 1,000 to 3,200 mg/l. (New Mexico standards are 1,000 mg/l and 600 mg/l, respectively.) The pH ranged from 8.1 to 8.6.

Other analyses of water ponded in the three mine pits were conducted in December of 1982 (Dames & Moore 1983). These tests found TDS values from 900 to 3,300 mg/l, sulfate values from 540 to 2,270 mg/l, and a pH range of 6.9 to 8.4 The high and low pH values came from the Jackpile pit; the low values were found in the southern part of this pit, and the high values occurred in the northern part.

More recent analysis (BIA 1984) have been completed on pond waters taken from the same locations as the December 1982 samples. This series of tests has shown the evaporative concentration of pond waters is causing an annual increase in water conductivity ranging between 300 and 2,000 micromhos per centimeter per year (μmho/cm/yr), an average of 975 umho/cm/yr. Sulfate is increasing at an average rate of 565 mg/l per year. The TDS has increased over 900 mg/l since the earlier samples at the Jackpile pit.

Water Use

Surface waters from the Rios Paguate and Moquino are used for irrigation upstream from the villages of Paguate and Seboyeta, respectively. Surface water is also consumed by livestock at Paguate Reservoir, and on the Rio Paguate between the reservoir and the minesite at points of access. The incidence of human consumption of surface waters from the Rio Paguate Basin is not known.

Sulfate concentration is the limiting factor for use of water in most of the mine area. The water in the Rio Moquino is high in sulfate before it reaches the minesite; this high-sulfate water also dominates the water quality in the Rio Paguate below its confluence with the Rio Moquino. It is within the range acceptable for livestock use and may even be used for irrigation of crops semi- tolerant to salinity, but is not recommended for human consumption.

Above the confluence and within the minesite, water of the Rio Paguate is of good quality. The stream is designated by the New Mexico Water Quality Control Commission for the following uses: domestic water supply, fish culture, high quality coldwater fishery, irrigation, livestock and wildlife watering, and secondary contact recreation. This water is within the range acceptable for livestock use and irrigation, but due to occasional increases in sulfate it is considered unpalatable for human consumption.

Although the ponds in the pit bottoms are a consequence of mining activities and were not planned for livestock use, irrigation, or human consumption, incidental unauthorized use of the pond water could occur.

Concentrations of some elements fail to meet standards established by the Environmental Protection Agency (EPA--40 CFR, Part 141.11; 40 CFR, Part 143.3) for public supply, agricultural, and industrial use. Table 2-26 lists surface water quality data from sample sites (Visual A) where element levels exceed EPA drinking water standards.

Ground Water

Water-Bearing Units (Aquifers)

The ground water characteristics of the sedimentary strata exposed in the Laguna area are given in Table 2-27. Stratigraphic descriptions are found in the Geology section of this chapter.

Data from 17 wells within the lease area has been used to characterize the quality of the ground water. Typical Jackpile Sandstone water is a sodium-sulfate-bicarbonate type of pH 6.5 to 8.3. TDS concentrations range from 600 to 2,600 mg/l. Minor chemical constituents are generally at low concentrations.

Alluvial water at the minesite has higher calcium, magnesium and TDS levels (average 1,332 mg/l) compared to typical Jackpile Sandstone water (Hydro-Search 1981).

Recharge and Flow in the Pit Areas

Ground water flow in the minesite area converges on the Rio Paguate and Rio Moquino. Data indicates that most of the flow into the area is from locations high on the flanks of Mount Taylor to the west, and probably from Mesa Chivato to the north (Hydro-Search 1981). Much of the flow from the west is intercepted by the North and South Paguate pits. Local flow from the east probably comes from Gavilan Mesa. Flow in the southeast part of the mine is not defined, but is probably toward the Rio San Jose to the southeast.

Seepage is obvious on the walls of the North Paguate, South Paguate and Jackpile pits at elevations much higher than ponds at the pit bottoms. One large seep in the North Paguate pit flows approximately 100 gallons per minute. The ponds are also below water levels in adjacent wells. Potentiometric surface contours indicate ground water seepage into the pits. About two-thirds of the water in the pits is thought to be from ground water seepage, the remainder is from surface runoff. Water loss is by evaporation, and when the mine was operative, by use of this ponded water to wet roads. Salt balance and water balance calculations suggest that 150 acre-feet, or one-third of the water contained in the ponds, is gained by, and then evaporated from, the ponds each year. Premining ground water, however, would have flowed across and

TABLE 2-26

CHEMICAL QUALITY OF SURFACE WATER: DISSOLVED CONSTITUENTS THAT EXCEED NATIONAL DRINKING WATER STANDARDS

	Constituents[a/], [b/]						
	SO_4	Na	Mn	F	B	Se	Ra-226[c/]
EPA Standard	600	250	0.050	1.4-2.4	0.75	0.01	15.0
Sample Identification[d/]							
RM 104	1,000		0.1				
RM 105	1,550	330	0.08				
RP 108	665		0.17				
RP 109	925		0.1				
Pond V	1,879	1,094		2.5	0.76	0.03	18.0
Pond W	2,117	444				0.05	46.0
Pond Y	1,052	377					22.0
Pond Z	3,592	908					

Sources: Hydro-Search 1981; Dames and Moore 1983; USDI, BIA 1984.

Notes: [a/] All constituents in milligrams per liter except where noted.
[b/] SO_4=sulfates, Na=sodium, Mn=manganese, F=fluoride, B=boron, Se=selenium, Ra-226=radium-226.
[c/] Measured in picocuries per liter.
[d/] Refer to Visual A for location; RM refers to the Rio Moquino and RP to the Rio Paguate; Pond V - South Paguate pit; Pond W - North Paguate pit; Pond Y - Jackpile pit (south end); and Pond Z - Jackpile pit (north end).

TABLE 2-27

GROUND WATER CHARACTERISTICS OF THE STRATIGRAPHIC SECTION AT THE JACKPILE-PAGUATE MINE

Formation	Yield and Water-Bearing Properties [a]
Alluvium	Yields of 15 to 90 gpm; quality good
Colluvium	Mostly above water table
Mancos Shale Dakota Sandstone	Yields from Tres Hermanos Sandstones range from 5 to 20 gpm; quality fair to good
Morrison Formation	
Jackpile Sandstone	Principal bedrock aquifer; yields of 8 to 34 gpm; quality fair to poor; under confined conditions
Brushy Basin Member	Yields of 25 to 100 gpm from sandstone lenses; quality fair to poor
Westwater Canyon Member	Yields up to 5 gpm; quality poor
Recapture Member	Not known to yield water to wells
Bluff Sandstone	Yields to 20 gpm reported; quality poor
Summerville Formation	Not known to yield water to wells
Todilto Formation	Not known to yield water to wells
Entrada Sandstone	Yields of 4 to 10 gpm; quality poor

Source: Modified from Dames and Moore 1976.

Notes: [a] Abbreviations: gpm = gallons per minute; TDS = total dissolved solids; ppm = parts per million; SO_4 = sulfate. Water Quality: Good = TDS below 500 ppm, SO_4 below 250 ppm; Fair = TDS 1,000 to 500 ppm, SO_4 300 to 250 ppm; Poor = TDS above 1,000 ppm, SO_4 above 300 ppm.

through the present pit areas, in a northeasterly and easterly direction at the North and South Paguate pits, and in a generally southwesterly direction at the Jackpile pit (Hydro-Search 1981).

Interpreting potentiometric surface contours in the Gavilan Mesa area is highly speculative. The most plausible direction of flow is from Gavilan Mesa, the highest local area, toward the northwest, west, and southwest.

Hydro-Search (1979) describes water gains to the Rios Paguate and Moquino of about 20 gallons per minute near their confluence, and water losses from the Rio Paguate in the segment from the Village of Paguate to 1,000 feet above the confluence. The potentiometric surface contours indicate that water gains come from the Jackpile Sandstone, which discharges into the Rios Moquino and Paguate near the confluence. The contours do not show ground water mounding under the Rio Paguate (upstream from the confluence). It is likely that the waste rock underneath the modified Rio Paguate in this area is permeable enough to drain water losses from the river without ground water mounding (refer to the Glossary).

Little data is available to accurately describe water flow through pit backfill and waste dumps. A well drilled into the Jackpile pit backfill at the southwest end of the pit determined that the water table elevation was 5,968 feet in August 1981. The direction of flow could not be determined. A well drilled into backfill at the north end of the South Paguate pit determined a water table altitude of 5,981 feet in June 1981. This water likely flows south to the low point of the South Paguate pit, north towards the Rio Paguate, or both. Pit backfill above the water table may become partly saturated after major storms.

The recharge rate in the Rio Paguate drainage basin is about 0.1 inches per year, based on the calculated sum of base flow and underflow through alluvium. Rates may vary locally with elevation, ground slopes, rock type, and distribution of alluvial and aeolian deposits. For instance, recharge is probably greater in alluvium at valley bottoms than it is on exposed bedrock. Regional recharge to rocks at the mine is from high areas on the flanks of Mount Taylor to the west, and probably from Mesa Chivato to the north. Some recharge may occur locally at the mine, especally on Gavilan Mesa, where it is likely that a perched water table exists in fractured Mancos Shale and Dakota Formation. This water likely recharges the underlying Jackpile Sandstone aquifer in this area.

The hydraulic conductivity is about 22 feet per day for the undisturbed alluvium, and 0.3 feet per day for the Jackpile Sandstone and sandstone lenses of the Brushy Basin Member. Most of the local water flow in alluvium and the Jackpile Sandstone discharges to mine pits, underground mines, and the Rios Paguate and Moquino. Permeability and hydraulic conductivity of the disturbed material and existing backfill is highly variable. Among ten recent well tests in backfill, one yielded a permeability value of 2,700 feet per day, one a value of 13 feet per day, and the remainder between 1.2 and 6.2 feet per day (Dames & Moore 1983).

Flow in Waste Dumps

Most precipitation falling on waste dump tops at the minesite either evaporates, infiltrates uniformly into the dump materials, or collects in depressions, dissipating by flowing vertically downward into cavities (pipes). No seepage faces have been observed at the bases of dumps during dry weather, indicating that saturation is of limited duration, or that flow may be vertical through the dump bases to the underlying alluvium. Hydraulic conductivity and local soil piping may promote rapid infiltration and discharge of water from high rainfall events, preventing long-term saturation. Cross-sectional flow analyses of precipitation infiltration into waste piles confirm that the formation of a saturated zone in waste dumps is unlikely because of evaporation of surface and near-surface water, and, to a lesser degree, the effects of high hydraulic conductivity in draining off water from large storms.

Water Use

Ground water on the Laguna Pueblo is used for livestock, public supply and industry. As of 1975, the pueblo maintained 52 stock wells on tribal lands; these wells averaged less than 5 gallons per minute (gpm). The majority of the population is served by a central water supply system, extending from Seama to Mesita. The system, which has a combined pumping capacity of 385 gpm, receives its water from wells drilled into alluvium of the Rio San Jose at the western end of the pueblo, at New Laguna, and at Mesita (Lyford 1977). The Village of Paguate obtains water from two wells (averaging 90 gpm) located in the alluvium of the Rio Paguate upstream from the minesite.

Industrial water usage at the minesite during mining averaged 17 gpm, mostly from Well 4 in the Jackpile Sandstone. Approximately 200 gpm were removed by dewatering of the underground workings. One water well, the IR-Test 9 in Township 10 North, Range 5 West, Section 26, exists in the alluvial aquifer down-gradient from the mine; this well is plugged and abandoned (Lyford 1977).

Table 2-28 lists ground water quality data from sample sites (Visual A) where element levels were found to exceed EPA drinking water standards.

Erosion

Arroyo Headcutting

Many arroyos in central New Mexico are actively eroding by headward cutting, a process by which the arroyo bed forms a near-vertical face (headcut) that migrates upstream as erosion of the bed continues (Figure 2-13). In response to lowering of the bed of the main arroyo, headcuts often migrate up tributary streams, and significant amounts of soil loss result.

Arroyo headcuts near the minesite have moved as far as 650 feet during the 43 years between 1935 and 1978. Aerial photography indicates that headward cutting of arroyos was an active premining process. The main

TABLE 2-28

CHEMICAL QUALITY OF GROUND WATER: DISSOLVED CONSTITUENTS THAT EXCEED NATIONAL DRINKING WATER STANDARDS

	Constituents [a], [b]									
	SO_4	Na	Cd	Pb	Se	Fe	Mn	B	Co	Ra-226[c]
EPA Standard	600	250	0.01	0.05	0.01	0.30	0.05	0.75	0.01	15.0
Sample Identification[d]										
M-1P		305					0.085			22.0
M-2P							0.09		0.02	
M-4	1,230	294				0.44	0.09			
M-5		340	0.16	0.13			0.085			
M-6		295							0.02	
M-8		305					0.11			
M-10P		390							0.06	
M-14P	920	418				0.64	0.39		0.07	
M-16P	672	390				0.41	0.19		0.06	
M-22		305					0.21			
M-23		380								
M-24P	2,010	915					0.74	0.96		
B	5,560	1,400				139.00	1.7	1.2	0.2	
C	3,540						0.5			
D	2,010	1,160				0.34	0.17			

Sources: Hydro-Search 1981; Dames and Moore 1983; USDI, BIA 1984.

Notes: [a] All constituents in milligrams per liter except where noted.
[b] SO_4=sulfates, Na=sodium, Cd=cadmium, Pb=lead, Se=selenium, Fe=iron, Mn-manganese, B=boron, Co=cobalt, Ra-226=radium-226.
[c] Measured in picocuries per liter.
[d] Refer to Visual A for location.

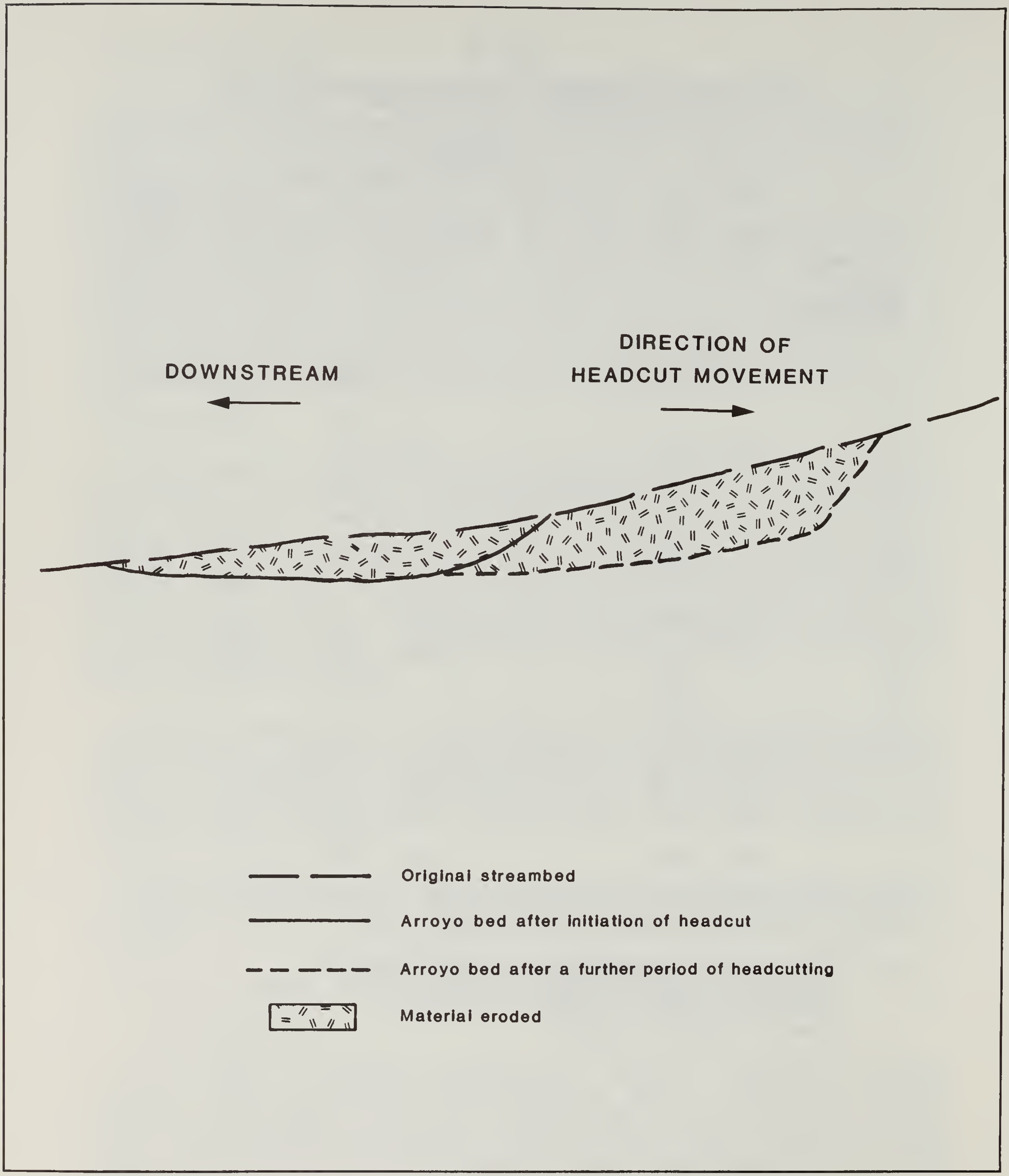


FIGURE 2-13

Cross-sectional, schematic diagram of arroyo headcut migration.

mechanisms responsible for headcutting at the minesite are rapid surface flow from floodwaters and, more importantly, piping. Caving of arroyo banks results when piping occurs near arroyos. At the minesite, piping is extensive at the most unstable headcuts.

Several areas of arroyo instability exist at the minesite, the most important of which are: (1) south of I, Y, and Y2 dumps; (2) west of dump FD-3; and (3) west of the airstrip (Visual A). The westernmost arroyo headcut system south of dumps I, Y and Y2 moved 100 feet upstream between 1935 and 1978. The amount of headward cutting on the arroyo just west of J dump could not be determined due to burial of the arroyo by the dump. This general area is highly unstable, and has 10 to 15 active headcuts that move by piping-induced bank caving. Because these headcuts have threatened the haul road at the base of I, Y and Y2 dumps, Anaconda has placed artificial fill at headcuts and constructed drainage diversions. The fill has slowed headward erosion, while the diversions have accelerated such erosion. Surface erosion and piping have continued to act in and around these modifications, making them only temporary measures.

The southwest-flowing arroyo west of dump FD-3 is discontinuously entrenched, and has several headcuts (Figure 2-14). The segment of this arroyo downstream from the road is very unstable due to piping and bank caving. The headcut at the road has been treated with artificial fill, but a bypass headcut that will threaten the road is forming. Headcuts upstream from this area are held up by resistant sandstone, which renders them relatively immobile.

FIGURE 2-14 ARROYO HEADCUTTING NORTH OF FD-3 DUMP

The arroyo headcut west of the airstrip moved upstream 650 feet between 1935 and 1978. This rapid movement occurred in easily erodible, thick alluvium; however, the headcut is now located in apparently less erodible alluvium, with only minor piping present. Anaconda has dumped artificial fill at the headcut located at the road, and the fill seems to be successfully inhibiting further movement.

As a consequence of mining activities, three arroyos at the minesite have been blocked by waste dumps or protore stockpiles (Visual A). The drainage blocked by waste dump J and protore stockpiles SP-17BC and SP-6-B will be unblocked during reclamation as all of these materials will be used as pit backfill. The drainages north of waste dumps F and FD-1 will remain blocked. The drainage areas upstream from these blockages measure 0.9 square miles and 1.7 square miles, respectively. These arroyos are normally dry, except during and immediately after thunderstorms when water ponds at the blockages. In general, the ponded water is quickly lost to infiltration and evapotranspiration. Up to 16 feet of water could be ponded north of F dump after a 24-hour rainfall (100-year flood). A maximum of about 25 feet of water could be ponded north of FD-1 dump after such a rainfall. Both blockages are sufficiently high to hold such a quantity of water.

Sedimentation in Paguate Reservoir

Sediment has nearly filled Paguate Reservoir since construction of the dam in 1940. Dames and Moore (1980) calculated that the rates of deposition in the reservoir during 1940-49 and 1949-80 were 71 acre-feet per year and 22 acre-feet per year, respectively. The higher rate of deposition from 1940 to 1949 was due to:

1. Greater sediment transport due to above-normal precipitation; and, more importantly,

2. Much greater efficiency of sediment entrapment in the early years. Efficiency would have been 100 percent just after construction and would have decreased as sediment filled the reservoir.

Based on the lower rate, the volume of sediment deposited since mining began (1952) is 620 acre-feet, or 47 percent of the total 1,333 acre-feet per year accumulated.

Stream Stability

Above the Rio Moquino/Rio Paguate confluence, the Rio Paguate is a non-meandering stream incised into alluvium between 33 and 69 feet. Aerial photographs show that essentially no lateral migration of the channel occurred from 1935 to 1951. Vertical change (incision or deposition) in the river bed has also been minimal (less than 2 feet), as no headcuts or mid-stream bars have been noted on the pre- and post-mining stream. Vegetation inside the main channel in 1935 and 1980 was dense and stable in appearance. These observations, taken together, suggest that this reach of the Rio Paguate had attained a stable state before mining. Because the channel characteristics of the relocated channel are similar to those of the pre-mining channel, the stream should remain in a stable condition.

The Rio Paguate below the confluence is incised up to 65 feet into alluvium. This segment also showed essentially no lateral migration between 1935 and 1951, and vertical instability (headcuts or deposition) was not seen on pre-mining photographs and during field checks. This section of the Rio Paguate, like that above the confluence, apparently was stable in regard to lateral and vertical changes before mining. Because present channel characteristics are similar to those existing before mining, the stream is expected to remain in a stable condition.

Dumping of mine waste material onto meanders has considerably straightened the Rio Moquino. The stream, which is incised from 40 to 68 feet into alluvium, meandered with no evidence of vertical instability (incision or aggradation) before mining. The meander belt of the pre-mining stream was 400 feet wide. Lateral channel migration by this stream of up to 150 feet between 1935 and 1951, as well as historical lateral movement of up to 250 feet, has occurred at the minesite. These significant rates of lateral channel migration suggest that the pre-mining Rio Moquino meandered across its alluvial plain at the minesite with little resistance. Analysis of data from drill holes adjacent to the Rio Moquino confirms that, in most places, no geologic constraints exist to lateral channel movement. For the past several years, the river has not migrated laterally or incised vertically as shown by field checks. However, historical evidence indicates that this stretch of the Rio Moquino still retains a significant potential for lateral migration.

Waste Dump Slopes

The 32 waste dumps at the mine cover approximately 1,266 acres, or about 48 percent of the total disturbed area. The dump materials consist of Mancos Shale, Dakota Sandstone, and both barren and ore-associated Jackpile Sandstone. The waste dumps approximate the form of nearby mesas; that is, the majority of their areal extent is composed of relatively flat dump tops that abruptly change to steep slopes. The height of the waste dumps ranges from 20 to 230 feet, and the slope percentage from 15 to 51 percent. Table 2-29 gives slope percentage, length and height of the larger dumps.

Reclamation attempts have been made on approximately 485 acres of 17 waste dumps (Anaconda Minerals Co. 1982). Waste dumps tops have been revegetated with varying success. Revegetation of dump slopes has failed because of steepness, length of slopes and resultant erosional soil loss. Most dump slopes have been cut by gullies greater than 8 feet wide and up to 13 feet deep. Dumps E, I, S, T and V have been severely gullied. Most of the larger gullies have been initiated by piping at dump crests and the resultant flow of water diverted from dump tops into pipes and down steep slopes. However, numerous smaller gullies have formed in the middle of dump slopes. This indicates the water velocities resulting from rainfall and runoff on steep slopes are sufficient to initiate gully erosion.

TABLE 2-29

WASTE DUMP DIMENSIONS

Waste Dump	Slope Percent	Height (feet)	Slope Length[a] (feet)
FD-2	37	230	423
FD-3	47	130	195
I[b]	15	50	206
I (Slope Segment 1)	41	120	120[c]
I (Slope Segment 2)	43	40	40[c]
I (Slope Segment 3)	38	20	20[c]
N[b]	47	80	120
N	41	46	76
N	30	40	89
N2	34	30	58
R	51	25	35
South[b]	50	90	127
South	50	140	198
South	35	60	112
SP-1	42	31	51
SP-2	40	40	68
T	42	100	164
U[b]	41	60	100
U	34	60	100
V[b]	43	215	345
V	40	150	258
Y	40	115	196
Y2	41	150	249

Source: Anaconda Minerals Co. 1980.

Notes: [a] Slope length = surface extent of slope measured from toe to crest.

[b] Measurements were made at more than one location on these waste dumps, as follows: I - two locations (three segments at one location), N - three locations, South - three locations, U - two locations, and V - two locations.

[c] Total slope length of waste dump I at this location = 180 feet.

The existing rates of sheetwash and small rill erosion, calculated with the Universal Soil Loss Equation (USLE), range from 27 tons per acre per year to 105 tons per acre per year (Table 2-30). The USLE is an empirically developed equation which relates soil loss to amount, frequency, and intensity of rainfall, soil characteristics, length of slope, slope angle, vegetation or ground cover and erosion control practices. Cumulative gully erosion (calculated by measurement of gully dimensions) ranges from 4 tons per acre to 561 tons per acre, and the mean annual rate is 15.6 tons per acre per year. Total computed and measured erosion (sheetwash plus gully erosion) ranges up to 121 tons per acre per year by adding 15.6 tons per acre annual mean to the calculated sheetwash erosion (Table 2-30).

A positive correlation has been found between accelerated erosion and long, steep slopes. The least amount of calculated and measured erosion occurs on the most gentle slopes and also on those slopes that are covered by boulder-size rock debris. Therefore, the main factors controlling erosion on dump slopes are slope length, steepness, and surface roughness; of these, slope steepness and roughness seem to be the most critical.

AIR

Meteorology

Temperatures

Monthly mean temperatures at the meteorological station at the Village of Laguna range from the mid-30's (degrees Fahrenheit) in winter to the mid-70's in summer. Large annual and daily temperature ranges are characteristic, but extended periods of below-freezing temperatures are rare. Summer temperatures average in the upper 80's with occasional maximums over 100°F, but long spells of temperatures over 100°F are unusual.

Precipitation

The mean annual precipitation at Laguna is 9.07 inches, about 61 percent of which occurs from June to September as rain, mostly from short, intense thunderstorms. Precipitation frequencies range, on the average, from 1.2 inches per 24-hour period every 2 years, to as much as 2.8 inches per 24-hour period every 100 years (U. S. Department of Commerce 1967). Annually, an average of 7.3 inches of snow is received, 60 percent of which occurs in December and January. Because of generally warm afternoon temperatures, snow rarely accumulates.

Evaporation

The mean annual pan evaporation (refer to the Glossary) at Laguna is about 70 inches, more than 60 percent of which occurs from May to September. Mean annual pan evaporation is about 61 inches more than mean annual precipitation, resulting in a net moisture deficit.

TABLE 2-30

SHEETWASH AND TOTAL EROSION FOR SELECTED WASTE DUMP SLOPES
(tons per acre per year)

Waste Dump(s)	Sheetwash Erosion	Total Erosion[a]
A & B	61.2	76.8
C,D,E,F,G	52.7	68.3
FD-3	100.3	115.9
I	51.6	67.2
K	59.5	75.1
L (South)	39.1	54.7
N	49.9	65.5
N2	28.9	44.5
P1	34.0	49.6
P2	64.6	80.2
R	27.2	42.8
S (North)	59.5	75.1
South	90.9	106.5
T	76.5	92.1
U	56.1	71.7
V	105.4	121.0
Y	76.5	92.1
Y2	93.5	109.1

Source: BLM 1983.

Note: [a]Total erosion = sheetwash erosion + gully erosion.

Moreover, months of greatest evaporation correspond to months of greatest rainfall, compounding aridity problems.

Winds

Winds in the mine area are generally of light to moderate intensities, with wind speeds greater than 15 miles per hour (mph) accounting for less than 11 percent of all occurrences. However, strong winds may accompany frontal storms during winter and spring months, and occur during intense summer thunderstorms. Average wind speeds are greatest during the spring months. Average wind speeds range from 5.3 mph from the east, to 11.6 mph from the west-northwest.

Surface winds at the mine occur primarily from the southeast and northwest. Nocturnal winds flow from higher areas to the west and northwest, at an average of 7 mph. The most frequent daytime winds are from the southeast. However, the strongest winds are northwesterly, with speeds averaging 13.5 mph.

Air Quality

Anaconda has four air quality sampling stations at the minesite. The samplers monitor suspended particulate levels and several radionuclides (discussed in the Radiation section of this chapter). The State of New Mexico operates an air quality monitoring station at Paguate Village. No pre-mining data are available.

Particulates

Total suspended particulates (TSP) have been measured at the mine since 1973. Sampling techniques have varied throughout the monitoring program. Prior to 1979, an average of one 24-hour TSP sample per month was taken from the West Gate and Well 4 stations. Since 1979, one 168-hour sample has been taken each month at the four sampling stations. The annual geometric mean and seven-day average of TSP values from 1979 to 1981 are presented in Table 2-31. These data show that TSP levels have mostly been within State of New Mexico standards. The general trend of decreasing TSP values from 1979 to 1981 may be due to decreased mining activity.

TSP data have also been obtained at the State air quality station at Paguate. The data has been collected from weekly 24-hour samples. For 1979 through 1982, the annual geometric means of TSP at this station were 79, 56, 59, and 35 micrograms per cubic meter (mg/m^3), respectively (Table 2-31); these compare to State and Federal standards of 60 and 75 respectively. Again, decreasing values may reflect decreased mining activity. Generally, TSP standards have been met both at Paguate Village and the mine, although the seven-day average and annual geometric mean standards have sometimes been exceeded.

Other Pollutants

Neither Anaconda nor the State has measured sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), or lead (Pb) levels at the minesite

TABLE 2-31

TSP DATA FOR THE JACKPILE-PAGUATE MINE, 1979-1981
(values in micrograms per cubic meter)

	Dump F	Mine Vent	West Gate	Well 4	Paguate
Range	2-172	2-62	2-101	2-96	— [a]
Annual Geometric Mean [b]					
1979	50	9	35	21	79
1980	29	9	28	32	59
1981	15	15	22	14	56
High Seven Day Average [c]					
1979	172	27	95	96	—
1980	98	62	101	72	—
1981	48	46	82	38	—

Source: BLM 1984.

Notes: [a] The symbol — reflects data not available.
[b] State standard = 60
Federal standard = 75
[c] State standard = 110

or Paguate Village. Because these constituents are associated with major point-source polluters and metropolitan areas with many automobiles, they are probably present in only trace amounts at the mine.

Anaconda conducted a brief monitoring program for nitrogen dioxide (NO_2) in February 1973, and found that 24-hour average concentrations ranged up to a maximum of 0.0079 parts per million. This is well below the New Mexico 24-hour average standard of 1.10 parts per million.

SOILS

Undisturbed Soils

Natural soils in the vicinity of the Jackpile-Paguate mine are shallow in most upland areas (generally less than 3 feet deep) and are significantly deeper in the valleys (up to 6 feet deep) because of alluvial depositions. The upland soils belong to the Penistaja-Travesilla-Rockland Association. The Penistaja soils occur on gently to strongly undulating valley slopes, and consist of shallow surface layers of brown, fine, sandy loam over subsoils of brown, sandy, clay loam. Below this horizon is a loam with lime concretions and a prominent lime zone below a depth of 40 inches. Travesilla soils, which are underlain by sandstone at shallow depths, occur on valley slopes and mesa tops. They are composed of a shallow surface layer of brown, fine, sandy loam underlain by a coarse-grained, sandy subsoil over sandstone bedrock. Rockland soils consist of a shallow, coarse-grained, sandy mantle of soil between outcrops on steep slopes.

Valley soils belong to the Lohmiller-San Mateo Association. Lohmiller soils, which are deep, fine-textured, and locally saline, occur on floodplains and swales. These soils have a brown, calcareous, clay loam topsoil underlain by brown, heavy clay, silty clay, or clay loams. San Mateo soils occur on floodplains and consist of a surface layer of brown, calcareous loam underlain by 5 feet or more of sandy and light clay loams.

Stockpiled Soils

Approximately 3.1 million cubic yards of topsoil material were stockpiled at the mine. These soils consist of some Lohmiller and Penistaja, but mostly Rockland types. The Rockland soils consist primarily of crushed Tres Hermanos Sandstone. The important chemical and physical properties to the Tres Hermanos Sandstone are indicated in Table 2-32. The stockpiled soils are situated at three different locations within the minesite (Figure 2-15).

Soil Borrow Site Characteristics

Soils at the borrow site (Visual A) are Lohmiller types, which include clay loams and sandy clay loams. These are deep, fine-textured soils that the U.S. Soil Conservation Service classifies as having fair permeability, fair to good salinity, good moisture-holding capacity, and fair to good organic matter content. Arsenic and selenium concentrations are low. Chemical and physical properties are given in Table 2-33.

TABLE 2-32

CHEMICAL AND PHYSICAL PROPERTIES OF THE TRES HERMANOS SANDSTONE
[concentrations in parts per million (ppm)]

Calcium (Ca)	7,850
Magnesium (Mg)	1,465
Sodium (Na)	40
Potassium (K)	238
Phosphorus (P)	4.1
Nitrate (NO_3)	24.6
Iron (Fe)	.02
Zinc (Zn)	.25
Cadmium (Cd)	.28
Copper (Cu)	.5
Manganese (Mn)	18.0
Lead (Pb)	1.0
Mercury (Hg)	.005
Cobalt (Co)	.12
Chromium (Cr)	.05
Nickel (Ni)	.45
Arsenic (As)	.3
Selenium (Se)	.03
Chlorine (Cl)	15.7
pH	7.2
Organic matter	0.5 percent
Cation exchange capacity	8.8
Electrical conductivity	0.8 mmhos/cm
Moisture content at field capacity	35.9 percent

Source: Los Alamos National Laboratories 1979.

FIGURE 2-15 TOPSOIL STOCKPILE TS-3

TABLE 2-33

CHEMICAL AND PHYSICAL PROPERTIES OF SOIL BORROW SITE

Selenium (Se)	<.1 ppm
Nitrate (NO_3)	14.38 ppm
Phosporus (P)	.20 ppm
Potassium (K)	133 ppm
Boron (B)	1.37 ppm
Arsenic (As)	<.2 ppm
pH	7.85
Organic matter	1.2 percent
Electrical conductivity	4.02 μhos/cm
Moisture - 1/3 Bar	24.1 percent
- 15 Bar	12.0 percent

Source: Ludeke 1983.

FLORA

Within the 7,868-acre lease area there are presently three types of physical terrain successional situations:

Undisturbed Natural Vegetational Areas (4,727 acres)

These undisturbed portions of the lease area are characterized by broad mesas and plateaus separated by deep canyons, wide alluvial valleys and dry washes. Elevations range from 5,800 feet in the valley bottoms to 6,700 feet on the mesa tops. Three types of natural settings occur on the undisturbed terrain. Dominant topographic features and associated plant species are described as follows:

Valley Bottoms

Valley bottoms can be level, undulating or incised. They have moderately deep to deep soils that support shrub species such as fourwing saltbush, rabbitbrush, cholla and broom snakeweed. Prevalent grasses include alkali sacaton, galleta, feathergrass and red threeawn. Forbs that are plentiful include fleabane fireweed, sandverbena, stickleaf, paperflower, daisy and cutleaf primrose.

Only a small portion of the riparian habitat along the Rio Moquino was left undisturbed by mining activity. Plant species commonly found in this area include saltcedar, desert willow, Emory baccharis and rabbitbrush. Understory grasses include alkali sacaton, galleta, cane bluestem and western wheatgrass.

Mesa Slopes

Mesa breaks and sideslopes are steep and have shallow to moderately deep soils interspersed with rock outcrop. These sites are occupied by scattered woody plants which include one-seed juniper, feather indigobush, soaptree yucca and winterfat. Understory grasses include galleta, feathergrass, red muhly, red threeawn, blue and sideoats gramas, bottlebrush squirreltail and wolftail. Understory forbs include wild buckwheat, pinque, plains blackfoot and stickleaf.

Mesa Tops

Mesa tops are nearly level to undulating and have shallow rocky soils. These areas are generally dominated by a woody overstory consisting of one-seed juniper, soaptree yucca and rabbitbrush. Prinicipal grasses include galleta, feathergrass, Indian ricegrass, sideoats and blue gramas, red threeawn and bottlebrush squirreltail. Forbs include fleabane daisy, four o'clock and cutleaf primrose.

Surface Disturbed Areas Not Reclaimed (2,171 acres)

These areas primarily consist of open pits, waste dumps, protore stockpiles, depleted ore stockpiles, topsoil stockpiles and miscellaneous support facilities. Vegetation is either absent in these areas or in a low successional state with a sparse scattering of pioneer plants.

Dumps created by overburden removal contain a mixture of waste materials. The most common geologic materials that form the dumps are Jackpile Sandstone, Tres Hermanos Sandstone and Mancos Shale. The basal unit of the Dakota Sandstone is very thin within the lease area and therefore does not constitute a major portion of the overburden materials. Table 1-4 in Chapter 1 lists the surface composition of each waste dump. With few exceptions, the internal composition is unknown. It should be noted that the surface area of disturbance had reached sizeable proportions before reclamation became an important consideration. Therefore, the need for surfacing areas with a viable growth medium brought about an examination of the overburden strata.

The ability of plants to grow on overburden materials varies with several chemical properties. The low pH of the Dakota Sandstone eliminates it as a suitable growth medium. The Jackpile Sandstone and Mancos Shale are low in several major nutrients and restrictively high in sodium content. Observations of dump sites with various geologic substrates left undisturbed for 20 years show the following vegetational establishment: Dakota Sandstone - no vegetation; Mancos Shale - plants rare, some forbs and grasses; Jackpile Sandstone - plants rare, annual and perennial grasses, few shrubs; Tres Hermanos Sandstone - plants common, perennial and annual grasses and forbs, several shrub species.

As indicated, the Tres Hermanos Sandstone offers the best possibilities for plant establishment. However, in order to meet topdressing requirements, material may be required in addition to the Tres Hermanos Sandstone presently stockpiled at the mine. A topsoil borrow location, comprising approximately 44 acres, has been identified in the north - central portion of the lease area as the additional source. Chemical and physical properties of the Tres Hermanos Sandstone and soils from the borrow site are discussed in the previous section.

Surface Disturbed Areas Reclaimed (485 acres)

Between 1976 and 1979, Anaconda Minerals Company conducted reclamation activities on 17 waste dumps, comprising approximately 485 acres. Refer to Table 1-4, Chapter 1 and for waste dumps reclaimed to date.

Surface Preparation

In general, many dump tops were contoured, numerous small depressions constructed for water harvesting, and a series of erosion control berms were developed. The dump surfaces were initially conditioned with overburden and alluvial material that tested suitable from chemical and physical laboratory evaluations.

Following topsoil placement, the dump surfaces were ripped to a depth of approximately 8-12 inches followed by a fine surface soil scarification. Organic mulching was performed with the addition of two tons per acre of barley straw and incorporated into the soil profile utilizing a Finn notched disc crimper. The areas were fertilized at an average rate of 30-50 pounds per acre of nitrogen (N), 30 pounds per acre of phosphorous (P_2O_5), and 30 pounds per acre of potassium (K_2O) relative to deficiencies in the disturbed soils.

Plant Selection

Plant species used in previous reclamation efforts were selected primarily on the following characteristics: drought tolerance, season of growth, temperature tolerance, salinity tolerance, soil texture adaptation, vigor, rate of establishment, longevity, seed mix compatibility and grazing potential. Legumes were also considered for their nitrogen fixing characteristics. Plant selections were also made from this group to conform with edaphic conditions particular to the Tres Hermanos Sandstone growth medium.

Mixtures of plant species used in previous reclamation efforts at the mine are given on Table 2-34. The seeding rates were developed with the aid and recommendations of the Grants Office of the Soil Conservation Service (SCS), utilizing base information from non-irrigated land and critical area seeding technical guides. All seed drilling rates represented in Table 2-34 are higher than those of conventional guidelines and equal or exceed the seeding rates recommended for planting critical areas by the New Mexico Interagency Range Committee and the SCS.

In most situations, a seed mixture was planted with a rangeland drill. This type of machinery is adapted to rough and rocky terrain and is especially designed to operate efficiently in disturbed soil seeding environments.

Following seeding, barley straw was broadcast over the top of the seed and incorporated into the surface soil.

Revegetation Success

Sampling procedures and plant growth monitoring were conducted on an annual basis beginning in 1979 to include plant density (determined by the number of plants per species in one meter quadrant), and vegetative cover (measured by line intercept of a 30.5 meter transect line).

Reference areas were established on undisturbed areas around the mine area with vegetative types differing at the various locations. The areas were sampled for vegetative density, basal cover and botanical composition and were used for comparative purposes.

Success of vegetative establishment on the reclaimed areas relative to the reference areas is shown in Table 2-35. It should be noted that the reclaimed site cover and density figures were compared to an <u>average</u> reference site figure for cover and density.

TABLE 2-34

SEED MIXTURES USED FOR RECLAMATION FROM 1976 THROUGH 1979

Common Name	1976		1977		1978-1979	
	Percent of Mixture	PLS[a/] Mixture lbs./Ac.	Percent of Mixture	PLS Mixture lbs./Ac.	Percent of Mixture	PLS Mixture lbs./Ac.
Blue grama (Lovington)	30	1.05	25	.625	30	.9
Indian ricegrass (Paloma)	5	.4	10	.7	10	1.1
Fourwing saltbrush	0	—	5	1.8	5	1.5
Crested wheatgrass (Nordan)	0	--	15	1.2	0	--
Alkali sacaton	5	.4	15	.15	15	.25
Weeping lovegrass	10	.3	15	.15	15	.25
Sand dropseed	15	.15	10	.05	0	—
White clover	0	—	5	.1	0	--
Sideoats gramma	5	.7	0	—	10	1.8
Yellow sweetclover	0	—	0	—	5	.25
Western wheatgrass	5	1.0	0	--	10	2.4
Little bluestem (Pastura)	15	1.2	0	—	0	--
Sand bluestem	5	.8	0	—	0	—
Sweet clover	5	.4	0	--	0	--
TOTAL	100	6.4	100	4.78	100	8.45

Source: Anaconda Minerals Company 1982.

Note: a/Pure Live Seed

TABLE 2-35

RECLAIMED SITE TO REFERENCE SITE COMPARISONS FOR BASAL COVER AND DENSITY

	1980				1981				1982			
Site	Percent Cover	Percent of Reference Site Ave.	Density - Plants/M^2	Percent of Reference Site Ave.	Percent Cover	Percent of Reference Site Ave.	Density - Plants/M^2	Percent of Reference Site Ave.	Percent Cover	Percent of Reference Site Ave.	Density - Plants/M^2	Percent of Reference Site Ave.
C, D, E[a/]	2.62	59	23.1	32	4.38	71	55.66	69	3.70	60	48.28	71
F, G[a/]	2.83	64	17.0	24	5.47	89	69.85	86	6.12	59	23.28	34
J[a/]	6.49	146	60.75	85								
O, P, P1, P2[a/]	3.87	87	25.75	36	4.82	78	88.75	110	5.46	88	107.0	158
S[a/]	4.68	105	30.0	42								
X, I, Y2[b/]					5.21	85	67.0	84	4.44	72	70.54	104
T[b/]					4.05	66	76.66	95	4.25	69	107.0	158
L[b/]					1.68	27	418.75	518	3.19	52	57.0	84
K[b/]					2.14	35	694.32	859	3.66	59	110.33	163
Reference Site Average	4.45	100	71.5	100	6.16	100	80.83	100	6.17	100	67.74	100

Source: Ludeke 1983.

Note: [a/]Reclaimed 1976-1977.
[b/]Reclaimed 1978-1979.

Waste dumps S and J, reclaimed in 1976 and 1977, respectively, developed basal plant cover values that exceeded those of the native reference areas; therefore, monitoring studies were dropped in 1981 (Figure 2-16).

FIGURE 2-16 SUCCESSFUL REVEGETATION OF S DUMP

Waste dumps F, G, J, O, P, P1 and P2 were seeded in 1977 and reflect basal cover values of approximately 90 percent of the average cover estimates collected from reference areas. Dump sites I, T, X and Y2 were seeded in 1979, and after completion of three growing seasons, are exhibiting basal cover percentages near 70 percent of the reference areas sampled. Numerous dump sites sampled in 1982 have exceeded 100 percent of the plant density represented by the reference areas. These include dumps C, D, E, I, K, O, P, P1, P2, X and Y2.

No quantitative data exists to assess the establishment of vegetation for reclamation attempts on steep dump slopes. However, qualitative assessment indicates that almost no vegetation has been established on such slopes due to severe erosional problems and surface soil movement.

Table 2-36 lists levels of uptake of chemical and radiological constituents by plants on reclaimed sites. The heavy metal concentrations are below those generally considered to be toxic to livestock (5.0 parts per million).

TABLE 2-36

RECLAIMED SITE VEGETATION ANALYSIS

		Chemical[a]							Radiological[b]		
Sample Site	Date Taken	As	Se	Mo	Pb	V	Cd	Zn	Ra-226 (pCi/gm)	U-Nat. ($\mu g/gm$)	Th-230 (pCi/gm)
Dump J (R2)	7-17-79	0.25	1.0	0.7	1.2	1.0	0.1	25.0	1.59	1.02	0.53
Dump J (R4)	7-17-79	1.2	1.6	1.3	2.0	1.0	0.1	22.9	0.24	2.14	1.85
Dump S (Composite)	7-27-79	0.4	1.0	0.1	1.0	3.9	0.1	30.9	0.32	3.66	0.43
Dump S (R4)	7-27-79	0.4	1.0	0.1	0.5	3.0	0.1	35.0	0.28	1.76	0.52
Dump P1 (R3)	8-02-79	0.7	1.0	0.1	0.5	6.0	0.1	30.1	0.16	0.76	0.59
Dump C (R9)	9-24-80	0.3	0.07	0.7	0.5	0.9	0.1	32.0	1.15	7.13	1.17
Dump D (R8)	9-24-80	0.6	0.05	1.1	0.5	0.7	0.1	36.0	0.39	4.71	0.56
Dump E (R8)	9-24-80	0.7	3.0	0.7	0.5	0.8	0.1	57.0	1.14	5.37	2.56
Dump G (C4)	9-24-80	0.4	.49	0.1	0.5	0.5	0.1	43	1.02	2.89	0.84

Source: Anaconda Minerals Company.

Note: [a] All values are expressed in parts per million. As = arsenic; Se = selenium; Mo = molybdenum; Pb = lead; V = vanadium; Cd = Cadmium; Zn = zinc.
[b] Ra = radium; U = uranium; Th = thorium.

FAUNA

Many wildlife species prefer specific habitat types. The four wildlife habitat types and the animals typically associated with them in the area of the Jackpile-Paguate uranium mine are:

1. Grassland-desert shrub: Coyotes, prairie dogs, rabbits, rattlesnakes, gophers and several bird species.

2. Juniper "savanna": Foxes, squirrels, chipmunks, porcupines and a large number of bird species.

3. Riparian: Toads, lizards, invertebrates, ducks and other birds.

4. Bare ground: Coyotes, prairie dogs, other rodents and lizards.

A complete list of species to be found within the vicinity of the minesite is on file in the BLM Albuquerque District Office, Rio Puerco Resource Area.

The mine environment itself does not support an abundant wildlife population. Big game species are generally absent, with no individuals sighted in recent years. The natural flow of the Rios Paguate and Moquino does not support fish populations in the vicinity of the mine, although the Rio Paguate is classified by the State of New Mexico as a high quality coldwater fishery and is regularly stocked and fished above the minesite. The existence of the mine places a restriction on wildlife presence. The larger, more mobile species tend to avoid areas of human activity, and the significant acreage of barren ground offers little for wildlife other than burrowing habitat for rodents and lizards.

Threatened and Endangered Species

Within the mine leases occur no species of plants or animals included on (or proposed for inclusion on) the list of endangered and threatened wildlife and plants. The bald eagle, peregrine falcon and black-footed ferret are species on the endangered list that could range in the minesite area; however, they would be transients. No known sightings have occurred, and the mine environment would not be a favorable one for these species. The U. S. Fish and Wildlife Service has determined that no listed or proposed species would be affected by the proposed reclamation of the Jackpile-Paguate uranium mine (letter dated May 12, 1981).

CULTURAL RESOURCES

The entire Jackpile-Paguate mine lease area has been archeologically inventoried, with a total of 217 archeological sites recorded (Anschuetz, et al. 1979; Beal 1976; Carroll and Hooten 1977; Carroll, et al. 1977; and Grigg, et al. 1977). Of this total, 205 remain. Seven of the sites were excavated, and five were formally determined to be insignificant prior to their destruction by mining. These sites demonstrate that the mine area has been intermittently utilized since the Archaic period (approximately 5,000 B.C.).

The archeological sites range in date and size from Archaic scatters of chipped stone to Basketmaker (A.D. 400-700) pit house villages and Pueblo (A.D. 700-1600) stone masonry rooms. Many sites of modern trash and structures associated with recent sheepherding activity have also been recorded. Four of the archeological sites are also of religious concern to the Pueblo of Laguna.

Access to archeological sites on the mine leases is presently controlled by Anaconda Minerals Company to protect them from vandalism.

VISUAL RESOURCES

The Jackpile-Paguate uranium mine site consists of 2,656 acres of disturbance surrounded by natural relief features including plateaus, mesas and valleys typical of much of the southeastern Colorado Plateau physiographic province.

Mining operations caused substantial changes to the natural landform, line, color and texture, resulting in a dominant, unnatural appearance. Along with the reshaping of the landform within the minesite, the stream channels of the Rios Paguate and Moquino were modified from their natural meandering conditions. The contrast between the minesite and its surrounding has degraded the visual resources in the general area.

Ninety percent of the disturbed acreage from the minesite consists of waste dumps and open pits. The majority of the dumps are relatively flat-topped with steep-sided slopes, a basic form that is characteristic of the surrounding mesas. However, these new man-made landforms exhibit a lighter surface coloration and smoother texture than the surrounding landscape. Thus, the concentration of these dumps, along with their distinct difference in color and texture, create a setting that contrasts with and dominates the surrounding landscape. It should be noted that previous reclamation efforts by Anaconda have enhanced the visual resource qualities of several waste dumps.

The three open pits at the minesite consist of large depressions with steep highwall slopes. The depressions vary in depth, with the deepest being the Jackpile pit (625 feet). The open pits are partially filled with water as a result of ground water seepage and surface runoff. These deep depressions and surface water bodies contrast sharply with the surrounding landscape.

The site also contains approximately 50 buildings in five main areas. These buildings were used for office space, equipment repair, shops, employee housing and storage. Many of these buildings are larger than other structures common to this rural area. Their size and the use of sheet metal siding have resulted in a prominent landscape feature.

SOCIOECONOMIC CONDITIONS

The Pueblo's economic base shifted from agriculture to mining in the early 1950's, and with the Jackpile mine's closing, little economic base remains.

Employment

Employment at the Jackpile-Paguate mine reached 700 to 800 persons in the early 1970's. The vast majority of mine workers were Laguna Indians with some non-Indians from the Spanish land grant immediately north of the mine and adjacent to the reservation. Permanent closure of the Jackpile mine affected 726 workers in the Cibola County labor market area, including 513 Pueblo workers. A survey taken in November 1980 by the Council of Energy Resource Tribes (CERT) estimated that 101 of the 513 workers were no longer in the local workforce. However, 412 workers were left without jobs and probably have not found new employment (CERT 1983a).

Employment data for Valencia County, and for Cibola County since its creation from Valencia County in 1981, show employment trends generally representative of the area. In Valencia County, employment in metals mining was 2,076 in the first quarter of 1977. It rose to 3,141 in the third quarter of 1980, and then declined to 415 in the first quarter of 1983 (Table 2-37). No metals mining employment has been reported for the present Valencia County area since the second quarter of 1981, indicating that metals mining prior to that time was taking place in the area formed by the new Cibola County.

Table 2-38 shows a decreased labor force in the area, indicating that some people have moved away. However, it also shows a very high unemployment rate (25.6 percent for Cibola County), indicating that many of those who have been laid off in mining or mining-related jobs remain in the area. The Lagunas' cultural traditions and desire to live and work on the reservation have prevented many of them from taking jobs available elsewhere.

The total number of people in the Pueblo of Laguna's labor force is estimated to be 1,200, with the unemployment rate reported to be over 50 percent (CERT 1983a). Laguna efforts to attract industry to replace the jobs lost when the Jackpile-Paguate uranium mine closed have not been successful.

Income

Current reliable income figures for the Pueblo are not readily available. However, figures presented by the CERT (1983a) show the median income of Lagunas who reported it to be less than half of the median New Mexicans in 1950 and 1960. By 1970, the median income reported by the Lagunas was $2,661, just under 75 percent of the median income reported by other New Mexicans.

The major sources of income for the Laguna and Acoma reservations in 1978 are shown in Table 2-39.

TABLE 2-37

NUMBER OF PEOPLE EMPLOYED IN THE MINING INDUSTRY,
VALENCIA AND CIBOLA COUNTIES
(By Quarter, 1983 to 1977)

Year	Quarter	County	Employment			
			Total	Metal	Oil and Gas	Non-Metal
1983	1	Cibola & Valencia	503	415	--	--
1982	4	Cibola & Valencia	708	624	--	--
	3	Cibola & Valencia	769	682	--	--
	2	Cibola & Valencia	1,381	1,296	--	--
	1	Cibola & Valencia	1,706	1,616	--	--
1981	4	Cibola & Valencia	2,063	1,970	--	--
	3	Cibola & Valencia	2,527	2,430	--	--
	2	Valencia	2,937	2,832	--	--
	1	Valencia	3,101	3,011	--	--
1980	4	Valencia	3,155	3,064	--	--
	3	Valencia	3,235	3,141	--	--
	2	Valencia	3,222	3,138	--	--
	1	Valencia	3,193	3,107	--	--
1979	4	Valencia	3,122	3,048	--	--
	3	Valencia	2,925	2,849	--	--
	2	Valencia	2,788	2,709	--	--
	1	Valencia	2,692	2,578	--	--
1978	4	Valencia	2,719	2,555	147	17
	3	Valencia	2,711	2,552	153	--
	2	Valencia	2,304	2,158	134	12
	1	Valencia	2,528	2,357	--	--
1977	4	Valencia	2,469	2,316	147	--
	3	Valencia	2,455	2,311	137	--
	2	Valencia	2,296	2,194	95	--
	1	Valencia	2,155	2,076	73	--

Source: New Mexico Employment Security Department 1983.

TABLE 2-38

LABOR FORCE AND EMPLOYMENT FIGURES, VALENCIA AND CIBOLA COUNTIES
(Selected Dates)

Month	Year	County	Labor Force	Employed	Unemployed	Unemployed Rate
July	1983	Cibola	12,102	8,999	3,103	25.6
July	1983	Valencia	10,373	9,092	1,281	12.3
July	1983	Cibola	12,765	9,821	2,944	23.1
July	1982	Valencia	11,477	10,073	1,404	12.2
Jan.	1982	Cibola	11,714	10,217	1,497	12.8
Jan.	1982	Cibola	11,449	10,321	1,128	9.9
July	1981	Valencia	25,174	22,536	2,638	10.5
July	1980	Valencia	25,682	23,348	2,334	9.1
July	1979[a]	Valencia	25,696	24,059	1,637	6.4
July	1978	Valencia	24,095	22,729	1,366	5.7
July	1977	Valencia	20,430	18,702	1,728	8.5

Source: New Mexico Employment Security Department 1983.

Note: [a] Preliminary figure used because no revised figure was available.

TABLE 2-39

MAJOR SOURCES OF INCOME - LAGUNA AND ACOMA RESERVATIONS (1978)

Employer	Number of Employees	Total Payroll	Average Annual Income
Anaconda Corporation	680	$11,492,000	$16,900
Sohio	270	4,744,000	17,570
Indian Health Service	100	1,941,229	19,412
Bureau of Indian Affairs	100	1,478,393	14,784
Laguna Tribal Programs	350	2,461,017	7,031
Others (estimated)	120	1,100,000	9,167
TOTAL	1,620	$23,216,639	$14,331

Source: Council of Energy Resource Tribes 1983a.

In addition to employment income, foodstamps were reported by CERT to have supplemented cash income for 69 households, and pensions and welfare were other sources of income. The non-wage sources of support are probably much higher since the mine's closing, although current figures are not available.

The Anaconda shutdown reduced the Laguna-Acoma total annual income by an estimated $8 million. The Sohio uranium mine is also closed (at least temporarily), and the loss of these two sources of income have reduced the total income shown in Table 2-39 by approximately 70 percent.

Social Problems

For nearly 30 years the Pueblo of Laguna depended almost exclusively on the Jackpile-Paguate uranium mine for employment. As typical of any area dominated by one employer, the mine closure had a major impact on the Pueblo of Laguna. The sudden loss of income caused the Laguna people to readjust their standard of living. Along with this readjustment came a variety of social problems including increased alcohol and drug abuse, and increased social work and family counseling caseloads (CERT 1983b). These problems can be expected to persist until the Pueblo of Laguna can diversify its economic base and subsequently reduce unemployment.

Chapter 3
environmental consequences

INTRODUCTION

Chapter 3 presents discussions of the environmental consequences which would result from implementation of the reclamation proposals. This chapter also presents the scientific and analytic basis for comparison of the reclamation proposals described in Tables 1-3 and 1-4, Chapter 1.

BLASTING DURING RECLAMATION

The No Action Alternative would require no blasting. All of the other reclamation proposals may use blasting to reduce the Jackpile pit highwall (Gavilan Mesa) or to construct the Jackpile pit drainage channel.

The blasting of Gavilan Mesa and the Jackpile pit drainage channel could be of sufficient magnitude to warrant concern about the effects on Paguate Village. The major adverse effects of blasting would be ground vibration and airblast. Both of these effects could cause annoyance to village residents and structural damage.

Ground vibration is usually described as the velocity of a particular point or particle in the ground (particle velocity), and it is expressed in inches per second (in/s). Airblast is an air overpressure generated by an explosive blast and resulting rock breakage and movement. It is commonly expressed as a relative sound level in decibels (dB) in a particular frequency range or frequency weighting that is measured in hertz (Hz).

While ground vibration and airblast are dependent on numerous factors (e.g., geology, distance from blast, weight of explosive, blast confinement and weather), blasts can be designed to minimize their magnitudes and any resulting effects. It is generally accepted that ground vibration less than 0.5 in/s and airblast in the range of 100 to 120 dB reduce annoyance and do not cause structural damage, depending on specific site characteristics (Siskind, Stachura, et al. 1980; Siskind, Stagg, et al. 1980).

The U.S. Bureau of Mines (USBM) has reviewed and evaluated blasting data for the Jackpile-Paguate uranium mine, previous reports on the effects of the blasting, and the blasting uses and locations proposed in the reclamation alternatives. Based on this review and evaluation, as well as previous studies on ground vibration and airblast, the USBM has made recommendations for controlling the effects of blasting during reclamation (USDI, Bureau of Mines 1983a and b). It should be noted that Anaconda did not propose such measures and that the following recommendations apply only to the DOI and Laguna reclamation alternatives.

1. The Village of Paguate should be inspected prior to blasts. Frequent and detailed inspections of one or a limited number of structures would be useful as a control measure.

2. Ground vibration airblasts and cosmetic damage to structures should be monitored. Initial blasts should be designed for the following limiting values:

a. Maximum ground vibration of 0.2 in/s, and
b. Maximum airblast of 125 dB (5 Hz high pass) or 128 dB (2Hz high pass).

If initial tests show that damage to structures does not occur at these values, levels could probably be increased to 0.5 in/s and by 3dB. However, this would likely produce increased numbers of complaints alleging damage. Actual damage is unlikely but this cannot be guaranteed.

The resulting monitoring data could be used to define certain site characteristics that would provide more flexibility in the design of the blasts. Ground vibration should be monitored with velocity-measuring seismographs having a frequency response of 5 to 200 Hz.

3. A test should be conducted to determine if the minimum charge delay of 9 milliseconds is sufficient, particularly for the blasts farthest from Paguate.

4. When the wind is blowing from the east, blasting should not be conducted unless the blasts are designed for sufficient confinement to avoid the likely increased airblast.

MINERAL RESOURCES

Introduction

The Jackpile-Paguate uranium mine was closed because extraction of the uranium deposits was no longer profitable for Anaconda Minerals Co. The entire deposit was not mined, and improved market conditions, better technology, or different economic circumstances could make future mining profitable. Protore was stockpiled in case it might become economical to process at some future time.

The following general conclusions have been reached regarding the remaining uranium resources at the minesite:

1. The protore has significant potential value to the Pueblo of Laguna as long as it remains readily accessible.

2. The resources in the P15/17, NJ-45 and P-13 underground deposits have significant potential value to the Pueblo.

3. The value of the NJ-45 and P-13 deposits would decrease if their adits and drifts are rendered inaccessible.

4. Additional mining and/or heap leaching are not considered viable at this time or in the foreseeable future.

No Action Alternative

A portion of Gavilan Mesa highwall would probably collapse on top of protore piles JLG, J-1A, J-1-A and SP-1 which presently serve as a buttress at the base of the highwall. These piles contain approximately 1.7 million cubic yards of protore. Future recovery of this buried material would be uneconomical except under the most favorable conditions.

Protore would remain accessible for a period of time. However, normal erosive processes would operate on all of the protore piles located outside the pits, and cause significant losses of these resources over many decades. It is not possible to quantify these losses.

The NJ-45 and P-13 underground deposits would be accessible through existing workings. However, this alternative does not provide for maintenance of these areas. Therefore, the workings would deteriorate over time making them unsafe and inaccessible. This would make it more costly to reopen these areas as time progresses.

Anaconda Proposal

Under this alternative, all protore would be placed in the open pits. This would totally eliminate the erosion impacts as described under the No Action Alternative.

Additional buttress material would be placed at the base of Gavilan Mesa. However, the upper portion of the highwall above the buttress could eventually fail and cover the material below. Future recovery of this buried material would be uneconomical except under the most favorable conditions.

Future production of underground deposits would require either the reopening of old adits or construction of new openings. However, these costs would be small in comparison to overall production costs.

DOI Proposal (Both Options)

This alternative would cause the same impacts as Anaconda's Proposal except that there would be less of a chance of Gavilan Mesa collapsing on the buttress material because the highwall would be contoured to a more natural profile following the existing joints in the rocks.

Laguna Proposal

This alternative would place the protore above the projected ground water recovery level on the assumption that dry material is easier and less costly to handle than wet material. However, given the uncertainity of predicting ground water recovery levels, the protore may still become saturated, thus negating the efforts to keep it dry.

The impacts to the buttress material (beneath Gavilan Mesa) and the underground deposits would be the same as DOI's Proposal. However, since the Pueblo of Laguna has recently decided not to reopen portions of the mine under their own management, the effects of this impact are less important.

NON-RADIOLOGICAL MINESITE HAZARDS

Highwall Stability

Highwall stability safety factors for each alternative are indicated in Table 3-1. The locations of trial failure surfaces are shown in Figure 3-1. Trial failure surfaces are zones along which mass failures could occur.

No Action Alternative

Under this alternative, the stability of highwalls would be the same as analyzed in Chapter 2. The North Paguate pit highwall would be stable and the South Paguate pit highwall would probably be stable over the long-term (hundreds of years) except for the usual loose or overhanging blocks. The alluvial cover on the highwall crests could slump or erode by piping. Any small rockfalls or alluvial slumps could be hazardous to humans and livestock. However, the probability of someone being underneath a highwall at the exact moment of failure is extremely low.

Under present conditions, the Gavilan Mesa highwall is probably very close to a state of limiting equilibrium; that is, it may be just on the verge of failure and is almost certainly unstable for the long-term. The highwall would probably undergo a large rotational failure which could be hazardous to humans and livestock. Again, the chance of such failure occurring while humans or livestock are present is extremely low.

Over the long-term, all highwalls at the minesite would approximate the geometry and stability of surrounding natural cliffs, i.e., sandstone slopes would be vertical, and shale slopes would approach 30 degrees.

The highwalls would remain an attractive nuisance, especially for young people. Anyone approaching the edge of the highwalls could accidentally fall off. Although there have been few reports of people going near the highwalls, this safety hazard would still exist. Continuation of existing security measures (i.e., limited fencing, locked gates and patrols) would not be sufficient to prevent persons from entering the minesite and going near the highwall crests. This potential hazard would be greater at South Paguate pit highwall due to the lack of fencing along the rim and its proximity to State Highway 279 (present location). North Paguate pit highwall would be less hazardous due to the presence of fencing. Even though Gavilan Mesa is not fenced, it would also be less hazardous due to its relatively isolated location within the minesite.

Anaconda Proposal

Scaling of the highwalls would reduce the amount and frequency of rockfalls for the short-term and thereby reduce the hazards to humans and livestock. Over hundreds of years, rockfalls would approach the amount, size and frequency of rockfalls on nearby natural cliffs. The

TABLE 3-1

HIGHWALL SAFETY FACTORS

Pit Highwall	Trial Failure Surface[a]	No Action Alternative	Anaconda Proposal	DOI Proposal (Both Options)	Laguna Proposal
Jackpile (Gavilan Mesa)	1	1.15	1.25	1.31	1.31
	2	NC[b]	1.35	1.46	1.46
	3	1.26	1.26	-	-
	4	1.24	1.24	-	-
North Paguate	1	-	1.91	1.91	No highwall (buttressed to crest)
	2	1.63	1.63	1.63	
	3	1.58	1.58	1.58	
South Paguate	1	-	1.34	1.34	No highwall (pit back-filled to original contour)
	2	1.29	1.29	1.29	
	3	1.78	1.78	1.78	
	4	1.55	1.55	1.55	
	5	1.55	1.55	1.55	
	6	3.05	3.05	3.05	

Source: Smith 1983.

Notes: [a] Refer to Figure 3-1 for locations of trial failure surfaces.
[b] NC Indicates failure of solution to converge to a meaningful result.

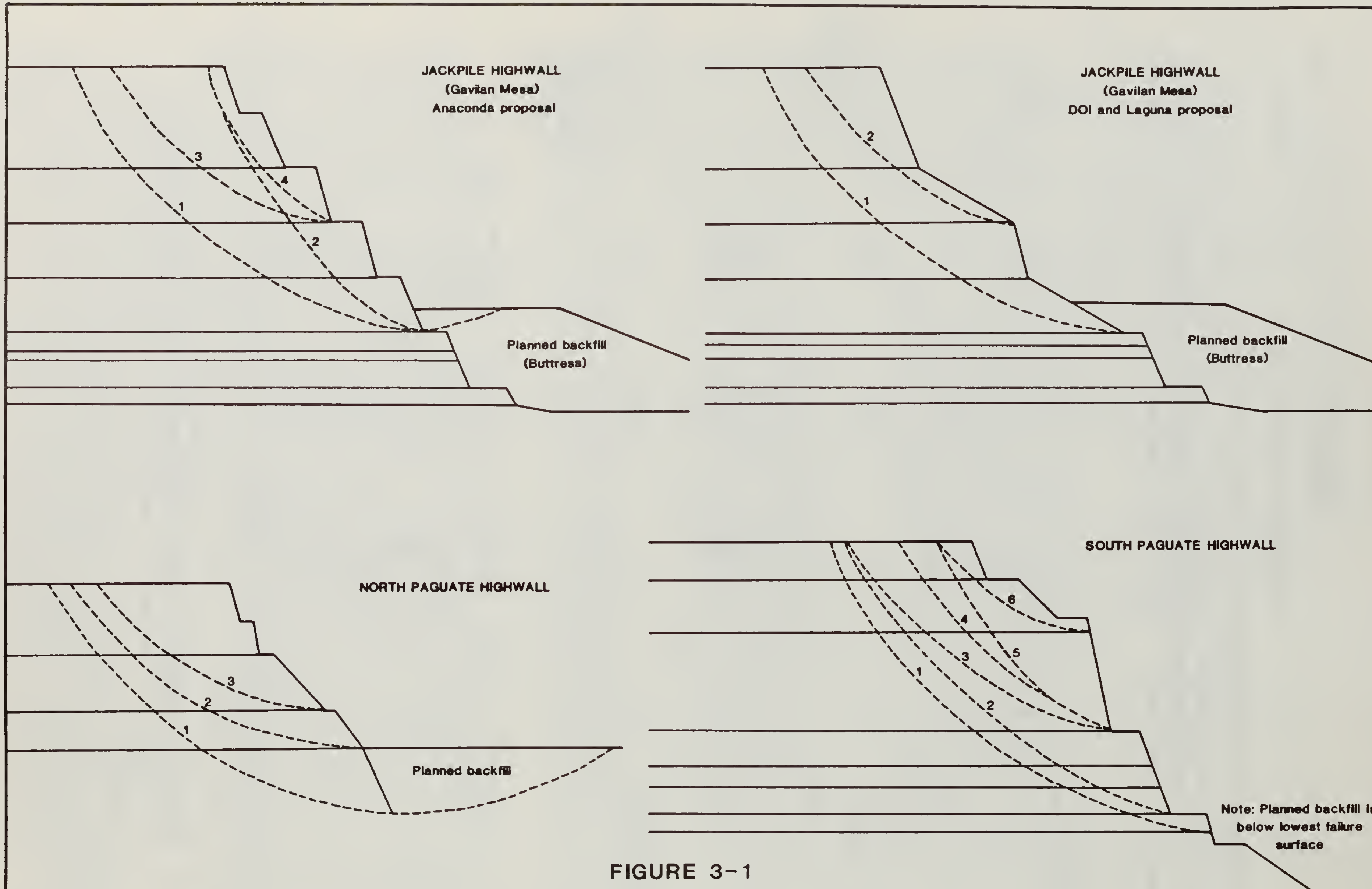


FIGURE 3-1

Locations of Trial Failure Surfaces

alluvial cover on the North and South Paguate pit highwalls could slump or erode by piping. These alluvial slumps could be hazardous to humans and livestock.

Anaconda's proposed stabilization measures for Gavilan Mesa would not significantly increase the overall stability of the highwall or blend the highwall into the natural surrounding. The planned buttress would stabilize the lower portion of the highwall but would do nothing for any potential failure surface which daylights above the top of the buttress. The alternate method of removing the upper portion of the highwall, by either blasting or hauling, would not significantly increase the stability of the highwall (Figure 3-2). It would result in higher unbenched slopes with the upper part of the highwall not much flatter than the existing slope. In all, a significant safety hazard would still exist.

The potential hazard for people falling off the highwalls would be the same as described under the No Action Alternative.

DOI Proposal (Both Options)

The impacts of scaling the highwalls would be the same as Anaconda's Proposal. Under this alternative, the upper 10 feet of alluvial material at the North and South Paguate pit highwall crests would be sloped 3:1 to prevent slumping and piping. This measure would reduce the risk of injury to humans and livestock below the highwalls.

Based on observations of natural buttes and mesas in the vicinity of the Jackpile - Paguate mine, it was concluded that it is not feasible to reclaim the Gavilan Mesa highwall to a state of absolute stability. The measures proposed under this alternative would reshape the Gavilan Mesa highwall to conform to the surrounding natural slopes as closely as possible; that is, approximately 30 degree slopes in the shale intervals and nearly vertical slopes, following natural joints, in the sandstone beds, with some benches (Figure 3-2). Two vertical joint sets, striking N. 25° E. and N. 35° W., have been identified in the Gavilan Mesa highwall (Seegmiller 1979a). In plan view, the highwall would follow these joint directions as closely as possible. This modification, including the planned buttress, would increase the safety factor of the highwall to 1.4. Besides blending the mesa into the natural surrounding, these measures would increase the stability of the highwall and thereby reduce the safety hazard compared to Anaconda's Proposal.

The proposed fencing for the South Paguate pit highwall would not totally preclude access to the rim of the highwall, but would serve as a deterrent, especially for young children and the curious.

Laguna Proposal

Under this alternative, the North Paguate pit highwall would be buttressed to its crest and the buttress material sloped 3:1. South Paguate pit would be backfilled to its original contour. These measures would totally eliminate the highwalls and associated safety hazards.

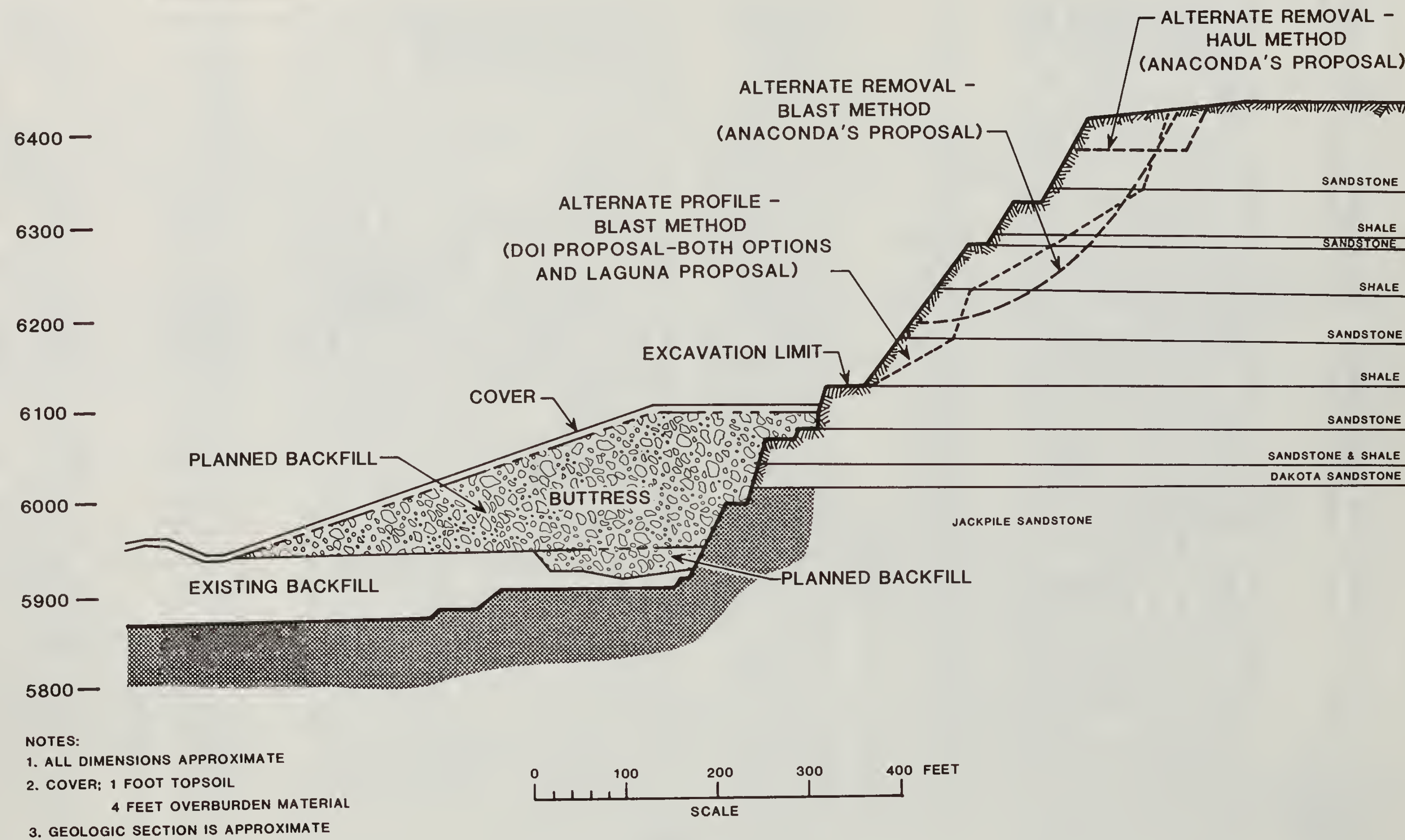


FIGURE 3-2

Gavilan Mesa Highwall cross-section - Alternate methods of stabilization

Stabilization measures for Gavilan Mesa would be essentially the same as DOI's Proposal. The only exception is that a monitoring program would be implemented to detect future areas of instability. Unstable portions of the highwall would be repaired as needed by scaling or other appropriate methods.

Waste Dump Stability

No Action Alternative

Under this alternative, it is probable that rotational slope failures would occur on FD-2 and V dumps. FD-2 could also exhibit base translational failure.

If FD-2 dump were to fail, a slump would probably displace the upper one-third to one-half of the dump, with the displaced material falling to the blocked drainage at the base.

V dump is located approximately 500 feet northeast of the confluence of the Rio Moquino and Rio Paguate, and at one point is within 300 feet of the Rio Moquino. A massive failure of V dump could result in damming of the Rio Moquino, while a small failure would probably cause a greatly increased sediment load in the streams.

For the short-term (that is, the dump materials exhibit some cohesion), the rest of the waste dumps at the minesite would be stable. However, experience has shown that cohesion is not an effective agent for holding up a slope over the long-term.

To assess the long-term stability of all waste dumps at the minesite, the DOI (Smith 1982) estimated safety factors for dry, cohesionless slopes. These calculations indicated that a 2:1 slope would have a safety factor of 1.06; a 2.8:1 slope would have a safety factor of 1.5; and a 3:1 slope would have a safety factor of 1.6. A 2:1 slope would only be marginally stable over the long-term, while a 3:1 slope should give an adequate margin of safety against mass failure. Since virtually all of the waste dumps at the minesite exhibit slope angles greater than 2:1, they would eventually fail. These failures could result in blockage of natural drainage channels, alteration of stream courses and increased sediment load (including radioactive materials) in the streams.

Piping is an active feature at the minesite and can be expected to eventually occur on most waste dumps. Piping can initiate large gullies which are sources of rockfalls, earth slides and high velocity concentrated runoff. These gullies could also expose radioactive materials within the interior of dumps and thus increase the radiological hazards at the minesite.

Anaconda Proposal

Under this alternative, most waste dumps would be sloped steeper than 3:1 with intermediate slopes ranging up to 2:1. A system of terraces, berms and rock-lined drainage structures is also planned as part of the slope modification (Table 1-4, Chapter 1).

The steep intermediate slopes do not meet the safety factor criteria of 1.5 or greater. These intermediate slopes could therefore fail over the long-term. The dumps proposed for overall slopes of 2:1 or steeper include: C, D, E, F, G, K, O, P, P1, P2, part of S, parts of T and W. These dump slopes would have a safety factor of less than one and therefore would be unstable over the long-term. Dumps proposed for overall slopes less than 2:1 but steeper than 3:1 include: FD-1, FD-2, FD-3, I, N, N2, South Dump, part of T, U, V, Y and Y2. These dump slopes would be marginally to probably stable. Dumps proposed for overall slopes of 3:1 or more gentle include: A, B, L, Q, R and the southern part of S dump. These dump slopes would be stable for the long-term.

The proposed terrace and drainage systems would require continuous and extensive maintenance in order to be effective. Without continued maintenance, the drainage channels at the back of the terraces would fill in with sediment and brush and become ineffective for drainage. The 5-foot high berms on the outer edges of the terraces would result in ponding of water on the terraces following rainstorms, causing local saturation of the soil and piping underneath the berms (Figure 3-3). Once a pipe is initiated, it would enlarge, rapidly causing the impacts noted under the No Action Alternative.

DOI (Both Options) and Laguna Proposals

Under these alternatives, most dumps would be sloped 3:1 or flatter with no terracing. The exceptions would be dumps FD-2, the southern portion of I, and Y2. The modification to FD-2 would be the same as Anaconda's Proposal because of the dump's location on the side of Gavilan Mesa which limits a 3:1 slope profile. The southern portions of I and Y2 would be sloped 2.5:1 with no terracing. These three dumps would be marginally to probably stable over the long-term. All dumps sloped 3:1 would have a safety factor of 1.6 and would therefore be stable over the long-term. The 3:1 slopes and contour furrowing would virtually eliminate the hazards resulting from mass failure and piping as described in the No Action Alternative and Anaconda's Proposal.

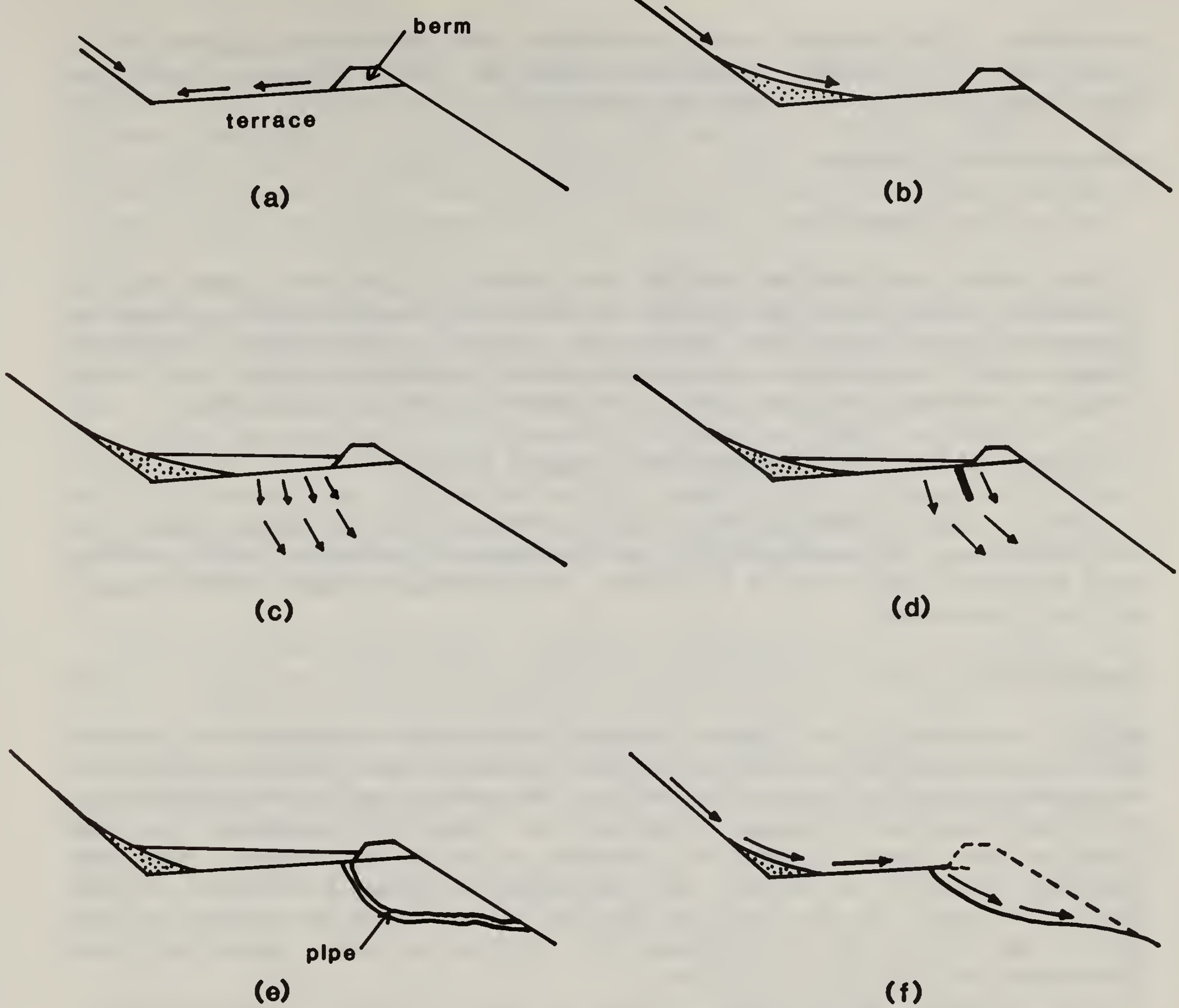
Subsidence

No Action Alternative

Under this alternative, the possibility exists that the ground above the P-10 mine decline could experience subsidence of significant magnitude and rate. A sudden change in ground elevation could result in injury to humans and livestock standing immediately above the decline area. All other areas above underground workings are in a low risk category with regard to subsidence and therefore do not pose a hazard.

Anaconda, DOI (Both Options) and Laguna Proposals

The P-10 mine decline would have a cement bulkhead placed approximately 680 feet below the surface opening. The decline would then be backfilled from the bulkhead to the surface with overburden



Explanation:

(a) Water collects on terrace

(b) Drainage channel silts-up and becomes ineffective

(c) Water ponds after rainfall

(d) As water seeps into terrace, pipe forms

(e) Pipe is complete

(f) Berm and terrace wash out, forming a large gully

Note: Arrows show direction of waterflow.

FIGURE 3-3

Waste Dump Slope Failure due to Piping

material. This measure would eliminate the subsidence hazard above this area. All other underground workings would pose no hazard as described under the No Action Alternative.

Underground Openings

No Action Alternative

Six adits, one decline and 20 vent holes are presently open at the minesite. These openings present a physical hazard in that people or livestock could use them to access unstable underground workings. These areas could also contain elevated levels of radon and radon daughter products and thus pose a localized radiological hazard.

Anaconda, DOI (Both Options) and Laguna Proposals

Under these alternatives, all underground openings would be backfilled so no entrance to the underground workings would exist. This measure would totally eliminate the hazards described under the No Action Alternative.

RADIATION

NOTE: Initially, the Laguna Proposal regarding treatment of protore was the same as the Anaconda and DOI Proposals, i.e. the protore would be placed into the open pits within the ground water recovery zone. This is how the Laguna Proposal is presently analyzed in the radiological impact section. Because of the additional time and expense involved to assess the radiological impacts of the revised Laguna Proposal, it was not possible to include this assessment in this EIS. The merits of evaluating the revised proposal have not been determined at this point in time.

Post-Reclamation Radiological Impacts

Introduction

The steps in an evaluation of potential radiological impacts for a site are as follows: 1) identify the sources of radiation; 2) define and delineate the pathways by which various components of the environment, especially humans, could be exposed to that radiation; 3) estimate the rates at which radioactivity is released along those pathways; and 4) use these estimates to calculate the total radiation exposure to the population of concern.

The primary sources of radiation at the Jackpile-Paguate minesite are the radioactive isotopes formed by the decay of uranium-238 in the remaining ore and waste materials at the site. Specifically, these are: uranium-238, uranium-234, thorium-230, radium-226, radon-222, lead-210 and polonium-210. Although other sources of radiation exist, the amount of radiation emitted at the minesite from these other sources is so small in comparison with radiation from the uranium-238 series that the other sources need not be considered here. (A more detailed description of the sources of radiation at the minesite is provided in Chapter 2.)

The principal pathways by which people may be exposed to radiation from the minesite are: 1) direct external exposure to radiation emitted from radioactive material in the air and on the ground; 2) internal exposure to radiation from radioactive material inhaled into the lungs; and 3) internal exposure to radiation from radioactive material ingested with drinking water and foodstuffs. These exposure pathways are shown diagrammatically in Figure 3-4.

The reclamation alternatives being considered for the minesite could variously affect the potential for, and amount of, human exposure to radiation along these pathways. Therefore, the possible radiological impacts of the reclamation alternatives have been evaluated with regard to: 1) calculation, for each alternative, of potential radiation doses that might be received by the general population after reclamation, and 2) conversion of these doses into possible numbers of radiation-induced health effects. The population groups considered in these evaluations are those people living near the boundaries of the minesite, and the entire population living within a 50-mile (80-kilometer) radius of the minesite following reclamation.

The potential radiological impacts summarized in this section are based on detailed evaluations presented in a report prepared by Momeni, et al. (1983). The evaluations in that report are based on data obtained from Anaconda Minerals Company, the U.S. Department of the Interior, published reports and other sources. A computer code--the Uranium Dosimetry and Dispersion (UDAD) Code--developed at Argonne National Laboratory (Momeni, et al. 1979) was used to calculate the radiation release rates, exposure rates and doses that form the basis of this radiological impact evaluation.

Assumptions

The mathematical models used to analyze radiological impacts require that a number of assumptions be made concerning basic physical, chemical and physiological processes that occur along radiation exposure pathways. These assumptions are used with data on radiological and environmental conditions at the site to make the calculations required for impact analysis. Some of the assumptions made in the evaluation of potential radiological impacts of the Jackpile-Paguate mine reclamation alternatives are outlined below.

Two basic sources of release of radioactivity to the air from the Jackpile-Paguate minesite have been identified: 1) distribution of radioactive particulates (contaminated dust particles) as a result of wind erosion of contaminated surfaces, and 2) diffusion of radon-222 gas from contaminated material into the air. The estimated rates of distribution of radioactive dust from the minesite to the air have been calculated with the wind erosion formulas incorporated into the UDAD Code (Momeni, et al. 1979). It was assumed that radioactive dust particles would be distributed in the air only under the No Action Alternative. Under the other alternatives, the minesite would be covered with a layer of uncontaminated soil, and although wind erosion would not be eliminated, the radioactive material at the site would not be exposed to wind erosion so long as the soil cover remained intact.

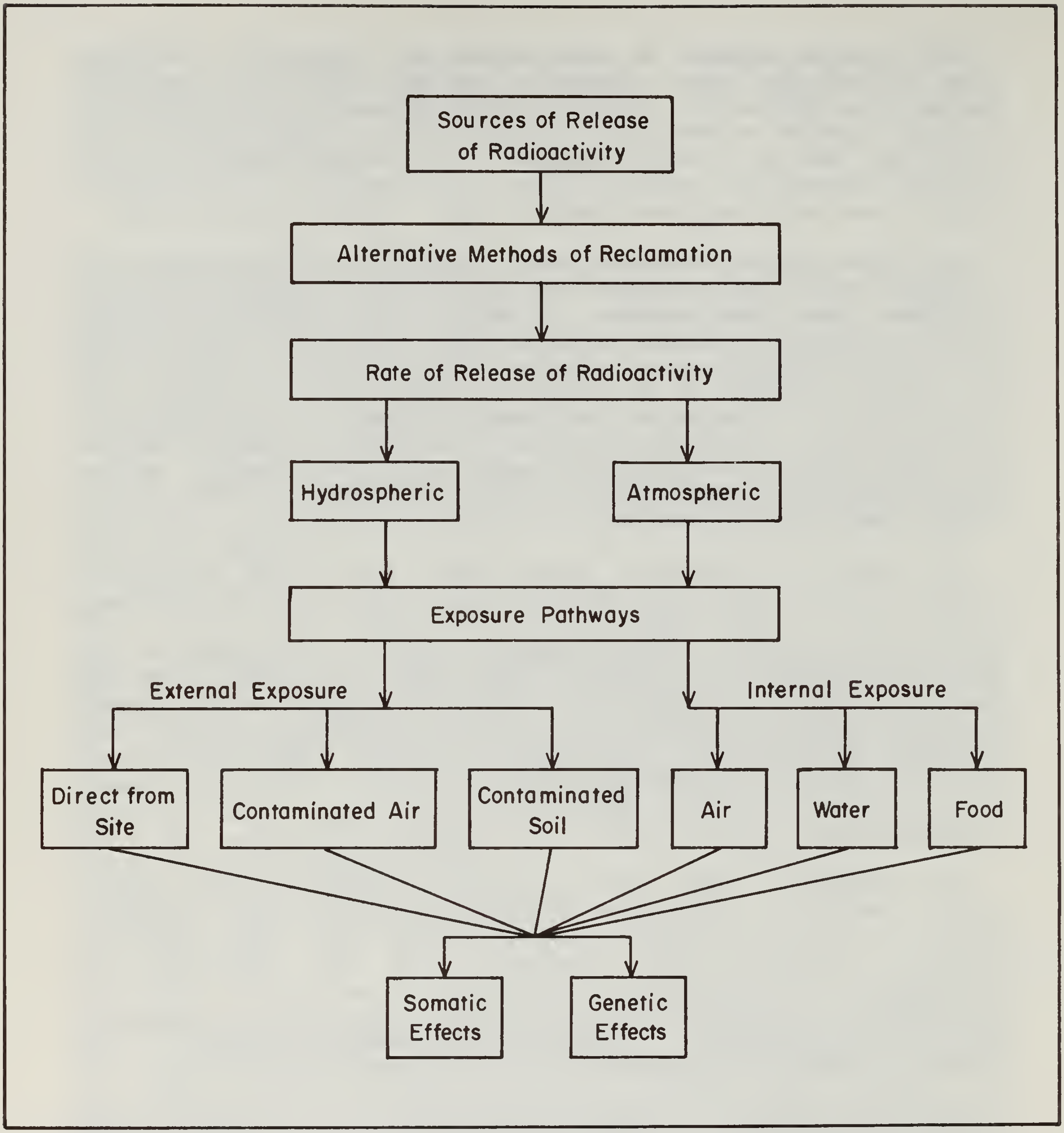


FIGURE 3-4

Potential Routes of Release of Radioactive Materials and Subsequent Exposure Pathways.

Source: Momeni, et al. 1983.

Evaluation of the diffusion of radon-222 gas (formed by the radioactive decay of radium-226, which is a solid) involves consideration of a factor known as "specific flux". This is the amount of radon-222 released from a given area of the ground over a given time for each unit concentration of radium-226 in the soil.

The calculations of radon-222 release from the minesite under the No Action Alternative have been based on an average specific flux of 0.5 picocuries of radon-222 from each square meter of ground each second for each picocurie of radium-226 per gram of soil. Under the other reclamation alternatives, the specific flux of radon-222 from the minesite would be reduced. However, it would not entirely be eliminated because even with a cover of uncontaminated soil over the site, some radon-222 would diffuse through the covering material and escape into the air. For the other alternatives, the release rate would be reduced to 8 percent of that for the No Action Alternative. The derivation of these values and the underlying assumptions used are given in Appendix D of Momeni, et al. (1983).

Ground and surface water also have been identified as potential pathways of radiation exposure at the minesite. Ground water can be contaminated by precipitation (rainfall and, less frequently, melted snow) soaking through waste dumps and carrying radioactive material into water supplies. Contamination of surface water can result from seepage of contaminated ground water into surface water, and by surface runoff of precipitation that has fallen on waste dumps and/or other contaminated surfaces.

For the other alternatives, surface soil and vegetation covers placed over the waste dumps within the minesite would tend to increase the ground water level in the area because of the reduction in ground water loss through evaporation. This elevation of the ground water level could increase the contact of ground water with the waste dumps, resulting in greater radioactive concentrations in this water that would subsequently be discharged into streams within the minesite. However, because evaporation in the entire region far exceeds precipitation, the effects of the reclaimed areas on regional ground water would be minimal. The overall movement of radionuclides to the ground water, and subsequently to nearby streams, would be negligible. Calculations supporting this conclusion are documented in Appendix C of Momeni, et al. (1983).

Part of the surface water passing through the minesite collects downstream in Paguate Reservoir. Water from the reservoir is used for irrigation downstream at the Village of Mesita and also consumed by livestock. The degree to which water from the reservoir is used for human consumption is not known. Thus, a potential pathway exists for indirect exposure of humans to radioactive materials through consumption of meat from cattle that have drunk from the reservoir. This pathway is discussed in the next section.

Assumptions about the amount of radioactive material retained by man following intake of radioactive material through air, water and food are contained in the internal dosimetry models of the International

Commission on Radiological Protection (ICRP 1959). These models, as well as other ICRP information, have been incorporated into the UDAD Code (Momeni, et al. 1979).

Post-Reclamation Radiation Doses

The principal pathways of radiation exposure have been identified as inhalation of airborne radionuclides, ingestion of contaminated food and/or water, and external exposure. Using the UDAD code, the individual dose commitments in the 70th year (average human life expectancy in the region) and the population dose commitments were calculated for all the alternatives at a number of locations within 50 miles of the minesite. The population dose commitment gives the average dose commitment for the people within a 50-mile radius of the minesite.

Dose commitment may be understood with the aid of the following example. Suppose that during the first year, an individual intakes a radionuclide having a long residence time in the body. Assuming that the nuclide delivers a dose of 100 millirems in the first year, then, without further intake, the presence of the nuclide in the body will result in a dose of 50 millirems in year 2, 25 millirems in year 3, and 12.5 millirems in year 4. If intake of the nuclide continues at the same rate, then, in the second year, the dose will be 100 millirems from intake in the second year plus 50 millirems already committed from the first year. After four years of intake, the annual dose will build up to 187.5 millirems (100 + 50 + 25 + 12.5), which is also the total 4-year dose from the intake that occurred in the first year only. This method allows calculation of the annual dose commitment for any period of time. In this EIS, the dose commitments are calculated for the 70th year following reclamation because it is assumed that the average life expectancy in the region is about 70 years.

The individual dose commitments (70th year) for selected locations (highest dose, lowest dose and Paguate Village) are presented in this EIS. Detailed data for additional locations can be found in Momeni, et al. (1983).

Some organs show higher sensitivity than others to radiation. The doses to these organs were calculated with the UDAD code for the various reclamation alternatives. In this EIS, only the dose commitments to organs at greatest risk in a given pathway are presented. When the total dose for a given period of time is shown, it is a summation of the individual doses received during each successive year for that period.

External Doses

External exposure results from radiation emitted from airborne and ground-deposited radionuclides on the minesite and in the surrounding region. It also results from gamma radiation emitted from the waste dumps and residual ores on the minesite, but only people on the minesite would be exposed to this radiation due to the limited range of natural gamma radiation.

No Action Alternative

Public access to the minesite would be restricted under the No Action Alternative; thus, no direct exposure of the population to gamma radiation at the site would occur. However, offsite transport of the radioactive material from the minesite would continue as a result of natural erosion. Residents of the region around the minesite would receive external exposure from such material deposited on the ground or suspended in air away from the site. Under this alternative, the highest external dose within 50 miles would be at the Range North location (3 miles north of the confluence of the Rios Moquino and Paguate), and the lowest external dose would be at Albuquerque. This information is summarized in Table 3-2.

TABLE 3-2

INDIVIDUAL DOSE COMMITMENTS (70th YEAR) FROM
EXTERNAL RADIATION EXPOSURE UNDER THE
NO ACTION ALTERNATIVE
(millirems per year)

Location	Whole Body	Lung	Red Marrow
Airborne Radionuclides			
Albuquerque	0.000869	0.00082	0.000907
Range North[a]	0.287	0.270	0.302
Paguate	0.119	0.112	0.127
Ground-Deposited Radionuclides			
Albuquerque	0.000833	0.000774	0.000902
Jackpile Housing	28.1	26.3	29.9
Paguate	7.12	6.68	7.6

Source: Momeni, et al. 1983.

Note: [a] This location is 3 miles north of the confluence of the Rios Moquino and Paguate.

Anaconda, DOI (Both Options) and Laguna Proposals.

External radiation exposure would be close to natural background levels under these reclamation alternatives, because gamma radiation release would be reduced by the soil cover placed over the waste dumps and residual ores at the minesite. The radionuclides previously deposited beyond the disturbed areas of the minesite would continue to be a decreasing source of external exposure. However, according to data collected by the EPA (Eadie, et al. 1979) and EGG (Jobst 1982), minimal off-site deposition of radioactive materials has occurred. Therefore, exposure along this pathway would be negligible.

Inhalation Doses

Potential doses from inhalation result from exposure to: 1) airborne particulates (all the radionuclides in the uranium series except those from short-lived radon decay products); and 2) airborne radon decay products that enter the respiratory system. A fraction of the total radioactive material inhaled is directly exhaled, and a portion of the material deposited in the respiratory system is subsequently ingested.

The dose in a given organ at any time from the inhalation of any airborne radionuclide depends upon the concentration of that radionuclide in that organ. The concentration is a net result of intake, excretion and radioactive decay. With continuous intake of radionuclides, the concentration in a given organ of the body increases to an equilibrium value and thereafter remains relatively constant.

Particulates

No Action Alternative

Of the four alternatives analyzed, the No Action Alternative would result in the maximum dose commitment to an individual from inhalation. Again, individual dose commitments would be highest at Jackpile Housing and lowest at Albuquerque. A summary of the inhalation dose commitments to the more important body organs is given in Table 3-3.

TABLE 3-3

INHALATION DOSE COMMITMENT AT SELECTED LOCATIONS DUE TO PARTICULATES RELEASED UNDER THE NO ACTION ALTERNATIVE (millirems per year)

	Dose to Lung Tissue		Dose to Other Organs	
Location	Tracheobronchial	Pulmonary	Bone	Whole Body
Albuquerque	0.0000121	0.00535	0.0071	0.00029
Jackpile Housing	0.033	13.7	17.8	0.586
Paguate	0.0122	5.24	6.66	0.218

Source: Momeni, et al. 1983.

Anaconda, DOI (Both Options) and Laguna Proposals

Under these three alternatives, radioactive particulate emissions would be greatly reduced by covering the minesite with a layer of uncontaminated soil. This, in turn, would reduce the dose commitment from particulates to values corresponding to background levels.

Radon

No Action Alternative

For inhalation of radon decay products, the dose commitment has been calculated on the basis of 14 hours daily residence inside a structure and 10 hours outside. Only the dose to the most sensitive part of the human body, the bronchial epithelium tissue of the lung, has been calculated. As expected, the lowest dose commitment would be at Albuquerque, and the highest dose commitment at Jackpile Housing. The dose commitments due to radon inhalation are summarized in Table 3-4.

TABLE 3-4

DOSE COMMITMENTS (70th YEAR) DUE TO INHALATION OF RADON AT SELECTED LOCATIONS UNDER THE NO ACTION ALTERNATIVE (millirems per year)

Location	Bronchial Epithelium
Albuquerque	0.0578
Jackpile Housing	68.7
Paguate	28.0

Source: Momeni, et al. 1983.

Anaconda, DOI (Both Options) and Laguna Proposals.

The rate of release would be reduced under these alternatives. Dose commitments would be 8 percent of the values under the No Action Alternative. For example, under these alternatives, the dose commitment at Jackpile Housing would be 5.50 millirems per year.

Ingestion Doses

Radiation doses from ingestion normally result from consumption of food and/or water contaminated with radionuclides. However, surface water in and adjacent to the minesite is not used for human consumption, and it is unlikely that the ground water in the immediate vicinity of the mine would become a source of contamination for at least 100 years. Large-scale farming is not presently practiced near the mine. Therefore, the major ingestion pathway for radionuclides would be the consumption of locally raised meat.

Two approaches have been used in this analysis: 1) evaluation of the doses that would result at the Village of Paguate and San Fidel if meat from livestock grown near these locations was consumed only in the area where grown; and 2) evaluation of the doses that would result if equal portions of meat raised within 50 miles (80 kilometers) of the minesite were consumed by all members of the population within the region. In the first approach, it was assumed that the amount of meat produced in an area would not be sufficient to provide for the entire yearly intake of the local residents and, thus, locally grown meat would constitute less than 100 percent of the diet near the location where it was grown. The second approach provides an estimate of population dose based on agricultural marketing and distribution patterns.

No Action Alternative

Under this alternative, no grazing of livestock would be permitted on the minesite. However, the radioactive materials now exposed at the site would not be covered, and offsite transport of radionuclides by natural processes (e.g., wind erosion, surface runoff) would continue. Therefore, livestock would continue to be exposed to and consume radionuclides originating from the unreclaimed minesite.

The dose commitments to the whole body, bone, kidney and liver calculated under the first approach (meat consumed only in the area where it was grown) for the Paguate and San Fidel regions are summarized in Table 3-5. These two locations would experience the highest and lowest dose commitments, respectively, within the 50-mile radius.

TABLE 3-5

AVERAGE DOSE COMMITMENT (70th YEAR) TO SELECTED ORGANS
DUE TO INGESTION OF MEAT UNDER THE NO ACTION ALTERNATIVE
(millirems per year)

Location	Whole Body	Bone	Kidney	Liver
Paguate	1.1	10.4	6.68	1.99
San Fidel	0.00798	0.00723	0.00756	0.00225

Source: Momeni, et al. 1983.

The average total dose from ingestion of meat to an individual belonging to the population within a 50 mile radius of the minesite is given in Table 3-6. These values were calculated under the most realistic assumption that the meat raised in this region is distributed equally to all members of the population within the region.

TABLE 3-6

AVERAGE DOSE COMMITMENT (70th YEAR) TO AN INDIVIDUAL FROM INGESTION OF MEAT LOCALLY RAISED WITHIN A 50-MILE RADIUS OF JACKPILE-PAGUATE MINESITE UNDER THE NO ACTION ALTERNATIVE
(millirems per year)

Organ	Dose
Whole body	0.00148
Bone	0.014
Kidney	0.00624
Liver	0.00184

Source: Momeni, et al. 1983.

Anaconda, DOI (Both Options) and Laguna Proposals

Under these reclamation alternatives, no additional contamination of meat would take place, because the sources of airborne particulates would have been covered with a layer of uncontaminated soil. This would prevent contamination of pasture grass, because there would be no further offsite transport of soil and particulates from the minesite.

Total Individual and Population Dose Commitments

No Action Alternative

The representative total annual dose commitments estimated under the No Action Alternative are presented in Table 3-7 for Paguate (the nearest village to the minesite) and Jackpile Housing (the location of the highest individual dose commitment). The total individual dose commitment for a given organ is obtained by summing the contributions from each pathway. Similarily, the total population dose commitment for a given organ is obtained by summing the individual contributions from each pathway (Table 3-8).

The U.S. average background exposure to the bronchial epithelium is 450 millirems per year (National Council on Radiation Protection and Measurements 1975). Under the No Action Alternative, the dose commitment would be an additional 6 percent of the annual average at Paguate and an additional 15 percent of the annual average at Jackpile Housing.

For purposes of perspective, the estimated population dose commitments under the No Action Alternative are compared with the background population dose commitments in Table 3-9. The population dose commitments under the No Action Alternative are negligible in comparison with the background dose commitments.

TABLE 3-7

TOTAL ANNUAL DOSE COMMITMENTS (70th YEAR) TO AN INDIVIDUAL UNDER THE NO ACTION ALTERNATIVE (millirems per year)

Organ	Dose for Various Pathways: External	Ground	Inhalation	Radon	Ingestion	Total[a]
Paguate						
Whole body	0.119	7.12			1.12	8.4
Bone					10.4	10.4
Kidney					6.68	6.68
Liver					1.99	1.99
Bronchial epithelium				28.0		28.0
Tracheobronchial			0.012			0.012
Pulmonary			5.24			5.24
Lungs	0.112	6.68				6.80
Red marrow	0.127	7.00				7.72
Jackpile Housing						
Whole body	0.18	28.1				28.3
Bronchial epithelium				68.7		68.7
Tracheobronchial			0.033			0.033
Pulmonary			13.7			13.7
Lungs	0.109	26.3				26.5
Red marrow	0.194	29.9				30.1

Source: Momeni, et al. 1983.

Note: [a] Background: whole body - 100 mrem/yr.; bone - 135 mrem/yr.; lung - 200 mrem/yr.; bronchial epithelium - 200 to 600 mrem/yr. (ANL/EIS-16).

TABLE 3-8

POPULATION DOSE COMMITMENTS (70th YEAR) UNDER THE NO ACTION ALTERNATIVE FOR THE AREA WITHIN A 50-MILE RADIUS OF THE MINESITE (person-rems per year)

Organ or Tissue	Inhalation		Ingestion	External		
	Particulates	Radon		Ground	Cloud	Total
Bronchial epithelium		122.0				122.0
Pulmonary	16.5			13.5	0.845	30.8
Whole body	68.6		10.5	14.3	0.896	94.3
Bone	21.0		97.7	16.7	1.01	136.0
Kidney	62.3		64.1			126.4
Liver	14.8		19.1			33.9
Red marrow				15.3	0.941	16.2

Source: Momeni, et al. 1983.

TABLE 3-9

COMPARISON OF ESTIMATED POPULATION DOSE COMMITMENTS (70th YEAR) UNDER THE NO ACTION ALTERNATIVE TO THE BACKGROUND POPULATION DOSE COMMITMENT (person-rems)

Organ	From Releases Under the No Action Alternative	From Natural Background Radiation[a/]
Whole body	94.3	47,620
Lungs	30.8	95,240
Bone	136.0	66,668
Bronchial epithelium	122.0	214,290

Source: Momeni, et al., 1983.

Note: [a/] Estimated from data in Report No. 45 of the National Council on Radiation Protection and Measurements (1975). The estimated total population is 476,200 in the 70th year (Momeni, et al. 1983).

Anaconda, DOI (Both Options) and Laguna Proposals

Under these alternatives, the dose commitments from external exposure, ingestion and inhalation would be reduced to background levels except for the dose commitment from radon. As mentioned previously, the radon dose commitment at Jackpile housing would be 5.5 millirems per year and for Paguate, the dose commitment would be 2.2 millirems per year.

Post-Reclamation Health Effects

Introduction

The post-reclamation health effects of primary concern are those resulting from radiation doses received by individuals as a consequence of exposure to ionizing radiation from radionuclides in or near the minesite. These health effects include somatic effects (diseases affecting an individual during his lifetime; primarily cancer) and genetic effects (disorders affecting offspring of the irradiated individual). About half of all cancers are nonfatal (American Cancer Society 1978).

A computer code developed at Argonne National Laboratory, "Potential Radiation-Induced Biological Effects in Man (PRIM)" was used in estimating the somatic and genetic effects in the population within a 50-mile radius of the Jackpile-Paguate minesite (Momeni, et al. 1983). Two mathematical models of the National Academy of Sciences (1980) were employed in estimating the number of cancer deaths: the absolute risk model and the relative risk model.

The absolute risk model expresses the number of additional cases of cancer that arise per unit time per unit dose in a population of exposed individuals, or the total number of expected cancers in the group. This model ignores any possible correlation between the incidence of the radiation-induced effects and those due to the other cancer-causing materials to which the population is exposed. The relative risk model, on the other hand, defines the ratio of the risk of cancer in the irradiated population to the risk in a comparable nonirradiated population. Thus, the risk of radiation may be expressed as a percentage of the natural cancer incidence per unit dose per unit time.

Two main criticisms of the relative risk model exist. First, it predicts a very nonlinear response as a function of age at irradiation, and no biological evidence supports this effect for radiation damage. Second, the relative risk model predicts a higher total incidence than the absolute model for the same incidence rate, and little epidemiological evidence supports this difference. In spite of this, the BEIR III Report (National Academy of Sciences 1980) presents results in terms of both models, although the International Commission on Radiological Protection has continued to use the absolute risk model. In this EIS, estimates from both the models are summarized.

Somatic and Genetic Effects

No Action Alternative

The predicted radiation-induced cancer deaths for the period 1982 through 2072 are 95 under the absolute risk model and 243 under the relative risk model. Under the absolute risk model for the same period, about 135,000 natural cancer deaths are predicted (Momeni, et al., 1983). This represents an increase of less than 0.1 percent in predicted cancer deaths over the 90-year period. Under the relative risk model for the same period, the predicted increase would be about 0.2 percent.

The total number of radioactive-induced genetic disorders has been calculated using parameters given in two different sources: U.S. Nuclear Regulatory Commission (1975) and National Academy of Sciences (1980). For the region of the Jackpile-Paguate minesite, the value of the estimated ratio of radioactive-induced to naturally occurring genetic disorders is about 0.0003.

Anaconda, DOI (Both Options) and Laguna Proposals

Under these reclamation alternatives, the somatic risks--except cancer of the lung--would be reduced to less than 0.1 percent of those levels calculated for the No Action Alternative. The lung cancer risk would be 10 percent of the No Action Alternative.

Under these alternatives, the estimated genetic effects would be reduced to less than 0.1 percent of those calculated for the No Action Alternative.

Comparison to Other Health Risks

Another way of considering the risk from radiation is to assume that cancer results in a shortening of life that would not otherwise take place. When considered in this way, the average background radiation of 100 millirems per year would result in an estimated life shortening of 8 days. For comparison, estimates of life shortening expected from various activities are listed in Table 3-10.

Radiological Impacts to Workers Involved in Reclamation

There are no Federal or State regulations governing radiation exposure to workers involved in surface mining or reclamation activities at open pit uranium mine. The reason is that the radiation doses received during such operations are within the generally accepted guidelines for unrestricted areas (Table 2-12, Chapter 2). From information gathered in preparing this EIS, there is no data to indicate that workers involved in reclamation would be exposed to levels exceeding those that occurred during mining operations; therefore, exposures are expected to be within generally accepted guidelines. However, to ensure that there are no site-specific conditions that would alter this conclusion, Argonne National Laboratory will study the radiological impacts to workers involved

TABLE 3-10

ESTIMATED AVERAGE LOSS OF LIFE EXPECTANCY FROM HEALTH RISKS
(days)

Health Risk	Average Decrease in Life Expectancy
Smoking 20 cigarettes a day	2,370 (6.5 years)
Overweight (by 20 percent)	985 (2.7 years)
All accidents combined	435 (1.2 years)
Auto acidents	200
Alcohol consumption (U.S. average)	130
Home accidents	95
Drowning	41
Natural background radiation	8
Medical diagnostic X-rays (U.S. average)	6
All catastrophes (e.g., earthquake)	3.5
1 rem occupational radiation dose (industry average about 0.65 rem/yr)	1
0.5 rem/yr for 30 years	15

Source: Adapted from Cohen and Lee (1979).

in reclamation. The information will be submitted to the DOI in a report separate from the EIS. If the report reveals that there would be radiological conditions which could cause workers to receive doses in excess of the accepted limits, Anaconda Minerals Company would be required to provide mitigation.

HYDROLOGY

Introduction

Mining at the Jackpile-Paguate uranium mine disturbed the Jackpile Sandstone aquifer and reshaped the local topography. Now that mining has ceased, water is ponding at the surface in the pit bottoms. Eventually, the ponds will reach an equilibrium with water inflow, outflow and evaporation losses. When the pits are backfilled they will saturate to a stable water table elevation that will be higher than the present pond elevations. This is called the "ground water recharge level" or "recovery level". Considerable technical debate has taken place concerning ground water recovery levels in the pits at the Jackpile-Paguate uranium mine. Continuing technical analysis has shown that it is difficult to forecast specific ground water recovery levels.

The main reasons for concern over the ultimate ground water recovery levels is the adverse environmental impacts that would result if the initial backfill levels were insufficient. Salt water ponds could form on the surface. Alternatively, as a result of evaporation at the surface, about 3 to 4 tons per acre per year of salt could be deposited and stored in the soils of the pit bottoms if they re-saturate to near the level of the reclaimed land surface. After a few years of such conditions, the productivity of salt-tolerant plants such as saltgrass or alkali sacaton, for example, would be reduced by 50 percent, and within a decade the bottom areas would become entirely unproductive, playa-like saline wastelands. The soils and any intermittent water in the pit bottoms could become toxic due to concentrated radiochemicals, metals and salts stored at the surface.

A secondary concern arising from the reclamation approach for the pit areas is one of containment of water and sediment in closed pits or, alternatively, restoration of the natural process of overland runoff of water and sediment. DOI has addressed both approaches as reclamation options.

Ground water recharge levels have been estimated by Dames and Moore, a consultant to Anaconda Minerals Company, for use in formulating Anaconda's reclamation plan. These estimates were made by using mathematical models of predicted future conditions in the backfilled pits, and then specifying the variables affecting ground water in this model. Such variables take into account the permeability of backfill materials and the contribution that surface waters (rainfall and stream inflow) may lend to ground water volumes. Selection of values for these variables is based on field data and scientific judgment, but remains uncertain. The time for ground water recovery levels to reach essentially steady-state conditions was estimated to be 30, 150 and 300 years for the North Paguate, South Paguate and Jackpile pits, respectively. The Dames and Moore report and modeling analysis, including assumptions used, is available at the BLM Albuquerque District Office, Rio Puerco Resource Area. Anaconda has indicated that their proposed minimum backfill levels based on the ground water model may be raised if excess material from other reclamation operations eventually is disposed of in the pits.

At the Bureau of Land Management's request, the Water Resources Division, U.S. Geological Survey (USGS), carried out a number of numerical simulations of the ground water flow system in the vicinity of the Jackpile-Paguate mine. The simulations were performed using a standard USGS generic model for two-dimensional ground water flow; the simulations employed hydrologic parameters which, in some cases, were identical to those used in an analysis by Dames and Moore, and in some cases were systematically varied from those values. The USGS model was mathematically adjusted to give the same or approximately the same results as the Dames and Moore model when running the same parameters as the Dames and Moore model.

The USGS work established that the model used by Dames and Moore contained no inconsistencies of a mathematical or programming nature which significantly affected its results. The analysis further demonstrated that the changes in the method of simulating the outcrop and the streams produced significant water level differences only in the immediate vicinity of those features. However, variation in recharge and hydraulic conductivity caused water levels to change many 10's of feet within the simulated reclaimed mine pits.

After reviewing the USGS results and discussing the findings with Departmental personnel, it was decided that additional modeling would not provide conclusive answers regarding ground water recovery levels. Therefore, DOI decided that alternatives should be presented for controlling water and salt in the pit areas. Two engineering approaches for the management of the risks associated with the uncertain future water table position and the containment or restoration of natural hydrologic and geomorphologic processes at the pit areas have been outlined in Table 1-3, Chapter 1. The DOI Monitor Option provides the possible advantage of minimizing backfill requirements, while the DOI Drainage Option overcomes the uncertainty of the final water table position by restoring the pit bottoms to allow surface drainage of surplus water or dissolved salt through the original overland watercourses. The level of backfill under the DOI Proposal is determined largely by the volume of excess material derived from other reclamation operations and disposed of as backfill in the pit areas.

The Laguna Proposal would provide for higher backfill levels on the basis that it would eliminate the potential for ponded water in the open pits.

The backfill levels indicated under Anaconda's Proposal in Table 1-3, Chapter 1 are based upon the Dames and Moore estimates. It should be noted that the risks associated with salt storage and ponded water would be reduced to the extent that Anaconda eventually may raise these backfill levels by disposing of other waste material in the pit bottoms. Because of differences between ground water recovery levels in the east and west portions of the North Paguate pit, Dames and Moore recommended the placement of low permeability materials (hydraulic conductivity of 1 ft./year) to form an internal cut-off and reduce backfill requirements in that area. Prior to placement of the cut-off, ponded water would be removed and the ground surface would be cleared of loose materials.

For the reasons cited in the Radiation section of this chapter, the following analysis does not address the impacts of placing the protore above the projected ground water recovery level.

Surface Water Quantity

No Action Alternative

Under this alternative, the mine pits would not be backfilled. Ground water would continue to seep into the pit bottoms, augmented by precipitation and runoff. During mining operations pit waters were used for dust suppression; however, now that such operations have ceased, the water has ponded in the pits. These ponds are permanent water bodies whose surface elevations will reflect an equilibrium condition between runoff, ground water seepage into the pits and evaporation from the ponds.

Below the confluence of the Rio Moquino and the Rio Paguate, the surface discharge of ground water adds to the base flow of the stream. Ground water lost to the pits, and to subsequent evaporation, would not be available for that surface discharge into the Rio Paguate. The ponds in the pits are expected to cover a total of about 50 acres; therefore, the estimated evaporation loss would be about 200 acre-feet per year in perpetuity.

Anaconda, DOI (Monitor Option) and Laguna Proposals

These alternatives provide for backfill in the mine pits. Ground water and any infiltration from the surface would saturate the pit backfill material to the level of ground water recovery. The risks of surface ponding and salt storage in the soils by evapotranspiration from shallow ground water would vary among the three alternatives. Anaconda's proposal would rely upon evapotranspiration from the reclaimed pit areas (100 acres or more at the Jackpile pit) to remove water from the pit backfill. The quantity of water lost would approach that of the No Action Alternative, about 200 acre feet per year. The DOI Monitor Option would be based on a performance standard, such that surface ponding and salt build-up would be prevented by successive additional layers of backfill. The Laguna Proposal calls for 7 feet of unsaturated backfill above the DOI's Monitor Option, a thickness that would prevent evapotranspiration losses and salt build-up. Under these proposals, some of the ground water would be discharged to the streams. However, about 3,000 to 4,000 acre-feet of this ground water would percolate into the backfill material in the pits over a 20-year period; during this period, this quantity of ground water would not be discharged to the streams. This one-time loss would be less than the perpetual losses due to evaporation from pond surfaces as described under the No Action Alternative.

DOI Proposal (Drainage Option)

Under this option, surface water from the pits would flow through man-made channels, which would restore the watercourses that originally drained the site, to reach the Rio Paguate. Surface runoff would consist of precipitation runoff, and possibly, ground water that would seep into the pits. The total discharge to the streams would approximate that of pre-mining conditions. Under this option, there would also be a loss of water to storage beneath the drained surface. This amount might approach the 3,000 to 4,000 acre-feet estimated for the other alternatives.

Surface Water Quality

No Action Alternative

Surface water quality under this alternative would, for some time, remain essentially the same as described in Chapter 2. However, as earthen berms on protore dumps along the Rio Paguate are eventually breached, surface water quality would deteriorate. Water ponded in the open pits (presently 36 acres) would have elevated levels of virtually all constituents now present; the water would be unfit for use and some constituents could be concentrated in toxic levels.

Anaconda, DOI (Monitor Option) and Laguna Proposals

Under these alternatives, backfilling of open pits to above the future ground water recovery levels would cause intermittent ponding of surface water runoff in the pits. These intermittent ponds, up to 200 acres in area, would be saline and unfit for use in the case of Anaconda's Proposal. The DOI Monitor Option would overcome any salt storage by means of supplementary backfill. The Laguna Proposal would cause relatively temporary and fresh ponding in the pits. For all proposals, mulching and revegetation of disturbed areas combined with flattening of slopes would act to increase water infiltration and decrease erosion on waste dumps. Because pre-mining water quality data does not exist, it is impossible to quantify the effect of re-establishment of vegetation and therefore, decreased erosion on surface water quality. However, it is expected that decreased erosion would lead to decreased amounts of TDS and heavy metals in stream waters. It is important to note that current amounts of these constituents in surface waters are not abnormally high, and that the decreases noted above would be minor. Anaconda's Proposal would store salts in the pit areas and thereby reduce somewhat the leachate loading of the Rio Paguate.

Theoretically, increased water retention could lead to increased infiltration of buried mine wastes, which are porous, oxidized and susceptible to leaching of toxic elements. However, the geochemical environment within the backfill could limit this process (Dames and Moore 1983). These infiltrating waters would ultimately be discharged to the streams, and have a minor impact on surface water quality. Development of saturated waste dumps and subsequent leaching of toxic elements is unlikely.

DOI Proposal (Drainage Option)

Under this option, ponding of surface water would not occur. The pits would be reclaimed to the same standards as the other disturbed areas. Surface waters emanating from the reclaimed pits would enter stream courses. This water would consist of precipitation, suspended sediment and, possibly, ground water that seeps into the open pits. Other surface water quality effects would be the same as the other reclamation alternatives.

Ground Water Quality

No Action Alternative

Under this alternative, ground water quality would be essentially the same as described in Chapter 2. Increases in the concentration of leached material from the minesite would vary according to the original concentration of source waters. Laboratory (batch) tests indicate that, neglecting evaporative concentration, source waters of about 1,500 micromhos per centimeter would be expected to undergo at least a doubling of conductivity as the result of flow through mine materials.

Anaconda Proposal

Salt and other dissolved constituents of ground water would be stored in the soils of the pit bottoms. Salt concentrations in ground water would build-up a salt water lens below the pit areas but a smaller salt load would be routed to the Rio Paguate.

DOI (Both Options) and Laguna Proposals

Under these alternatives, backfilling the pits above the ground water recovery level would increase ground water contact with waste materials. This increased contact with oxidized and broken waste would initially increase TDS and heavy metal concentrations. The specific level of this increase cannot be accurately predicted, but is expected to be temporary. Eventually, ground water in the reclaimed pits would revert to a chemically reducing condition and thus significantly decrease the leaching of elements from the backfill. Leachate in the ground water would approximately double the background conductivity values.

Recharge and Flow in Pit Areas

No Action Alternative

Under this alternative, water from direct precipitation, surface runoff, and ground water discharge would continue to cause ponding in the open pits. Equilibrium between water inflow and evaporation would occur after about 50 acres in the low areas of the pits are ponded. Depths of ponded water would generally be greater than 20 feet. Such ponded water would have elevated concentrations of salts, radionuclides and other minor elements. These constituents would continue to concentrate over time and could have deleterious health effects if ingested by wildlife, livestock or humans.

Anaconda Proposal

Under this alternative, the open pits would be backfilled to at least 3 feet above the projected ground water recovery levels as determined by Dames and Moore. Ground water would locally converge in the pit bottoms where water would be evaporated and salts retained in the soil. Except for the amount evaporated, the ground water would move through the pits in the general direction of the Rio Paguate. Generally, the ground water is predicted to flow west to east in the South Paguate pit (with a small amount moving northeasterly to discharge into alluvium of the Rio Paguate drainage), northwest to southeast in the North Paguate pit, and northeast to southwest in the Jackpile pit.

DOI (Both Options) and Laguna Proposals

Recharge and ground water flow patterns would be similar to natural conditions. The Monitor Option and Laguna Proposal would have higher recharge rates at the closed pit areas.

Erosion

Arroyo Headcutting

No Action Alternative

Under this alternative, headcuts south of dumps I, Y and Y2 would continue to erode and migrate upstream. Arroyos would eventually breach the haul road at the base of these dumps, and would subsequently erode the bottoms of the waste dumps. Accelerated gullying of dump slopes would ensue and could lead to possible exposure of radioactive materials. Offsite impacts due to this gullying may include increased stream sediment loads and deterioration of water quality. The headcut at the road southwest of dump FD-3 would move upstream by piping-induced erosion. The road and, possibly, the low dam upstream from the road would be breached. However, arroyo encroachment onto waste dump FD-3 would be prevented by resistant sandstone outcrops in the arroyo upstream from the dam. The arroyo headcut west of the airstrip is predicted to remain relatively stationary.

Anaconda Proposal

This proposal consists of armoring the headcuts south of dumps I, Y and Y2 with gravel and cobble material (Figure 3-5). This basic armoring design would slow the progress of headcutting arroyos. However, previous armoring of arroyo headcuts in areas of piping at the mine has led to only temporary success (less than 5 years) followed by headward cutting (by-pass) around the armor plug and subsequent headcut migration upstream. This process is expected to occur under Anaconda's Proposal, with the resultant probability of arroyo encroachment onto waste dump slopes. Accelerated gullying of dump slopes would lead to the impacts discussed under the No Action Alternative. Headward cutting at the road southwest of dump FD-3 would eventually breach the road and possibly the upstream stock dam.

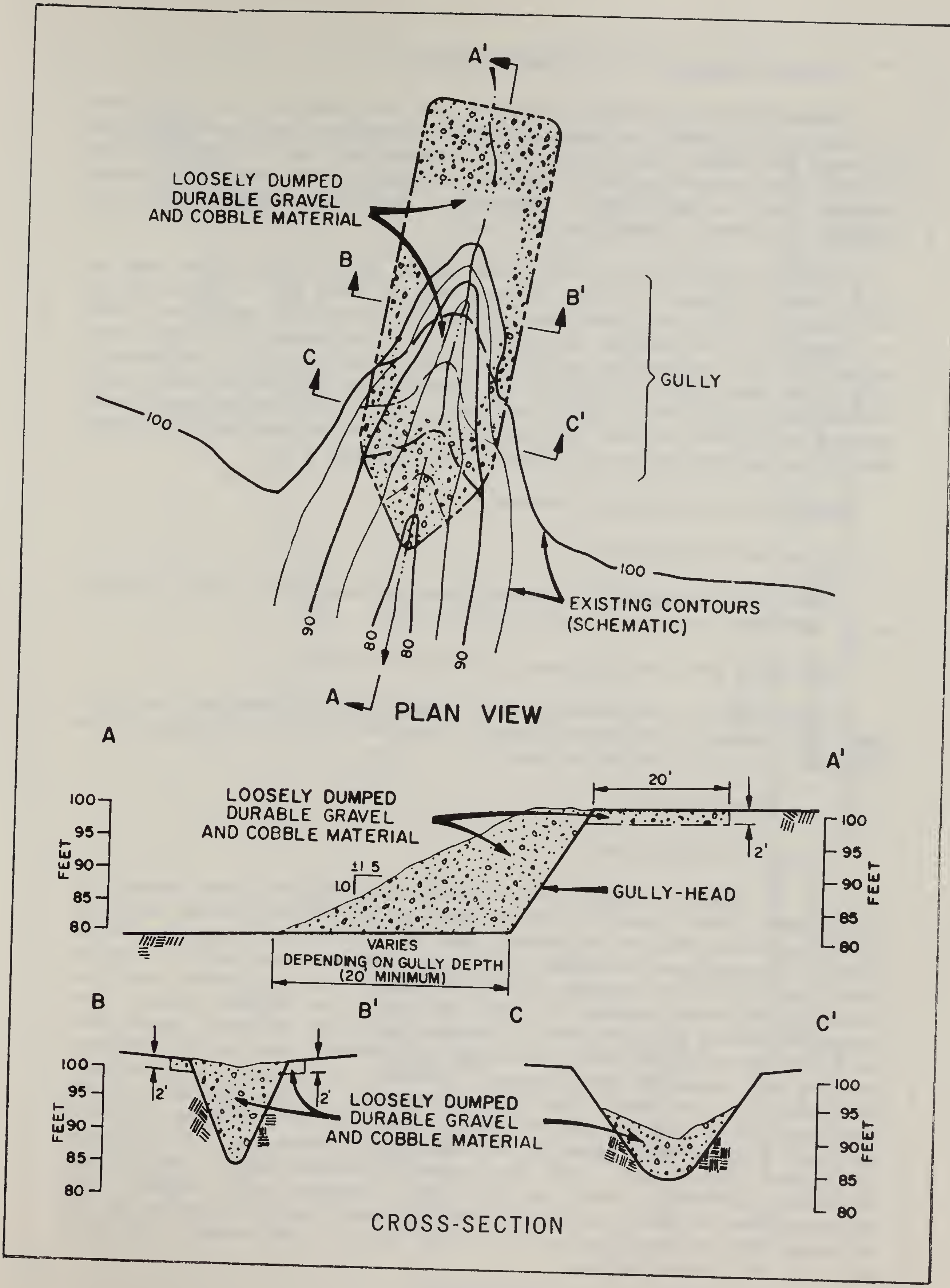


FIGURE 3-5

Design of Armoring to Reduce Headcutting -- Anaconda's Proposal

DOI (Both Options) and Laguna Proposals

Stabilization of arroyo headcuts has two important requirements: 1) porosity in order to avoid excessive pressures and thus eliminate the need for large, heavy structural foundations, and 2) some type of inverted filter that leads the seepage gradually from smaller to larger openings in the structure. Otherwise, the soils would be carried through the control, resulting in erosion.

Arroyos that would be stabilized under these alternatives are the areas south of dumps I, Y and Y2, and west of dump FD-3. The walls of the headcuts would be sloped back and the fill material would be placed in layers of increasing particle size from sand to large rock aggregate. The toe of the rock fill would be stabilized by utilizing a rock check dam. This dam would be designed to dissipate energy from the chuting flows and to catch sediment. Deposition of sediment would further stabilize the toe of the rock fill by encouraging vegetation during periods with no or low channel flow (Figure 3-6).

Sedimentation in Paguate Reservoir

No Action Alternative

Under this alternative, mine-related sedimentation would continue at an estimated rate of 22 acre-feet per year.

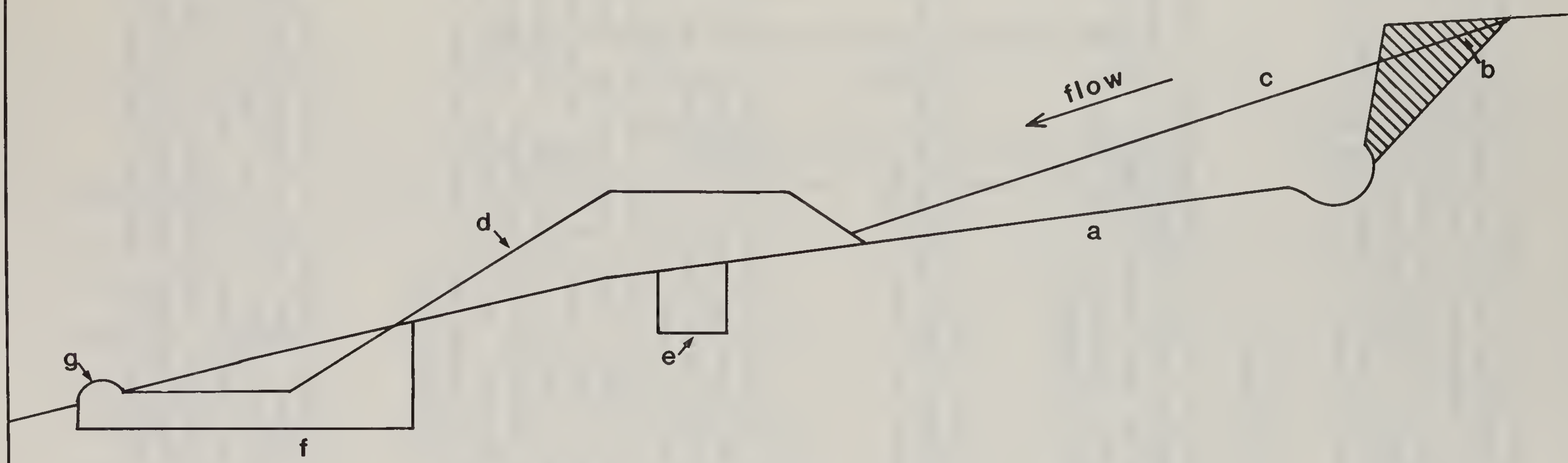
Anaconda, DOI (Both Options) and Laguna Proposals

Under these alternatives, the sedimentation caused by the mine would be reduced. However, Paguate Reservoir would continue to be affected by natural sedimentation.

Stream Stabilization

No Action Alternative

If no action is taken, waste dumps and protore piles lining the two streams would remain in place and intermittently slough into the Rios Moquino and Paguate as normal bank caving processes operate during periods of moderate and high streamflow. During occurrences of major flood runoff, the Rio Moquino might cut deeply into the waste dumps and remove significant amounts of dump material from meander bends. The increased stream gradient due to straightening of the river might lead to incision of the stream, resulting in headcut erosion up tributary arroyos and increased bank caving. However, no tendency for incision has been noted to date. The limited capacity of the culverts at the road crossing of the Rio Moquino would cause the road fill to act as a dam that would breach when it is overtopped, resulting in a greater flood peak downstream. The processes described above would cause increased sediment loads in the Rios Moquino and Paguate and deterioration of water quality. Specific water quality impacts may be increased TDS and salinity and, if dumps T and U are eroded, increased radionuclide concentrations.



Adopted from Heede, 1976

FIGURE 3-6

Construction plan for a gully headcut control - DOI and Laguna Proposals. The section of the structure is parallel to the centerline of the gully. a - original gully bottom; b - excavated area of headcut wall; c - rock fill; d - rock check dam; e - excavation for key; f - excavation for apron; g - end sill.

Anaconda Proposal

Under this proposal, the possibility of channel incision and the probability of breaching the road crossing would be the same as the No Action Alternative. However, due to movement of waste dumps 200 feet away from the Rio Moquino, any normal bank caving into the river would involve alluvium, not dump materials. The 200-foot waste-free zone should provide a sufficient buffer so that it would be unlikely that even several major flood events would cause lateral migration of the stream to waste dumps.

DOI (Both Options) and Laguna Proposals

Under these proposals, construction of a permanent cement base or flood-proof bridge for the Rio Moquino would eliminate the potential for breaching of the road crossing and would greatly reduce the potential for incision of the river channel. The impacts of bank caving would be the same as Anaconda's Proposal.

Waste Dump Slopes

In this section, estimates of waste dump erosion under the four alternatives are based on Universal Soil Loss Equation calculations and on site-specific gully measurements on dump slopes. Table 3-11 summarizes the estimates.

No Action Alternative

Total erosion (sheetwash plus gully erosion) predicted to occur under this alternative would be the same as that occurring at the minesite under the existing conditions described in Chapter 2. The mean total erosion is estimated to be 79.4 tons per acre per year; this compares to total erosion rates of 1.5 to 9.0 tons per acre per year on natural terrain near the minesite (USDA, Soil Conservation Service 1973.) An average of approximately 265 tons of U_3O_8 is estimated to reach the Rios Paguate and Moquino annually under this alternative. Impacts of these high erosion rates would include continued incremental additions of waste material to sediment in the rivers, and more deterioration of surface water quality (relative to other alternatives) due to higher TDS and radionuclide concentrations.

Anaconda Proposal

The mean soil loss due to sheetwash under this alternative is estimated to be 11 inches per 100 years. The total erosion from dump slopes would range from 12.8 to 51.9 tons per acre per year, with a mean total erosion of 26 tons per acre per year. This would be a 61 percent reduction from existing conditions. Approximately 27 tons of U_3O_8 are estimated to reach the Rios Paguate and Moquino annually under this alternative; this would represent a 90 percent decrease from the existing rate.

TABLE 3-11

ESTIMATED WASTE DUMP EROSION BY ALTERNATIVE[a]

Alternative	Mean Total Erosion (tons/acre/year)	Percent Reduction from Existing Erosion	Tons U_3O_8 Reaching Rivers Annually [b]	Percent Reduction from Existing Erosion
No Action	79.4	0	265	0
Anaconda Proposal	26	61	27	90
DOI Proposal (Both Options)	13	82	15	95
Laguna Proposal	13	82	15	95

Notes: a/ Total erosion rates on surrounding natural terrain range from 1.5 to 9 tons per acre per year (USDA, Soil Conservation Service 1973).
b/ This figure reflects the amount of 0 to 0.02 percent uranium (U_3O_8) reaching rivers.

The potential for extensive erosional soil losses due to sheetwash is relatively minor. However, the potential for slope gullying, resultant loss of grazing land, and exposure of radiologically active materials is significant, expecially on slopes planned to remain at 1.5 to 1. The rock-lined chutes designed to drain water off slopes would be maintenance dependent, and their stability is questionable. Failure of these structures due to high-velocity flow and breaching is considered probable. Extensive gullying would result.

DOI (Monitor Option) and Laguna Proposals

Under these alternatives, the mean soil loss as a result of sheetwash erosion is estimated to be 3 inches per 100 years. Total erosion from dump slopes would range from 8.5 to 19.8 tons per acre per year. Mean total erosion is estimated to be approximately 13 tons per acre per year, a reduction of 82 percent from existing conditions. A total of approximately 15 tons of U_3O_8 is estimated to reach the Rios Paguate and Moquino annually under this alternative, a figure that represents a 95 percent reduction from the existing rate. Up to two square miles of internal draining catchment would contain sediment on-site. It is predicted that relatively gentle 3:1 slopes and contour furrowing (on slopes and dump tops) would combine to retain water and reduce potential for gullying, so that maintenance-dependent drainage structures would be unnecessary.

DOI Proposal (Drainage Option)

Total erosion and impacts on dump slopes under this option would be the same as the DOI Monitor Option. However, pit areas would be contoured and channeled to allow external drainage. Sediment would be generated from up to two square miles of restored externally draining catchment. Sheetwash erosion is expected to remove a lesser amount of topsoil from the pits than from the dump slopes, because the pit bottoms would be contoured to more gentle slopes and the drainage gradients would be much less. Drainage courses would be designed on gradients flatter than existed at local natural watercourses to minimize the possibility of arroyo formation.

AIR QUALITY

No Action Alternative

As described in Chapter 2, the main non-radiological air quality parameter of concern is total suspended particulates (TSP). Under this alternative, TSP concentrations would remain at current levels. That is, most of the time, TSP levels would be below State and Federal standards. However, during periods of higher winds, the seven-day average standard could be exceeded. These short-term, higher levels would not pose any significant health impacts.

Anaconda, DOI (Both Options) and Laguna Proposals

As compared to the No Action Alternative, these proposals would signficantly reduce TSP levels because reclamation measures, especially revegetation, would reduce the amount of barren areas which are the main sources of TSP.

SOILS

No Action Alternative

Under this alternative, the ability of disturbed acreage to support vegetation would depend upon the geologic materials present at the surface. Areas covered with Dakota Sandstone, Mancos Shale or Jackpile Sandstone materials would not support plant communities. Some annual forbs, grasses and a few shrubs would become established, but plant densities would be extremely low. Consequently, water and wind erosion would continue to be high. Areas covered with Tres Hermanos Sandstone would continue to develop successional plant communities, except on steep slopes. These plant communities would eventually consist of shrubs, perennial and annual grasses, and forbs but would require many years to become established by natural processes. Additionally, up to 50 acres of land surface in the open pits would remain unproductive due to ponded water.

A topsoil borrow site would not be established therefore no environmental consequences would occur due to soil removal from such an area.

Anaconda, DOI (Both Options) and Laguna Proposals

Under these alternatives, topsoil would be taken from stockpiles and, if needed, a proposed 44-acre borrow area and distributed on all disturbed acreage. Stockpiled soils consist of Lohmiller, Penistaja and Rockland types. The latter is in greatest abundance and is an artificial soil created by pulverizing Tres Hermanos Sandstone. All three soil types have been successfully used to establish and sustain diverse and productive plant communities. Nutrient and physical properties of soils from the proposed borrow area would also provide a favorable growth medium.

Fertilizer would be applied during the initial season to ameliorate nutrient deficiencies in stockpiled or borrowed soils. Surface redistribution of reconstituted soils and subsequent reclamation would increase vegetative cover and decrease erosion rates.

At least 5 feet of topsoil would be left above arroyo bottoms in the borrow area. This area would be re-contoured so that previously deep, steep-walled arroyos would become shallow, gentle swales.

About 200 acres of soils could be abandoned from productive use by Anaconda Proposal for evaportranspirative discharge from the pits, and the subsequent salt storage in those soils. The DOI and Laguna Proposals would retain these areas as productive soils.

FLORA

No Action Alternative

Under this alternative, meager and scattered vegetative re-establishment would continue by secondary succession on habitable sites. Low stages of this succession would persist upon these sites for many years, and low values for plant cover, density and production would ultimately result.

Additionally, many disturbed areas are surfaced by overburden materials that have no present or future potential as plant growth media. Exposure to the elements and to biological interactions would not make this material less sterile or more hospitable to a plant community. Such sites would remain permanently devoid of vegetation and unprotected from erosional processes. Several waste dumps that have already been reclaimed would support vegetative communities having parameters that, in many cases, would approach or approximate those of surrounding undisturbed sites. Continued non-use by livestock of the reclaimed sites would lead to regression in plants successional stages because of poor soil conditions (i.e., capped soils) and lack of stimulus for plant growth.

As stated in the previous section under Soils, 50 to 200 acres of land surface in the open pits would remain unproductive due to ponded water.

Anaconda Proposal

Reclamation trials at the Jackpile-Paguate uranium mine have demonstrated that techniques such as mulching, fertilizing and reseeding with diverse seed mixtures can successfully revegetate disturbed areas. Successful reclamation of these sites, however, depends upon erratic precipitation events that may not materialize each year. Reseeding efforts may need to be repeated when adequate seedling establishment fails to occur during the initial growing season. Such areas would be replanted in the following year.

Proposed seed mixtures are presented in Tables 3-12 and 3-13. These mixtures may be modified where desirable to include species more adapted to any alkaline or droughty soils encountered. Such mixtures would be drilled into seedbeds constructed on all disturbed areas, including reconfigured waste dump tops and slopes. Artificial soil profiles would be reconstructed over all disturbed areas by overlying 1 foot of crushed Tres Hermanos Sandstone, amended by initial fertilizer applications. Anaconda has also agreed to plant between 500 and 1000 tree seedlings in the reclaimed areas, and will assure that a minimum of 400 trees survive three years after planting. The tree seedlings will consist of 95 percent one-seed juniper and 5 percent pinyon pine.

All disturbed areas would be revegetated to approximate the species density and diversity of the surrounding terrain. This objective would most likely be achieved on flat to moderately sloping areas. However, on waste dumps planned for 2:1 or steeper slopes, revegetation that

TABLE 3-12

PROPOSED SEED MIXTURES
(Seed Drill Mix 1)

Species	Single Species Critical Area Rate (lbs/acre)	% of Mixture	PLS[a/] Mixture lbs/acre	Purity %	Germination %	PLS[b/] Factor	Total lbs/acre
Blue Grama (*Bouteloua gracilis*)	3.5	11	0.39	76.90	80	61.5	0.63
Sideoats Grama (Vaughn) (*Bouteloua curtipendula*)	18.0	15	2.70	90.00	61	55.0	4.91
Crested Wheatgrass (Nordan) (*Agropyon cristatum*)	13.0	34	4.42	92.37	81	74.8	5.91
Indian Ricegrass (*Oryzopsis hymenoides*)	11.0	8	0.88	99.39	88	87.5	1.01
Galleta Grass (*Hilaria jamesii*)	16.0	6	0.96	51.97	41	21.3	4.51
Fourwing Saltbush (*Atriplex canescens*)	36.0	11	3.96	98.96	44	43.5	9.10
Small Seed							
Alkali Sacaton (*Sporobolus airoides*)	1.5	7	0.11	99.04	66	65.4	0.17
Weeping Lovegrass (*Eragrostis curvula*)	1.5	4	0.06	98.00	95	93.1	0.06
Yellow Sweetclover (*Melilotus officinalis*)	10.0	4	0.40	99.80	70	69.9	0.57
Total		100%	13.88				26.87

Source: Anaconda Minerals Company 1982.

Notes: [a/]Pure live seed.
[b/]Pure live seed factor: % germination x % purity.

TABLE 3-13

PROPOSED SEED MIXTURES
(Seed Drill Mix 2)

Species	Single Species Critical Area Rate (lbs/acre)	% of Mixture	PLS Mixture lbs/acre	Purity %	Germination %	PLS Factor	Total lbs/acre
Sideoats Grama (*Bouteloua curtipendula*)	18.0	16	2.88	70.70	54	38.2	7.5
Western Wheatgrass (*Agropyon smithii*)	24.0	21	5.04	89.67	90	80.7	6.3
Fourwing Saltbush (*Atriplex canescens*)	36.0	5	1.80	98.96	44	43.5	4.1
Small Seed							
Sand Dropseed (*sporobolus cryptandrus*)	.5	20	.10	99.04	93	92.1	0.1
Weeping Lovegrass (*Eragrostis curvula*)	1.5	11	.17	98.00	95	93.1	0.2
Alkali Sacaton (*Sporobolus airoides*)	1.5	17	.26	99.04	66	65.4	0.4
Yellow Sweetclover (*Melilotus officinalis*)	10.0	10	1.00	99.80	70	69.9	1.4
Total		100%	11.25				20.0

Source: Anaconda Minerals Company 1982.

approximates the density and diversity of natural terrain is unlikely because of soil surface instability and recurrent erosion.

This alternative would ensure an ultimate vegetative cover that attained only 70 percent of the basal cover and production of adjacent native reference areas. At that level, restored sites would be less productive than natural sites, less capable of supporting populations of native and domestic herbivores, and more open to surface soil loss from erosional processes.

DOI (Both Options) and Laguna Proposals

Proposed seed mixtures and revegetation techniques utilized on disturbed areas would be the same as those described under Anaconda's Proposal. However, revegetation efforts on waste dump slopes would meet with more success because gentler (3:1) slopes with contour furrows would significantly enhance the opportunities for plant community establishment. A 3:1 slope would also permit the use of conventional equipment (i.e., rangeland drill) for seeding operations. On-site trials to determine optimum slopes for vegetation establishment have not been conducted. However, reclamation projects on 33 percent contour furrowed slopes at similar sites have resulted in persistent plant communities that resemble stands on surrounding natural terrain in density and other measurable parameters.

These alternatives would also extend the vegetative parameters included in the data collection and comparison process to include density, frequency and foliar cover (canopy). Anaconda's proposal addresses basal cover and production but these criteria are not adequate to fully represent the vegetative response. Expansion of the data base to include the additional parameters would allow the descriptions of reclaimed sites and reference areas to extend to numbers and kinds of plants, distribution of plants, bare soil protected by foliage, and other important considerations. Collection of the additional data would require minimal increments of time or effort and would yield whole new dimensions and perspectives for plant community comparison.

These alternatives would also ensure that the vegetative parameters of density, basal and foliar cover, diversity and production on reclaimed sites would be at least 90 percent of that found on reference areas. Reclaimed plant communities would therefore be more comparable with natural communities in terms of vegetative diversity and production, soil retention and carrying capacity for native and domestic herbivores.

The DOI's preferred technique for data collection on both reclaimed sites and reference areas would be the Community Structure Analysis (CSA) method. This method was developed in northern New Mexico by scientists from the Rocky Mountain Forest and Range Experiment Station, and reported by Pase (1980). The CSA method combines density, frequency and cover values to derive an "importance value" (IV). The IV is commonly used to assess the relative importance of plants in a stand, thus permitting an array of species from "most important" to "least important" in the community (Pase 1980). The IV is theoretically little affected by year-to-year fluctuations in precipitation and any change in the IV indicates a change in condition.

In six years of research application on the BLM Rio Puerco Resource Area, the CSA method has proven to be an extremely objective and statistically sensitive measure of vegetative responses. The data base for the development of the method was the original Rio Puerco Grazing EIS area which geographically and floristically resembles the Jackpile-Paguate minesite. The CSA method provides the following advantages as cited by Pase (1980): 1) measurements can be repeated with measurable consistency, 2) sampling error can be computed and reliability can be evaluated, and 3) the quantitative data can be readily tested by conventional statistical methods.

FAUNA

No Action Alternative

Under this alternative, the present barren condition of most disturbed minesite acreage would remain for many years and be of no use to wildlife. Disturbed areas with Tres Hermanos Sandstone on the surface would revegetate to a limited extent. The existing undisturbed juniper and grassland/desert shrub habitats would remain essentially the same. Unchecked erosion of waste dumps could deteriorate the riparian habitat. The wildlife population may increase due to declining human presence and increased vegetation on Tres Hermanos materials, but wildlife habitat would be of such poor quality that any increase would be small.

Anaconda Proposal

Under this alternative, revegetation of disturbed areas of the minesite would increase the grassland/desert shrub habitat and decrease bare ground habitat. Deterioration of the riparian habitat would be alleviated because waste materials would be moved back from the Rios Paguate and Moquino. These habitat improvements would lead to increases in wildlife populations.

DOI (Both Options) and Laguna Proposals

Construction of 3:1 slopes would result in less erosion, and consequently, a greater improvement in grassland/desert shrub habitat than would occur under Anaconda's Proposal. A corresponding increase in wildlife population would result. Under the Drainage Option, the pits would be channeled to drain away accumulated surface water. The possible availability of additional surface water would tend to attract wildlife to the vicinity of the pits and surface drainages. A small increase in wildlife population over that of the Monitor Option would result from this attraction.

CULTURAL RESOURCES

Cultural resources within the lease areas have been inventoried. Consultation with the New Mexico State Historic Preservation Officer has resulted in a determination that no significant cultural resources (i.e., eligible for or listed on the National Register of Historic Places) would be affected by reclamation. Avoidance of significant cultural resources is a requirement of all reclamation activities.

No Action Alternative

Under this alternative no major impacts upon cultural resources would result. Access would continue to be controlled by Anaconda Minerals Company to protect the archeological and religious sites from vandalism.

Anaconda, DOI (Both Options) and Laguna Proposals

With the exception of the topsoil borrow area and Gavilan Mesa, reclamation activities would be confined to areas previously disturbed by mining. No archaeolgoical sites have been recorded within these two areas, therefore, the disturbance of additional archeological sites is not anticipated. Areas of religious concern would be avoided by reclamation efforts. Upon successful completion of reclamation, access to archeological sites and religious areas would be less controlled, allowing more vandalism as well as easier access for religious purposes.

VISUAL RESOURCES

No Action Alternative

Visual resource quality under this alternative would, for some time, remain essentially the same as described in Chapter 2. The modified landscape would remain visually unacceptable because of its unfinished appearance, and because of minesite features that are distracting and inharmonious with the surrounding natural landscape.

Anaconda Proposal

Through implementation of this alternative, the visual resources of the minesite would be enhanced. Implementation of the proposed reclamation measures would result in beneficial impacts through the reduction in form, color, line and textural contrasts.

Backfilling, reduction of slope angles, scaling of highwalls and revegetation measures would provide a more harmonious blending of the landscape features within the minesite with those of the surrounding area. The buttressing of Gavilan Mesa would do little to blend its shape into the surrounding landscape. Due to its large size and sharp contrast in color and texture, Gavilan Mesa would remain a highly visible feature for many years.

The removal of certain facilities, as specified in Table 1-3 (Chapter 1-3), would enhance the visual resource qualities of the mine area. However, those buildings and facilities to remain on lease No. 4 would contrast sharply with the surrounding natural landscape and reclaimed areas within the minesite. The majority of these buildings are metallic in texture and larger in scale than those in the nearby communities. They would draw more attention than other structures because of their sharp vertical lines and size. However, sight of these buildings may be acceptable to some viewers.

DOI Proposal (Both Options)

Implementation of this alternative would result in the alleviation of the adverse visual impacts in a similar way to Anaconda's Proposal. The beneficial impacts of this alternative would include a reduction of form, line, color and textural contrasts between the minesite and the surrounding undisturbed area.

This alternative includes a plan for greater slope modification than Anaconda's Proposal. The reduced angle of most slopes on the site to 3:1 or less would result in more stable slopes, a greater potential for revegetation, and therefore reduced color and textural differences once vegetation similar in density and diversity to the surrounding natural area is established.

In addition to buttressing, the west face of Gavilan Mesa would be recontoured to approximate its original profile for increased stability. This modification would be a slight visual improvement over that discussed under Anaconda's Proposal.

The visual impacts of either removing or leaving certain minesite facilities would be the same as Anaconda's Proposal.

Laguna Proposal

The implementation of this proposal would result in reduction of the minesite's adverse visual impacts through reclamation measures similar to those proposed under the DOI Proposal. Higher backfill levels proposed for this alternative would result in improved blending of the open pits with the adjacent natural topography.

SOCIOECONOMIC CONDITIONS

No Action Alternative

This alternative would not change the existing employment situation and associated social problems described in Chapter 2.

Anaconda, DOI (Both Options) and Laguna Proposals

Reclamation would temporarily increase employment and income. These increases would be proportionate to the reclamation measures approved by the DOI. (The final EIS will provide an estimate of the number of jobs generated for each reclamation proposal.) As reclamation is completed, workers will be released and unemployment will increase.

Increased job opportunities due to reclamation would temporarily decrease the existing social problems. However, as reclamation progresses and the work force is reduced, unemployment would resume and associated social problems would reappear.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

All reclamation alternatives, except for the No Action Alternative, would result in the irretrievable use of electricity, engine fuel and manpower. The use of these resources would have a negligible impact on the regional supply. The estimated uses are shown in Table 3-14. For the No Action Alternative and Anaconda's Proposal, a perpetual evaporative loss of 200 acre-feet per year of surface water would result. For the Anaconda, DOI and Laguna proposals, there would be a one-time loss of 3,000 to 4,000 acre-feet of water resaturating the pit backfill. Depending on future economic conditions, the buried protore could be reexcavated and the underground ore-bodies could be accessed by new entries. Therefore, there would be no permanent loss of these resources.

TABLE 3-14

ENERGY AND MANPOWER REQUIREMENTS

Item	No Action Proposal	Anaconda Proposal	DOI Proposal (Monitor Option)	DOI Proposal (Drainage Option)	Laguna Proposal
Fuel (millions of gallons)	0	5.4	5.3	5.5	5.5
Electricity (kilowatt hours)	0	292,000	290,000	290,000	290,000
Man Years Worked	0	201	198	203	204

Source: BLM 1985.

NON-RADIOLOGICAL ACCIDENTS

All proposals, except the No Action Alternative, would involve the extensive use of heavy costruction machinery such as dozers, scrapers, front-end loaders and heavy trucks. Use of this equipment would pose the risk of accidents and injuries. The U.S. Department of Transportation (1977) estimates that operation of all types of heavy machinery would result in about 0.15 non-fatal lost-time accidents per man year. Based on the man years worked (Table 3-14), the No Action Alternative would result in no accidents; Anaconda's Proposal 30.2; DOI's Monitor Option 29.8; DOI's Drainage Option 30.5; and the Laguna Proposal 30.7 accidents.

Chapter 4
consultation and coordination

INTRODUCTION

This Chapter describes the public involvement activities leading up to the preparation of this document. Also included is a listing of those agencies and affected parties requested to review and comment on this Draft Environmental Impact Statement (EIS), a listing of those individuals involved in the preparation of this document and a listing of consultants and contributors.

SCOPING

The Council of Environmental Quality (CEQ) Regulations implementing the procedural provisions of the National Environmental Policy Act (NEPA) require an early and open process for determining significant issues to be analyzed in depth in an EIS. This process is called "scoping". To ensure implementation of these regulations, the Department of the Interior (DOI) consulted and coordinated with various Federal, State and local agencies, the Pueblo of Laguna, Anaconda Minerals Company and interested persons.

The following listing is representative, but not all-inclusive, of the major events and consultation and coordination activities that took place prior to and during the development of this EIS. Public announcements, meeting attendance lists, summaries of meetings and written comments are on file at the BLM Albuquerque District Office, Rio Puerco Resource Area.

February 25, 1977 - Anaconda Minerals Company submitted a mining and reclamation plan for the entire life of all remaining mining operations. U.S. Geological Survey (USGS), Conservation Division (CD), prepared a draft environmental assessment; however, because of changes in the mining plan and additional environmental concerns cited by the USGS, no action was taken on the plan.

March 29, 1979 - Anaconda submitted a revised mining and reclamation plan which projected mining until 1985.

September 11, 1980 - Anaconda filed with USGS a three volume reclamation plan for the Jackpile-Paguate uranium mine. In the plan, Anaconda stated that it would discontinue production from two existing underground mines.

December 2, 1980 - The Chief of the USGS-CD, with concurrence by the Assistant Director for Resource Programs, determined that approval of the proposed reclamation plan would constitute a major Federal action; and therefore, that an EIS would be required.

February 19, 1981 - A "Notice of Intent" to prepare an EIS and to hold public scoping meetings on the reclamation of the Jackpile-Paguate uranium mine was published in the Federal Register (Vol. 44, No. 33, p. 13045). This Notice announced the availability of a proposed scoping document for the EIS. This scoping document summarized Anaconda's reclamation plan, anticipated issues and concerns, proposed alternatives and identified responsible personnel. The dates and locations of public meetings were also cited.

March 16, 1981 - A public meeting was held in the Laguna Tribal Council Building, Laguna, New Mexico. Seventy people attended including Laguna Councilmen, Anaconda representatives and local residents. Nineteen people made oral presentations. A scoping document containing preliminary issues, as identified by the DOI, was distributed to those in attendance. DOI representatives briefly discussed these possible issues which consisted of the following:

1. Release of radon gas into the atmosphere.

2. Radiological decontamination of existing buildings.

3. Radiological contamination of Paguate Reservoir and the Rios Paguate and Moquino.

4. Radiological contamination of ground water.

5. Radiological contamination of the human food chain.

6. Loss of uranium resources.

7. Abandonment of underground openings.

8. Highwall stabilization.

9. Waste dump stabilization.

10. Recontouring the minesite to prevent erosion.

11. Siltation of Paguate Reservoir.

12. Construction of a productive soil profile.

13. Selection of productive revegetation species.

14. Contamination of surface waters.

15. Future land use.

16. Aesthetic impacts of land form modification.

17. Reclamation costs.

18. Pueblo of Laguna employment during reclamation.

19. Reclamation standards.

20. Long-term monitoring.

The Governor of the Pueblo of Laguna outlined 5 main concerns of the Pueblo: 1) air and water quality and socioeconomic impacts; 2) preservation of and access to religious and cultural sites; 3) safety; 4) monitoring, and 5) unrecovered uranium reserves. Other comments were made with regard to the following: the EIS process and

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DTI                        Universal Search Module - Record List
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   Call Number: S621.5.S8 U57
        Author: U. S. Bureau of Land Management. Rio Puerco Resource Area.
                United States. Bureau of Land Management. Albuquerque
                District.
         Title: Draft environmental impact statement for the Jackpile-Paguate
                uranium mine reclamation project, Laguna Indian reservation,
                Cibola County, New Mexico
     Published: [Albuquerque, N.M.] : U.S. Dept. of the, 1985
   Description: 221 p. in various pagings : il
         Notes:  'February 1985'--Cover. One folded map in pocket.
         Notes: 'BLM-NM-ES-85-001-4134'--Cover. Includes bibliography and
                index.
    Subject(s): PUBLIC LANDS--NEW MEXICO.
                RECLAMATION OF LAND--ENVIRONMENTAL ASPECTS--NEW MEXICO--CIBOLA
                CO
                URANIUM MINES AND MINING--ENVIRONMENTAL ASPECTS--NEW
                MEXICO--CIBO
          ISBN:
       Volumes: 1     Copies: 1

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     88007297

   Call Number: TD195.U7 L365 1986
        Author: U. S. Bureau of Land Management. Rio Puerco Resource Area.
         Title: Final environmental impact statement for the Jackpile-Paguate
                uranium mine reclamation project, Laguna Indian Reservation,
                Cibola County, New Mexico.
     Published: Albuquerque, N.M. : U.S. Dept. of the In, 1986
   Description: 2 v. : ill., maps (some col.)
         Notes:  'October 1986'--Cover. One folded map in pocket of vol. 1.
                Bibliography: vol. 1, p. R-1 - R-8. Vol. 1 includes index.
                'BLM-NM-ES-86-018-4134'--Cover.
    Subject(s): PUBLIC LANDS--NEW MEXICO.
                RECLAMATION OF LAND--NEW MEXICO--CIBOLA COUNTY
                URANIUM MINES AND MINING--ENVIRONMENTAL ASPECTS--NEW
                MEXICO--CIBO
          ISBN:
       Volumes: 2     Copies: 1

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     áááááááááá    ááááááááá                          áááá
     88009818
     88043864

   Call Number: TD195.U7 J32 1985
        Author: United States. Bureau of Indian Affairs. Albuquerque Area
                Office.
                United States. Bureau of Land Management. Albuquerque
                District.
         Title: Jackpile-Paguate uranium mine reclamation project :
                environmental impact statement : draft.
     Published: Albuquerque, N.M. : US Dept. of the Inte, 1985
   Description: 1 v. (various pagings) : ill.,
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Notes: Cover title. 'February 1985.' 1 folded map in pocket.
Notes: Bibliography: p. R-1 - R-7. Includes index.
'BLM-NM-ES-85-001-4134.'
Subject(s): PUBLIC LANDS--NEW MEXICO.
RECLAMATION OF LAND--NEW MEXICO
STRIP MINING--ENVIRONMENTAL ASPECTS--NEW MEXICO
URANIUM MINES AND MINING--ENVIRONMENTAL ASPECTS--NEW MEXICO
ISBN:
Volumes: 1 Copies: 1

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End of Listing.

procedures, health effects (mining and post-reclamation), timetable to complete reclamation, level of backfill in each of the pits, radionuclide uptake into plant species, ore spillage at Quirk loading dock and along the rail spur, renovation of homes in the Village of Paguate and realignment of State Highway 279.

March 18, 1981 - A public meeting was held at the Classic Hotel, Albuquerque, New Mexico. Sixty-seven people attended including representatives from the Pueblo of Laguna and Anaconda Minerals Company. Seven people made oral presentations and six written comments were submitted. DOI representatives briefly summarized the same 20 issues presented at the meeting held March 16, 1981. Most of the comments received pertained to these issues. Other comments included a recommendation that the EIS adopt the Nuclear Regulatory Commission/Environmental Protection Agency regulations and standards for radiological clean up at uranium mill sites. Two commentors questioned the DOI's authority and need to prepare an EIS.

March 23, 1981 - DOI representatives met with the Laguna Tribal Council to explain the EIS process and solicit comments on major issues and concerns. Council members suggested that the EIS address the following: wildlife, farming, tourism, employment, waterflow and supply at the housing area, revegetation of native species suitable for livestock grazing, birth defects, cancer rates, drug abuse, alcoholism, sedimentation of Paguate Reservoir, placement of rock piles on reclaimed dumps, contamination of adjacent lands, renovation of homes in the Village of Paguate, timetable for reclamation, preservation of religious sites, realignment of the Rio Paguate, water quality, use of contaminated materials for home construction, compensation for the people psychologically damaged by the mining operations, plugging abandoned drill holes, reclamation of exploration roads on Black Mesa, and radiological contamination of crops grown and livestock raised on reclaimed areas.

August 20, 1981 - Anaconda withdrew the proposed reclamation plan submitted to USGS on September 11, 1980 because of plans to reroute State Highway 279 through the mine.

September 17, 1981 - DOI, POL and Anaconda met to discuss the rerouting of State Highway 279 through the minesite, and the recent withdrawal of Anaconda's proposed reclamation plan.

March 16, 1982 - Anaconda filed with USGS a revised three-volume reclamation plan for the Jackpile-Paguate uranium mine. This is the plan currently being evaluated in this EIS.

June 22, 1982 - DOI, POL and Anaconda agreed to form a technical committee to help define and resolve the differences between the Pueblo and Anaconda over reclamation of the Jackpile-Paguate minesite. The committee was comprised of representatives from DOI, POL and Anaconda. The committee met on several occasions and was able to resolve several issues. Those issues resolved included: removal of all rockpiles from the waste dumps, planting up to 1000 tree seedlings and agreement on the types of revegetation species to be used in the reclamation program. Issues not resolved included: the length of post-reclamation monitoring, configuration of waste dump slopes, stabilization of the North and South Paguate highwalls, disposition of the railroad spur, disposition of the buildings and equipment, damage to Paguate housing, sedimentation of Paguate Reservoir, the depth of topsoil cover, stabilization of arroyo headcuts, post-reclamation grazing management, disposition of protore stockpiles and the level of pit backfill. The last technical committee meeting was held November 10, 1982.

August 2, 1983 - In a letter to the Governor, Pueblo of Laguna, Anaconda proposed to resolve the reclamation issues concerning the Jackpile-Paguate uranium mine by providing payments and a donation of property to the Pueblo of Laguna. In return, the Pueblo of Laguna would have to agree to assume sole responsibility and obligation to perform any necessary reclamation of the Jackpile-Paguate uranium mine.

April 16, 1984 - BLM began to resurvey the minesite to accurately determine existing topography. Aerial photography and computerized techniques (digitizing) would then be used to calculate material volume requirements for reclamation.

May 18, 1984 - DOI officials met with the New Mexico State Environmental Improvement Division (EID) to present them with the status of the Jackpile-Paguate mine reclamation project and to solicit comments. EID asked questions regarding reclamation impacts on air and water quality.

August 21, 1984 - DOI representatives met with the Pueblo of Laguna Tribal Council to provide an update on the EIS and various studies including the USGS, Water Resource Division (WRD) hydrologic evaluation, radiological assessments and the photogrammetric/digitizing effort.

August 27, 1984 - USGS, WRD completed a short-term evaluation of the Dames and Moore ground water model. WRD established that this model contained no inconsistencies of a mathematical or programming nature which significantly affected its results. However, WRD's analysis revealed that the water levels computed by the Dames and Moore model were sensitive to the assumed input parameters.

October 1, 1984 - DOI, POL and Anaconda representatives met with the Assistant Secretary for Land and Minerals Management to discuss 1) Anaconda's cash settlement offer to the POL, and 2) the recent USGS, WRD evaluation of the Dames and Moore ground water model. In regard to the cash settlement offer, the Assistant Secretary informed all parties that the DOI would not be in a position to advise the POL on the suitability of the offer until the EIS is completed. In regard to the ground water recovery issue, the Assistant Secretary stated that the evaluation conducted by USGS, WRD placed the BLM in a position to adopt the Dames and Moore findings subject to a long-term monitoring program.

October 15, 1984 - BLM, through its photogrammetric and digitizing efforts, completed volumetric calculations for pit backfill levels, waste dumps and slope configurations. This information would be used for engineering design and reclamation cost estimates for the reclamation proposals being evaluated in the EIS.

PUBLIC REVIEW OF THE DRAFT EIS

Comments on the Draft Environmental Impact Statement will be requested from the following:

Tribal Government
- Pueblo of Laguna

Lessee
- Anaconda Minerals Company

Federal Government
- Advisory Council on Historic Preservation
- Environmental Protection Agency
- Nuclear Regulatory Commission
- U.S. Department of Agriculture
  - Agriculture Stabilization and Conservation Service
  - Forest Service
  - Soil Conservation Service
- U.S. Department of the Army
  - Corps of Engineers
- U.S. Department of Energy
- U.S. Department of Health and Human Services
  - Indian Health Service
- U.S. Department of Housing and Urban Development
  - Office of Indian Programs
- U.S. Department of the Interior
  - Bureau of Mines
  - Bureau of Reclamation
  - Fish and Wildlife Service
  - Geological Survey
  - Minerals Management Service
  - Office of Surface Mining, Reclamation and Enforcement
- U.S. Department of Labor
  - Mine Safety and Health Administration
  - Occupational Safety and Health Administration
- U.S. Department of Transportation

National Laboratories
- Argonne National Laboratory
- Los Alamos Scientific Laboratory

New Mexico State Government
- Governor of New Mexico
- Bureau of Mines and Mineral Resources
- Department of Agriculture
- Department of Energy and Minerals
- Department of Finance and Administration
- Department of Game and Fish
- Department of Health and Environment
- Division of State Forestry

Natural Resources Department
Office of Indian Affairs
State Engineer's Office
State Heritage Program
State Highway Department
State Historic Preservation Officer
State Land Office
State Park and Recreation Commission

<u>Local Governments</u>
Cibola County Commissioners
Mayor of Grants
Village of Milan

Copies of this Draft EIS will also be sent to various professional societies and organizations, interest groups and individuals.

TEAM ORGANIZATION AND CONTRIBUTORS

This Draft EIS was prepared by a team of professionals within the Department of Interior. These specialists were responsible for the preparation and/or review of various sections within the document. Departmental personnel involved in the preparation of this EIS are listed in Table 4-1. Consultants and other contributors are indicated in Table 4-2.

TABLE 4-1

LIST OF PREPARERS

Name	EIS Assignment	Education	Experience
Michael J. Pool	Overall Project Manager and BLM Task Force Leader	B.S. Agriculture	BLM - 5 yrs. Supv. Environmental Protection/Natural Resource Specialist - 2 yrs. Realty Specialist - 1½ yrs. Range Conservationist
William C. Allan	BIA Task Force Leader, Cultural Resources	B.A. Anthropology M.A. Social Sciences	BIA - 5 yrs. Environmental Quality Specialist - 4 yrs. Archaeologist UNM - 2½ yrs. Archaeologist Museum of NM - 2 yrs. Archaeologist
John M. Andrews	Technical Coordinator, Radiation and Air Quality	B.S. Geology	BLM - 1½ yrs. Environmental Protection Specialist MMS - 1 yr. Environmental Scientist USGS - 3 yrs. Environmental Scientist - 7 yrs. Physical Scientist NYGS - 1 yr. Geologist
Sarah W. Spurrier	Editor	B.A. Psychology	BLM - 7 yrs. Technical Publications Editor
John Arwood	Flora	B.S. Range Management, Animal Husbandry, Agricultural Economics	BLM - 16 yrs. Range Conservationist
Pete Balleau	Hydrology	B.A. Geology	BIA - 7 yrs. Hydrologist Consulting Firm - 4 yrs. Senior Hydrogeologist Geological Survey (Australia) - 3 yrs. Hydrogeologist Gov. of Kenya - 2 yrs. Provincial Water Officer
John Bristol	Visual Resources	B.A. Landscape Architecture	BLM - 2 yrs. Outdoor Recreation Planner - 5 yrs. Landscape Architect USFS - 8 yrs. Landscape Architect
Kent Hamilton	Economics and Reclamation Cost Estimates	B.S. Agricultural Economics	BLM - 7½ yrs. Economist BIA - 15½ yrs. Economist

TABLE 4-1 (Continued)

Name	EIS Assignment	Education	Experience
Dave Koehler	Standards of Vegetative Response	B.S. Range and Forestry M.S. Ecosystem Ecology PhD Range Ecology	BLM - 6 yrs. Chief, Br. Range Mgmt. Colorado State Univer. - 3 yrs. Research Assoc. (mine reclamation) Consulting Firm - 2 yrs. Envir. Consultant Oregon State Game Commission - 1 yr. Research Biologist USFS - 6 yrs. Range Conservationist
Noel Marsh	Flora	B.S. Range Management	BIA - 4 yrs. Range Conservationist SCS - 16 yrs. Range Conservationist
Mackie E. Murphy	Engineering Design and Blast Damage	B.S. Civil Engineering	BIA - 6 yrs. Civil Engineer - 7 yrs. Structural Engineer Army Corps of Engrs. - 3 yrs. Structural Engineer Engineering Firms - 9 yrs. Senior Vice President 2 yrs. Structural Engineer
Beverly Ray-Edwards	Socioeconomics	B.A., M.A. Psychology and Sociology PhD Sociology	BLM - 6½ yrs. Sociologist University Professor - 10 yrs. teaching in psychology sociology and anthropology
Vern Rulli	Geology and Mineral Resources	B.A., M.S. Geology B.S. Geology Engineering	BLM - 1½ yrs. Mining Engineer MMS - 1 yr. Mining Engineer USGS - 3 yrs. Mining Engineer
Dave Sitzler	Mining Operations, Non-Radiological Minesite Hazards, Engineering Design and Reclamation Cost Estimates	B.S. Geological Engineering	BLM - 1½ yrs. Mining Engineer MMS - 1 yr. Mining Engineer USGS - 4½ yrs. Mining Engineer
Bill Smith	Highwall and Waste Dump Stability	Geol. E., M.S., PhD Geological Engineering	USGS - 10 yrs. Geologist USBM - 2 yrs. Civil Engineer Colorado State - Professional Engineer
Greg Smith	Stream Channel Stability, Waste Dump Erosion and Arroyo - Headcut Erosion	B.S., M.S. Geology	MMS - 2 yrs. Geologist USGS - 2 yrs. Geologist Private Industry - 2 yrs. Geologist

TABLE 4-1 (Concluded)

Name	EIS Assignment	Education	Experience
Gary Stephens	Hydrology and Fauna	B.S. Geology	BLM - 1½ yrs. Inspection and Enforcement Specialist MMS - 1 yr. Environmental Scientist USGS - 5 yrs. Environmental Scientist Consulting Firm - 4 yrs. Geologist
Jerry Wall	Soils	B.S., M.S. Forest Soils	BLM - 7 yrs. Soil Scientist USFS - 9 yrs. Soil Scientist
Ralph Wilcox	Geology and Mineral Resources	B.S., M.S. Geology	BLM - 1½ yrs. Geologist MMS - 1 yr. Geologist USGS - 2½ yrs. Geologist - 1 yr. Hydrologist
Don Zoss	Blast Damage, Engineering Design and Reclamation Cost Estimates	B.S. Geological Engineering	BLM - 4½ yrs. Mining Engineer USGS - 5 yrs. Mining Engineer State Hwy. Dept. - 3 yrs. Geologist

<u>Administrative Support</u>

Anita Bardtrief - Secretary/Typist
Myrna Finke - Visual Information Specialist
Sandra Johnson - Clerk Typist
Emilio Montoya - Cartographic Technician
Irene Rivera - Clerk Typist
Millie Rose - Editorial Assistant
Tommie Teeter - Minerals Clerk
Shirley Torres - Supv. Clerical Assistant

<u>Technical Support</u>

Powell King - Mining Engineer
Jim Olsen - Geologist
Ted Rael - Economist
Joe Rasmussen - Mining Engineer
Joe Sovcik - Environmental Coordinator
Mary Zuschlag - Environmental Coordinator

TABLE 4-2

CONSULTANTS AND CONTRIBUTORS

Organization	Area of Assistance
Tribal Government	
Pueblo of Laguna	Information on the past and present land use of the minesite and surrounding areas.
Council of Energy Resource Tribes	Socioeconomic reports and consultant to the Pueblo of Laguna on various issues.
Lessee	
Anaconda Minerals Company	Information and technical reports on photogrammetry, hydrology, radiology, blast damage, plant stability evaluations, subsidence, highwall and waste dump stability.
Federal Government	
Environmental Protection Agency	Consultant to DOI on radiological assessments and analysis.
U.S. Department of Agriculture	
Forest Service - Rocky Mountain Forest and Range Experiment Station	Consultant to DOI on plant stability and revegetation
Soil Conservation Service	Guidance on seeding rates, seed mixtures and analysis of erosional impacts
U.S. Department of the Interior	
Bureau of Indian Affairs	Water quality analysis and hydrologic modeling evaluations
Bureau of Land Management - New Mexico State Office and Denver Service Center (Cadastral Survey, Divisions of Mapping Systems and Data Technology)	Cadastral survey, aerial photography, photogrammetric analysis and volumetric computations
Bureau of Mines	Assessment of potential blasting impacts from mine reclamation activities
Geological Survey	Analysis of minesite ground and surface water systems, water quality analysis, hydrologic modeling evaluations and analysis of erosional impacts
National Laboratories	
Argonne National Laboratory	Principal consultant to DOI on radiological impacts of mine reclamation

Appendices

Appendix A

Pit Backfill Levels

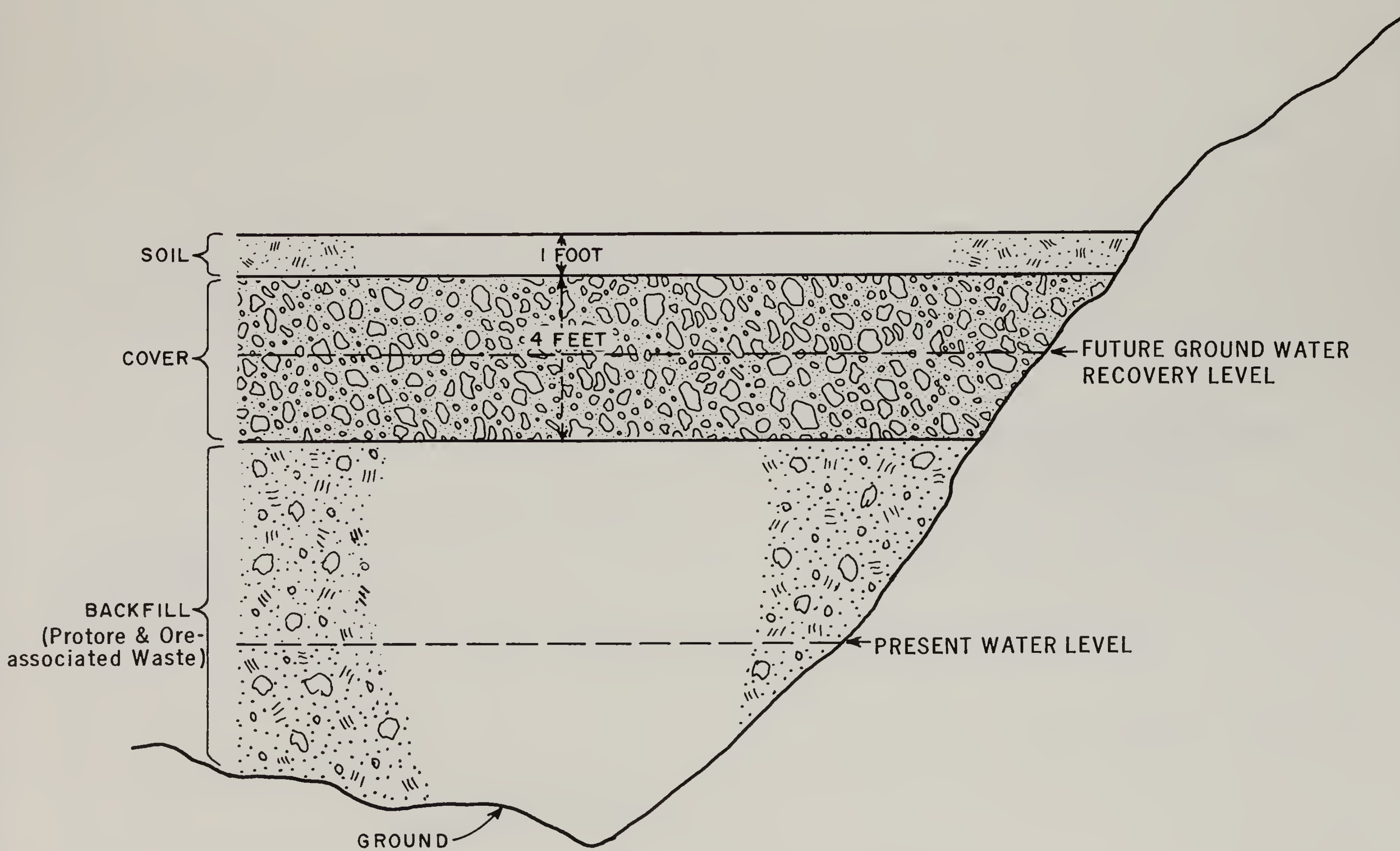

FIGURE A-1
Cross-sectional schematic diagram of pit backfill level – Anaconda and DOI Proposals.

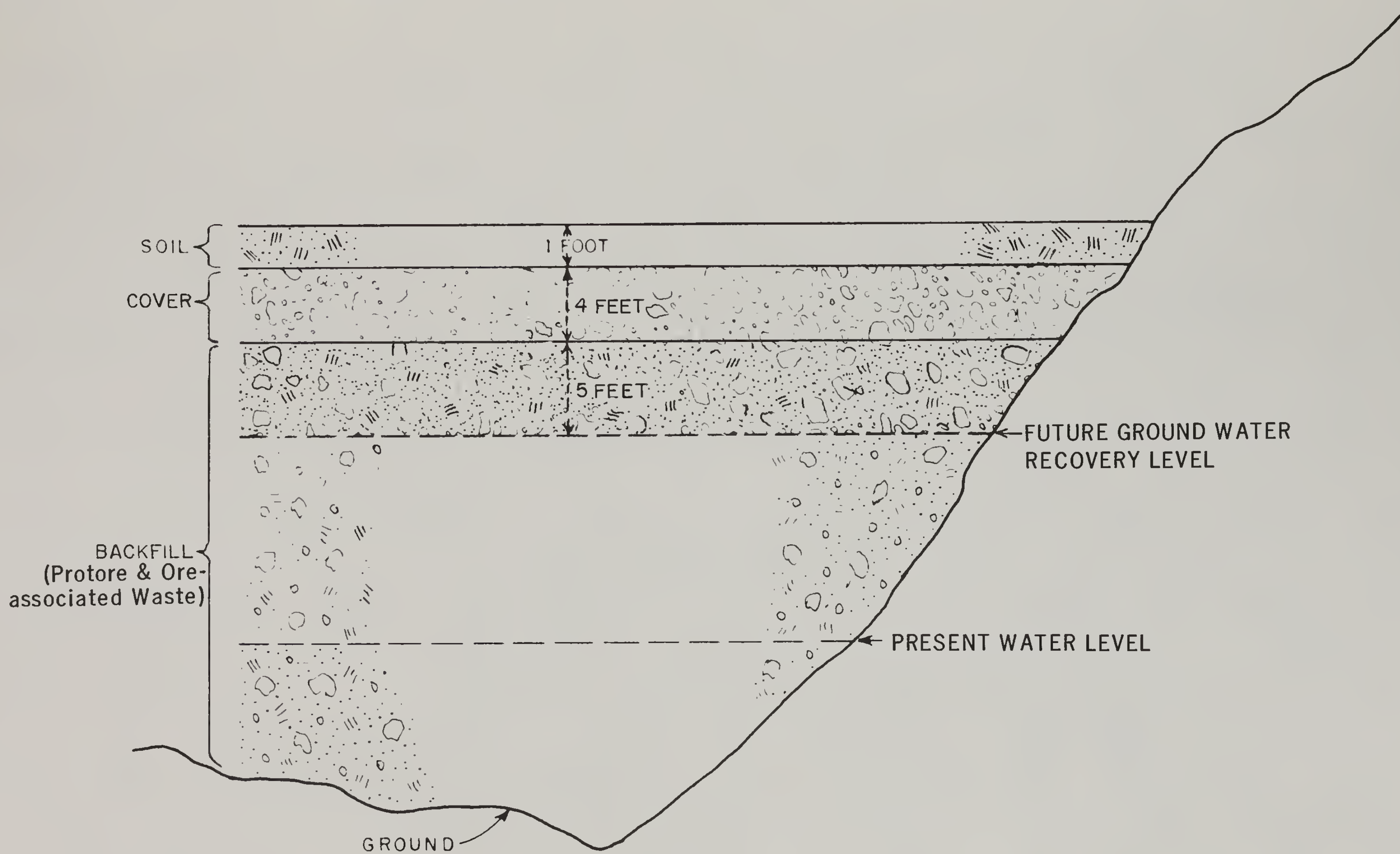

FIGURE A-2

Cross-sectional schematic diagram of pit backfill level - Laguna Proposal.

Appendix B
Waste Slope Modifications

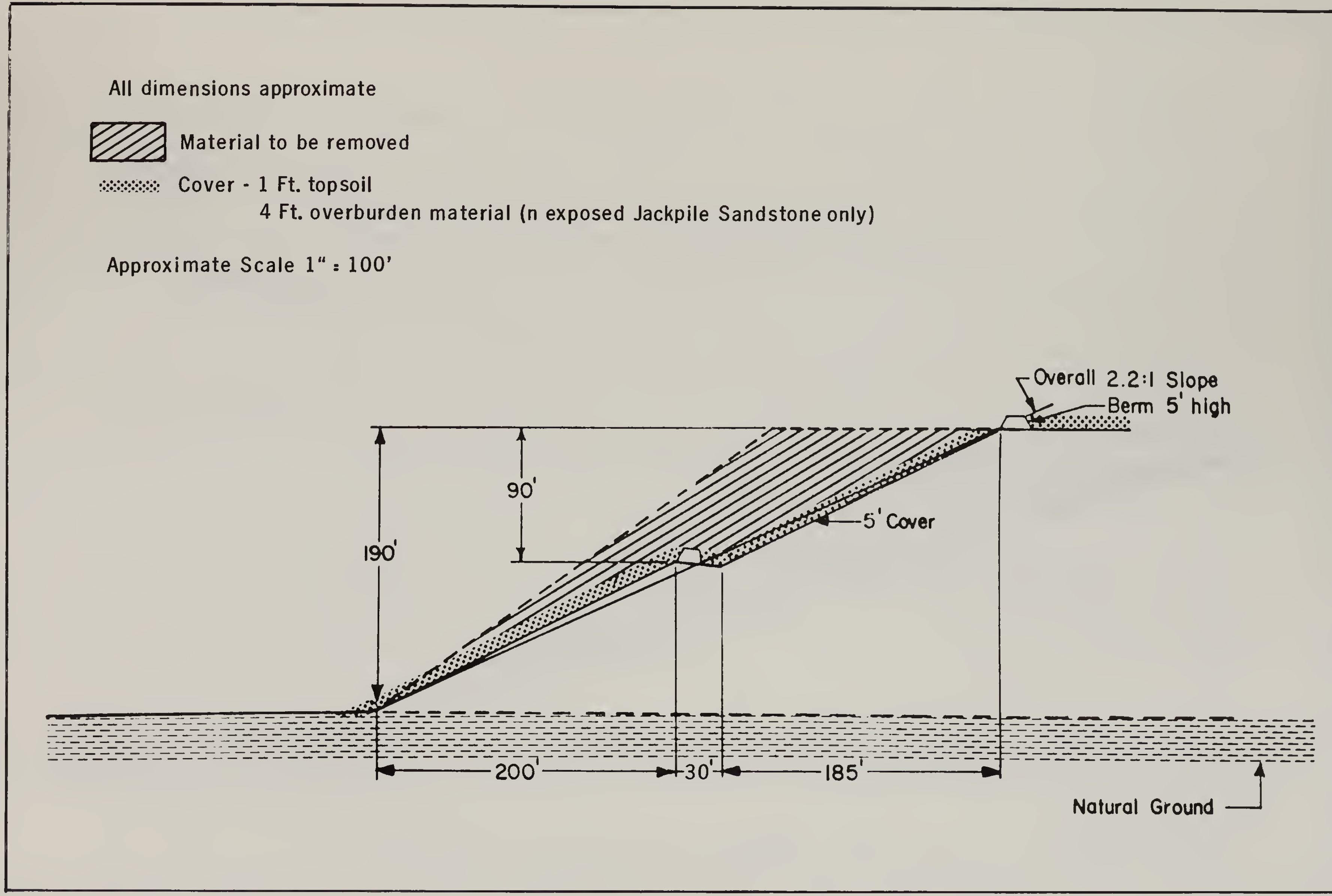

FIGURE B-1

Cross-sectional schematic diagram of waste slope modification -- Anaconda's Proposal.

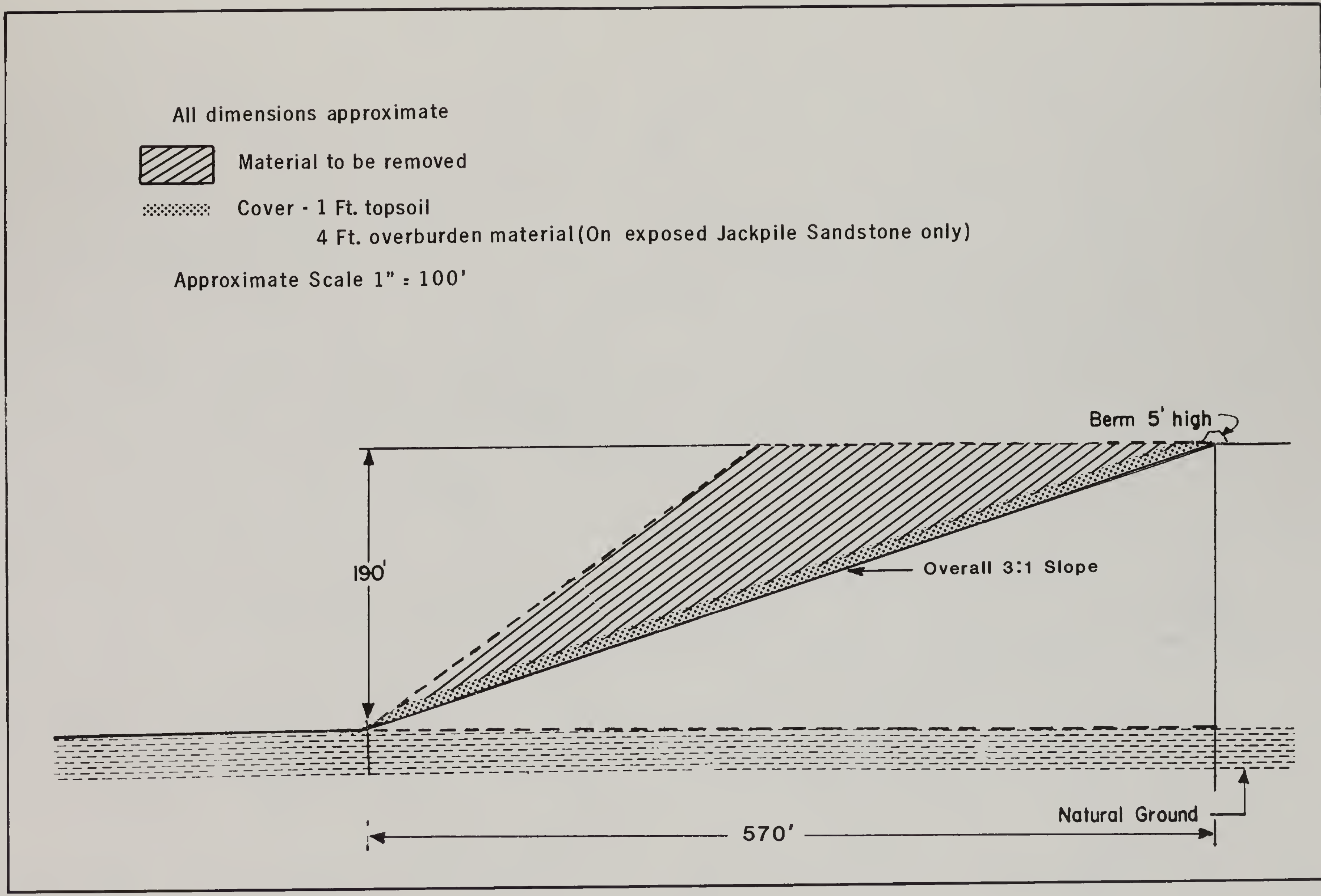

FIGURE B-2

Cross-sectional schematic diagram of waste slope modification -- DOI and Laguna Proposals.

Appendix C
Radiation

RADIATION

The following information is excerpted from Appendix C of the report, Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program (U.S. Department of Energy 1983). A copy of this document is on file at the BLM Albuquerque District Office, Rio Puerco Resource Area.

Radiation is the transmission of energy through space. Many kinds of radiation exist--including visible light, microwaves, radio and radar waves, and X-rays. All of these are electromagnetic radiations because they consist of a combined electrical and magnetic impulse traveling through space. Although much of this radiation (e.g., light) is vital to us, it can also be harmful; prolonged exposure to ultraviolet radiation from the sun can cause sunburn or even skin cancer.

Energy can also be transmitted through space by the motion of particulate radiations. These are either one of the fundamental particles of atoms (protons, neutrons, and electrons) or are a simple combination of the three fundamental particles.

The class of radiation of concern in evaluating the health risks of the material at the Jackpile-Paguate minesite is "ionizing" radiation. Ionizing radiation consists of either waves or particles with sufficient energy to knock electrons out of the atoms or molecules in matter. This disruption is termed "ionization."

The simplest example is the ionization of a single atom. The "nucleus," or center of the atom, is composed of particles called "protons" and "neutrons," the proton having a positive charge and the neutron having no charge. Negatively charged particles called "electrons" orbit the nucleus and are held in place by the attraction between the positive and negative charges. A neutral atom contains exactly the same number of electrons as protons, balancing the positive and negative charges.

When ionizing radiation knocks out an electron from an atom, the atom is left with a positive charge while the free electron is negatively charged. These parts of the atom are chemically active and react with neighboring atoms or molecules. The resulting chemical reactions are responsible for causing changes or damage to matter, including living tissue.

Types of Ionizing Radiation

The most common ionizing radiations of interest in this EIS are gamma rays, alpha particles and beta particles. The relative ionizing power of alpha to beta to gamma radiation is 100,000:100:1.

Gamma Rays

Gamma rays, like X-rays, are pure energy having no mass. They are part of the electromagnetic spectrum, as are light and microwaves, but have much shorter wavelengths and, therefore, have the ability to transmit larger amounts of energy than light and microwaves. Gamma rays are identical to X-rays, except that gamma rays originate in the nucleus of an atom whereas X-rays are produced by disruption and relocation of electrons. An X-ray or gamma ray, having no electrical charge to attract or repel it from protons or electrons, can pass through the free space in many atoms and, hence, through relatively thick materials before interacting. High-energy gamma rays can travel for about 500 yards in air.

Alpha Particles

Alpha particles are made up of two neutrons and two protons, a combination the same as the nucleus of a helium atom. Because of the presence of two protons with no counter-balancing negative electrons, the alpha particle is positively charged. Alpha particles transmit energy as kinetic energy, or the energy of motion, and travel 1 1/2 to 3 inches in air.

Because of the comparatively large size and the positive charge of an alpha particle, it interacts readily with electrons and does not easily pass through the spaces between atoms. It causes many ionizations in a short distance of travel. Because each of these ionizations dissipates energy, the alpha particle travels a very short distance. For example, most alpha particles will not pass through a piece of paper or the outer protective layer of a person's skin. However, if an alpha particle is produced by radioactive material inhaled or ingested into the body, it may cause many ionizations in more sensitive tissue.

Beta Particles

Beta particles are electrons moving at high speeds, some approaching the speed of light. They transmit energy as kinetic energy, and can travel up to 15 feet in air. Having comparatively small mass and a negative charge, their penetration through matter is intermediate between the alpha particle and the gamma ray.

Beta particles produce fewer ionizations along their path than do alpha particles. They can be absorbed by a sheet of rigid plastic or a piece of plywood. However, they can pass through the protective outer layer of the skin and reach the more sensitive skin cells in inner layers. If produced by radioactive materials inside the body, beta particles can damage internal tissue.

Radioactive Elements and Their Half-Lives

An atom is the smallest unit of an element; elements are the basic building blocks of all materials in nature. Over 100 known elements exist. In addition, elements may have several isotopes (atoms with the same number of protons but a different number of neutrons). Isotopes of an element react the same chemically.

Most atoms of the element carbon in a tree or in our bodies will remain atoms of carbon. In time, a carbon atom may change its association with other atoms in chemical reactions and become part of other compounds, but it will still be a carbon atom.

However, some isotopes are unstable. Unstable atoms spontaneously emit radiation and change to atoms of another element. These atoms are said to be "radioactive"; they exhibit the property of "radioactivity" (the spontaneous emission of radiation). Unstable isotopes of an element are referred to as "radioactive isotopes" or "radionuclides".

Radioactive atoms emit radiation (decay) at a characteristic rate dependent upon the degree of stability of the individual atom. The decay rate is characterized by a period of time called the "half-life." In one half-life, half the initial number of atoms decay, and the amount of radiation emitted also decreases by one-half. In the next half-life, the number of atoms and the amount of radiation will again decrease by one-half, thereby decreasing to one-quarter of the original amount. Half-lives are unique for each particular type of radioactive atom--that is, each isotope has its own half-life that cannot be changed. Half-lives for different radioactive materials range from a fraction of a second to billions of years. (In fact, some half-lives are so long that certain radioactive materials made at the time of the formation of the universe still exist. Examples include some isotopes of thorium and uranium.)

When an atom decays, radiation may be emitted from the nucleus as alpha particles, beta particles, neutrons or gamma rays. This changes the character of the nucleus, and the atom changes to an atom of a new element. Each type of radioactive atom decays with emission of characteristic types of radiation, each carrying away energy.

Atoms resulting from radioactive decay are called "decay products" or "progeny," whereas the original atom is called the "parent" atom. In some cases, the progeny resulting from the decay of a radioactive atom are also radioactive. For naturally occurring uranium and thorium, a sequence of as many as 12 to 14 radioactive decay products occur before the original uranium or thorium atom finally reaches stability as an atom of lead.

The half-lives of some of the radioactive materials in the uranium-238 chain that are important in this EIS, and the principal types of radiation emitted during decay, are shown in Figure C-1.

Units of Measure for Radioactivity and Radiation

The basic unit for measuring the amount of radioactivity or quantity of radioactive material is the "curie," named in honor of Madame Curie. The curie (Ci) is the amount of radioactive material in which 37 billion atoms are decaying each second; this is the approximate number of atoms decaying each second in one gram of radium-226, the element discovered by Madame Curie. The amount of material that releases one curie of radiation varies from one isotope to another, because of the differences in half-lives and atomic weights among the various radioactive isotopes. For materials with short half-lives,

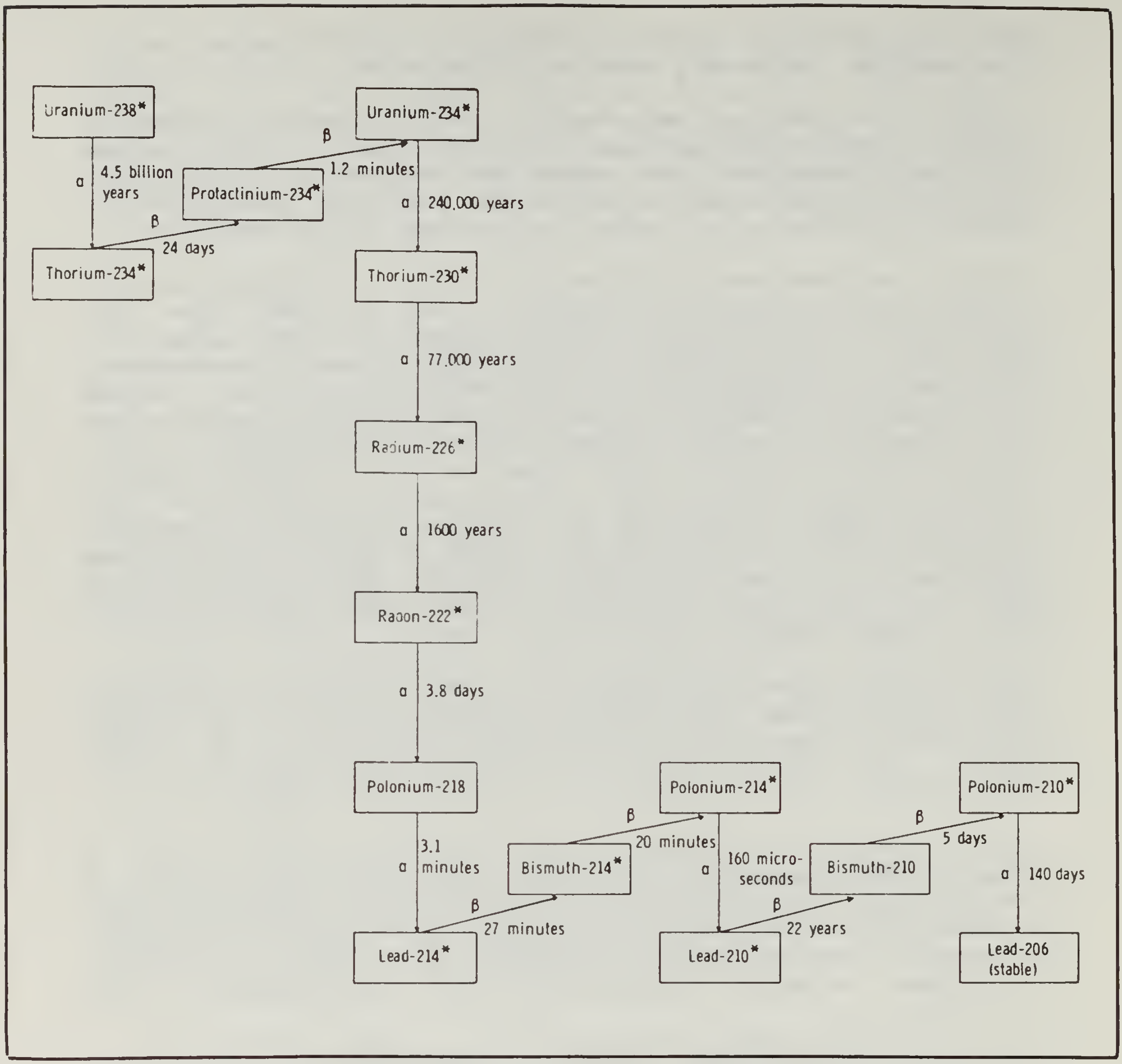

FIGURE C-1

Uranium-238 Decay Series

Source: Argonne National Laboratory (1982).

Note: Only the dominant decay mode is shown, and the times shown are half-lives. The symbols α and β indicate alpha and beta decay; an asterisk (*) indicates that the isotope is a gamma emitter.

more of the atoms present are decaying in any given second, and the weight of the material releasing one curie is smaller than a gram of radium-226. For radioactive material with a long half-life, the weight of the material releasing one curie will be larger. For example, the amount of naturally occurring potassium-40 releasing one curie of radiation weighs about 310 pounds, or about 140,000 times as much as the amount of radium releasing one curie.

The curie is a relatively large quantity of radioactivity for purposes of this EIS. The units used most often in this EIS are listed in Table C-1.

TABLE C-1

UNITS OF RADIOACTIVITY

Unit	Abbreviation	Disintegrations per Second	Equivalent Value in Other Time Units
Curie	Ci	37,000,000,000	---
Millicure	mCi	37,000,000	---
Microcurie	μCi	37,000	---
Picocurie	pCi	0.037	2.22 disintegrations per minute

In this EIS, radioactivity in environmental media such as air or soil is often discussed. In these cases, radioactivity is reported as a concentration, or the amount of radioactivity in or associated with a certain amount of air or soil. Much of the data on radioactivity in soils is reported in picocuries of some particular radioactive isotope per gram of soil (pCi/g). For example, a value of 2 pCi/g means each gram of soil has an associated radioactivity of about 4.4 disintegrations each minute. Concentrations of radioactivity in air are often reported as picocuries per cubic meter (pCi/m^3). This means that a certain number of picocuries of a radioactive isotope is dispersed throughout the volume of air equivalent to a cube that is 1 meter on each side (1 meter = 1.09 yards).

The basic unit for measuring radiation dose is the "rad" (acronym for radiation absorbed dose). It is the amount of radiation that deposits a specified amount of energy by ionization in each gram of material. The amount of energy released in the material is small--it increases the temperature of the gram of material by only a few billionths of a degree. However, it is not the amount of heat liberated or the temperature rise that is important; rather, it is the ionization that induces chemical changes. The rad is used to measure the dose from all types of radiation in all types of material that absorbs the radiation.

As discussed previously, different types of radiation produce ionizations at different rates as they pass through tissue. The alpha particle travels only a short distance, causing intense, closely spaced ionization along its path. The beta particle travels much farther, causing much less ionization in each portion of its path. Therefore, the alpha particle is more damaging to internal tissue than the beta particle for the same number of ionizations because the damage to cells in the tissue is more localized.

Besides the rad, the other commonly used radiation dose unit is the "rem" (acronym for roentgen equivalent in man). The rem quantifies the relative biological response to radiation rather than the amount of energy delivered to the tissue.

The biological damage done by an alpha particle is greater than that by a beta particle for the same total amount (rads) of energy deposited, and this difference is accounted for by the use of "quality factors" (1 for X- or gamma radiations and most beta particles, and 10 to 20 for alpha particles). Thus, 1 rad of energy from gamma rays would result in 1 rem of dose, while 1 rad from alpha particles would result in 10 to 20 rems of dose.

Because the relative degree of damage from each type of radiation is known, the rem can be used to estimate the approximate biological effect. The rem permits evaluation of potential effects without regard to the type of radiation or its source. One rem of exposure from natural cosmic radiation results in the same biological consequences as 1 rem of medical X-rays or 1 rem delivered by radiation produced by either natural or man-made radioactive decay.

A frequent error in the use of radiation units is their application to a standard weight of tissue rather than all of the tissue irradiated. A person can receive one rad or one rem of radiation from any of the following: (1) an X-ray of the teeth, where little tissue is irradiated; (2) a chest X-ray, where a moderate amount of tissue is irradiated; or (3) whole-body radiation, where all tissue in the body is irradiated. Although all these sources give 1 rem of radiation, the effects are different depending upon the organs involved. Thus, one must always keep in mind the portion of the body or organs involved and make comparisons only for corresponding exposures. For example, whole-body doses must be compared only to other whole-body doses or to whole-body dose standards.

In some cases, radiation measurements are expressed as a "dose rate," or the amount of radiation received in a unit of time. For example, some instrument measurements of background are reported in "microrem(s) per hour" (μrem/h). To calculate total dose, the rate is multiplied by the time of exposure. This is conceptually similar to multiplying speed (rate of travel--e.g., in miles per hour) by time to get total distance travelled. Dose may be expressed using rads or rems, depending on whether the emphasis is on the energy deposited or the biological effect.

Because many of the radiation doses discussed in this EIS are small, the metric prefixes "milli" for one-thousandth (1/1000 or 0.001, symbolized as "m") or "micro" for one-millionth (1/1,000,000, or 0.000001, symbolized as ("μ") are often used; 1,000,000 microrem (μrem) = 1,000 millirem (mrem) = 1 rem.

What Is Known About the Health Effects of Radiation

If molecules vital to the function of a cell are ionized by radiation, the cell may be destroyed; if enough cells are destroyed, an organ may be damaged. However, organ damage is usually associated with large doses and is generally referred to as a "short-term" effect of radiation.

People who receive high radiation doses also increase their risk of developing cancer and producing genetic damage to their progeny; these are "long-term" effects. The risk is proportional to the dose. How low-level exposure to radiation results in cancer is not fully understood, and the relationship between the amount of exposure and the probability that cancer will develop cannot be accurately predicted.

Radiation levels around uranium minesites are not generally considered to be high enough to cause short-term effects. They may, however, be sufficient to raise the risks of long-term effects, depending on conditions and length of exposure.

In spite of the uncertainties in the risk estimates, more is known about radiation and its health effects than is known about certain chemical hazards. Radiation has been studied extensively since the 1920's. Also, it is possible to detect the various types of radiation easily, making it possible to avoid areas of potential risk.

An important distinction exists between external and internal radiation sources and their impacts. When external radiation interacts with a person's body, it is quickly dissipated as ionization and eventually heat. However, radioactive materials can enter a person's body and remain there for some period of time, emitting radiation. Thus it is incorrect to say that "radiation is in a person's body." It is correct to say that the person has radioactive materials in his/her body and that radiation is emitted from these radioactive materials.

Background Radiation

"Background" is the term used to represent the natural levels of radiation (radioactivity) that are typical for an area. Naturally occurring radioactive elements are present in air, water and soil.

Background radiation results from cosmic and terrestrial sources. Cosmic radiation originates in the cosmos and enters the earth's atmosphere, while terrestrial radiation originates from the naturally occurring radionuclides in the soil. The level of background radiation in any particular area depends on such factors as altitude, local geology and meteorological conditions.

Radioactivity in the human body originates from the intake of naturally occurring radioactive elements in the food and water consumed, and in the air inhaled by each person. Human exposure to background radiation depends on personal lifestyle, diet and type of residence.

The annual background radiation dose rate in the area around the minesite as compared to U.S. averages is indicated in Table C-2. The local rates are higher than U.S. averages because the minesite is at a fairly high elevation (6,000 feet above mean sea level) and because of the elevated concentration of uranium throughout the Grants mineral belt.

TABLE C-2

ESTIMATED AVERAGE ANNUAL BACKGROUND WHOLE-BODY DOSE RATES (1970)
(millirems per year)

Source	U.S. Average Dose Rate	Colorado	Jackpile-Paguate Minesite
Environmental			
1. Natural			
Cosmic Radiation	44	90	70
Terrestrial Sources [a]	40	46	90
Internal Sources [b]	18	18	18
Subtotals	102	154	178
2. Global Fallout	4	4	4
3. Nuclear Power	0.003	0.003	0.003
Medical	73	73	73
Occupational	0.8	0.8	0.8
Miscellaneous	2	2	2
TOTALS (rounded)	182	234	258

Sources: Iowa Energy Policy Council 1975 (for U.S. average and Colorado figures); Momeni, et al. 1983 (for minesite).

Notes: [a] Crustal and building materials.
[b] Principally potassium-40.

Glossary

GLOSSARY

ACRE-FOOT. The quantity of water required to cover 1 acre to a depth of 1 foot. It is equal to 43,560 cubic feet or 325,851 gallons.

ADIT. A horizontal or near-horizontal passage from the ground surface into a mine or underground installation.

ADVERSE VISUAL IMPACT. Any impact on the land form, water form, or vegetation, or any introduction of a structure that negatively changes or interrupts the visual character of the landscape and disrupts the harmony of the natural elements.

AIRBLAST. A motion-producing sound generated by an explosive blast and resulting rock breakage and movement; it is commonly expressed as a relative sound level in decibels (dB) at a particular frequency that is measured in hertz (Hz). Like ground vibration, it is an undesirable side effect of the use of explosives to break rock for mining, quarrying, excavation and construction.

ALLUVIUM. Clay, silt, sand and gravel deposited by running water.

AMBIENT. Conditions in the vicinity of a reference point, usually related to physical environment (e.g., the ambient temperature is the outdoor temperature).

ANGLE OF REPOSE. The maximum slope at which a heap of any loose or fragmented solid material will stand without sliding when poured or dumped in a pile or on a slope; also called the angle of rest.

AQUIFER. A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield a significant quantity of water to wells or springs.

ATOM. A particle of matter indivisible by chemical means. It is the fundamental building block of the chemical elements. An inner core (the nucleus) is composed of protons and neutrons, while one or more much smaller electrons orbit the nucleus.

ATOMIC MASS UNIT (amu). One-twelfth the mass of an atom of carbon-12. 1 amu = 1.66057×10^{-27} kg.

ATOMIC NUMBER. The number of protons in the nucleus of an atom. It is shown as a subscript in atomic nomenclature. For uranium-238 ($_{92}U^{238}$) the atomic number is 92.

ATOMIC WEIGHT. The sum of the number of protons and neutrons in the nucleus of an atom. It is shown as a superscript in atomic nomenclature. For uranium-238 ($_{92}U^{238}$) the atomic weight is 238.

BACK. The rock above any opening, such as a tunnel, stope or drift; the roof.

BACKGROUND LEVEL. The concentration of a pollutant that would exist in the absence of the particular source under study. A "standard" against which the contribution of the particular source can be compared.

BACKGROUND RADIATION. The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements.

BALLAST. Rough, unscreened gravel used to form the bed of a railway or as substratum for new roads.

BASE FLOW. The sustained or normal flow of a stream.

BED. The smallest division of a stratified series of rock layers, marked by a more or less well-defined divisional plane from its neighbors above and below.

BENCH. In open-pit mines, a ledge that forms a single level of operation above which mineral or waste materials are excavated from a contiguous bank or bench face. The mineral or waste is removed in successive layers, each of which is a bench, several of which may be in operation simultaneously in different parts of and at different elevations in an open-pit mine.

BORROW PIT. Location from which soil materials are taken to be used as topsoil on reclaimed sites.

BULKHEAD. A tight partition of wood, rock or concrete in mines to contain some material.

CAVING. The action of caving in, collapsing; the failure and sloughing in of boreholes, mine workings or excavations.

CHARGE DELAY. The time separation, usually in milliseconds, between detonation of individual charges of explosives in a blast.

COEFFICIENT. In physics, a number commonly used in computation as a factor, expressing the amount of some change or effect under certain conditions such as temperature, length, time or volume.

COHESION. That property of like mineral grains that enables them to cling together in opposition to forces tending to separate them; measured in pounds per square foot.

COLLUVIUM. Loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity.

COLOR. The property of an object that reflects light of a particular wavelength, enabling the eye to differentiate otherwise unidentifiable objects.

CONSOLIDATED. In geology, having been pressed into a hard rock. In soil mechanics, having simply been brought into equilibrium with the applied forces causing a decrease in volume.

CONTOUR FURROWING. Plowing along the contour lines of uneven terrain to limit erosion.

CONTRAST. The effect of a striking difference in the form, line, color or texture of the landscape features within an area being viewed.

CONTROL. A standard of comparison in scientific experimentations; check.

COUNTRY ROCK. Rock adjacent to or surrounding a mineral deposit or dike in which no minerals of economic interest occur.

CREST. The top of an excavated slope; the highest natural projection that crowns a hill or mountain.

CROSSCUT. In underground mining, an opening driven across a deposit, or, in general, across the direction of the main workings.

CUBIC FOOT PER SECOND (ft^3/s or cfs). The rate of discharge representing a volume of 1 cubic foot of water passing a given point during 1 second. It is equivalent to 7.48 gallons per second, or 448.8 gallons per minute.

CURIE. The measurement of radioactivity of a substance. One curie equals the disintegration of 37 billion (3.7×10^{10}) nuclei per second, which is approximately the rate of decay of 1 gram of radium.

DAUGHTERS, PROGENY. Nuclides formed by the radioactive decay of other nuclides (the parents).

DECAY, RADIOACTIVE. The spontaneous emission of radiation from the nucleus a radioactive atom. This will either transform one nuclide into a different nuclide, or change the energy state of the same nuclide.

DECIBEL (dB). A unit used to express the relative intensity of sounds on a scale from 0 (for the average least perceptible sound) to about 130 (for the average pain level).

DECLINE. A shaft sunk at an angle from the vertical.

DENDRITIC. Formed or marked in a branched or tree-like pattern.

DIABASE (DIABASIC). A fine-grained intrusive rock composed mainly of plagioclase feldspar and pyroxene.

DIKE. An igneous intrusion that cuts across the planar structures of the surrounding rock (See Sill).

DIP. The angle of a slope, vein, rock stratum or borehole as measured from the horizontal plane downward.

DISCHARGE. The rate of flow at a given instant in terms of volume per unit of time (e.g., cubic feet per second or gallons per minute).

DOSE, ABSORBED. The amount of radiation absorbed; the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The special unit of absorbed dose is the rad.

DOSE COMMITMENT. The total dose that an organism is expected to receive in its lifetime from a given quantity of radioactive material deposited in the body.

DOSE EQUIVALENT. A common scale measurement of the effects of the different types of radiation. The unit of dose equivalent is the rem. The following are considered equivalent to 1 rem of dose: 1) a dose of 1 Roentgen (R) due to X- or gamma rays; 2) a dose of 1 rad due to X-, gamma or beta radiation; 3) a dose of 0.1 rad due to neutrons or high-energy protons; and 4) a dose of 0.5 rad due to particles heavier than protons (i.e., alpha radiation).

DRAWDOWN. Vertical distance the free water elevation is lowered, or the reduction of the pressure head due to the removal of free water.

DRIFT. A horizontal passage underground, with neither end reaching the surface.

ELECTRON. An elementary particle having a charge of -1 esu (electrostatic unit) and a mass of 1/1837 amu (atomic mass unit).

ENTRY. An underground passage for hauling, ventilation or as a way of transit for miners.

EPHEMERAL STREAM. A stream or portion of a stream that flows only in direct response to precipitation in the immediate locality, and whose channel is at all times above the water table.

EXPOSURE. The quotient dq/dm, where "dq" is the absolute value of the charge of the ions of one sign produced in air, when all the electrons (negatrons and positrons) liberated by photons in a volume element having mass "dm" are completely stopped by air. The special unit of exposure is the roentgen (R).

EXPOSURE RATE. The exposure per unit of time (e.g., roentgens/minute, milliroentgens/hour).

FACE. In any adit, tunnel or stope, the end at which work is progressing or was last done.

FAULT. A fracture or fracture zone along which there has been displacement of the two sides relative to one another and parallel to the fracture.

FLUVIAL. Of or pertaining to a river or rivers. Produced by the action of a stream or river.

FORM. The mass or shape of an object or objects which appear unified, such as in the shape of the land surface or patterns placed on the landscape.

FORMATION. A more or less related group of rocks grouped together into a unit that is convenient for description and mapping.

FRACTURE. Failure by the parting of a material.

FRICTION ANGLE. The angle between the perpendicular to a surface and the resultant force acting on a body resting on the surface, at which the body begins to slide.

FRICTION ANGLE (ANGLE OF INTERNAL FRICTION). The angle which characterizes the increase in sheer strength with increasing normal stress on a given plane in a material. The tangent of the angle of internal friction is the increase in shear strength for a unit increase in normal stress. It is approximately equal to the angle of repose for dry, cohesionless materials.

FUGITIVE DUST. Particulates made airborne by forces of wind, man's activities, or both.

GRADIENT. The ratio of vertical fall of a river's channel to its length.

GRANTS MINERAL BELT. Includes the area of uranium deposits from Gallup on the west to the western edge of the Rio Grande trough on the east.

GROSS ALPHA. The total rate of alpha particle emission from a sample without regard to energy distribution or source nuclide.

GROSS BETA. The total rate of beta particle emission from a sample without regard to energy distribution or source nuclide.

GROUND VIBRATION. An undesirable side effect of the use of explosives to break rock for mining, quarrying, excavation and construction; expressed as the velocity of a particular point or particle in the ground (particle velocity), and measured in inches per second (in/s).

GROUND WATER MOUNDING. The mound-shaped build-up of the potentiometric surface resulting from the downward percolation of water into an aquifer.

GROWTH MEDIUM. A soils material, natural or reconstituted, that will support a plant community.

HALF-LIFE. The time required for a radioactive element to lose half of its atoms through radioactive decay. Each radionuclide has a unique half-life.

HEAD, STATIC. The height above a standard reference point of the surface of a column of water that can be supported by the static pressure at a given point.

HEAD, TOTAL. The total head of a liquid at a given point is the sum of three components: 1) elevation head, which is equal to the elevation of the given point above a reference point; 2) pressure head, which is the height of a column of static water that can be supported by the static pressure at the given point; and 3) velocity head, which is the height the kinetic energy of the liquid is capable of lifting it.

HERTZ (Hz). A unit of frequency equal to one cycle per second.

HIGH PASS. A method of measuring airblast in decibels (dB) at a certain frequency in hertz (Hz).

HIGH-RADIATION AREA. Any area accessible to individuals in which a major portion of the body could receive, in any one hour, a dose in excess of 100 millirems.

HIGHWALL. The excavated face of exposed overburden and/or ore in an open-pit mine.

HORIZON. Layers (in a soil profile) resulting from soil-forming processes are grouped into three categories (A, B and C). The subdivisions of these categories are called horizons.

HYDRAULIC CONDUCTIVITY. The rate of flow of water in gallons per day through cross-section of 1 square foot of a subject medium. (Synonym, permeability coefficient.)

IN SITU. In its natural position or place.

INTERNAL RADIATION. Radiation from a source within the body as a result of deposition of radionuclides in body tissues by ingestion, inhalation or implantation.

INTRUSION. A feature (land and water form, vegetation or structure) that is generally considered out of context because of excessive contrast and disharmony with the characteristic landscape.

ION. An atom that carries a positive or negative electric charge as a result of having lost or gained one or more electrons.

IONIZATION. The process by which a neutral atom acquires a positive or negative charge.

ISOTOPES. Atoms with the same atomic number but different atomic weights. The difference in atomic weight is due to the number of neutrons in the atom's nucleus.

LEVEL. A horizontal passage or drift into or within a mine. It is customary to work mines by levels at regular intervals in depth.

LINE. The path, real or imagined that the eye follows when perceiving abrupt differences in form, color or texture. Within landscapes, lines may be found as ridges, skylines, structures, changes in vegetative types, or individual trees or branches.

MAJOR (STRUCTURAL) BLAST DAMAGE. The most severe type of damage to structures caused by blasting. This type of damage affects the load-supporting ability of a structure (e.g., rupture of arches, falling of masonry, structural weakening).

MINING HEIGHT. The height of an underground mine opening.

MINOR BLAST DAMAGE. An intermediate level of damage to structures caused by blasting (e.g., loosening and falling of plaster, hairline to 1/8-inch-wide cracks, falling of loose mortar).

MUCK. Broken ground from an underground mining operation.

NEUTRON. An elementary particle having no charge and a mass of 1 atomic mass unit.

ORE. A mineral of sufficient value (quality and quantity) that it may be mined with profit.

ORE ZONE. A horizon in which ore minerals are known to occur.

OVERBURDEN. Soil and rock horizons as measured from the surface down to a specific mineral layer.

OVERPRESSURE. The pressure in an airblast wave in excess of the atomopheric pressure.

PAN EVAPORATION. The amount of water that evaporates from a standard U.S. Weather Bureau 4-foot-diameter evaporation pan. Measured in inches per year.

PERCHED WATER TABLE. A water table, usually of limited area, maintained above the normal free water elevation by the presence of an intervening, relatively impervious, confining earth layer.

PERCOLATION. The movement of gravitational water through soil.

PIEZOMETER. An instrument for measuring pressure head, usually consisting of a small pipe tapped into the side of a closed or open conduit and flush with the inside. It is connected to a pressure gage, water column, or other device for indicating pressure head. May also be a small-diameter well placed in an aquifer.

PILLAR. In situ rock between two or more underground openings.

PIPING. Erosion by percolating water in a layer of subsoil, resulting in caving and the formation of narrow conduits, tunnels or pipes.

PLANT ASSOCIATION. Plant community of definite composition, presenting a uniform physiognomy and growing in uniform habitat conditions.

PLUTONIC. Of igneous origin.

PORE. Interstice or void; a space in rock or soil not occupied by solid mineral matter.

POROSITY. The ratio (usually expressed as a percentage) of the volume of voids in a given mass to the total volume of the mass.

PORTAL. The surface entrance to a decline or an adit.

POTENTIOMETRIC SURFACE. An imaginary surface representing the total head of ground water above a reference level for a particular area, and defined by the level to which water will rise in a well drilled in that area. (Synonym, piezometric level.)

PRESSURE. Force per unit area applied to the outside surface of a body.

PRESSURE HEAD. Equivalent to the height of a column of water that can be supported by the pressure.

PROTORE. As used in this EIS, a component of the Jackpile Sandstone. This component material was stockpiled during mining because it contains elevated but sub-economic uranium concentrations that might become economical to process at some future time because of rising prices or improved technology. At the Jackpile-Paguate mine, the protore contains .02 to .059 percent uranium (U_3O_8).

RAD. The special measurement unit of absorbed dose; the quantity of any type of ionizing radiation that imparts a dose of 100 ergs to 1 gram of tissue (from Radiation Absorbed Dose).

RADIATION. Particles or energy emitted from the nucleus of a radioactive atom.

RADIATION AREA. Any area accessible to individuals in which a major portion the body could receive, in any one hour, a dose in excess of 5 millirems (mrems) or, in any 5 consecutive days, a dose in excess of 100 mrems.

RADIOACTIVE MATERIAL. Any material (solid, liquid or gas) that emits radiation spontaneously.

RADIOACTIVITY. The disintegration of unstable atomic nuclei by the emission of radiation.

RADIUM-226. A radioactive metallic element in group II of the periodic system; one of the alkaline-earth metals. Radium resembles barium in its chemical properties.

RADIUS OF INFLUENCE (OF A WELL). The distance from the center of a pumping well to the closest point at which the ground water is not lowered.

RADON-222. A heavy, radioactive gaseous element. It emanates from (i.e., is a daughter product of) radium-226. Radon has a half-life of 3.823 days and is an alpha particle emitter.

RAISE. An opening, like a shaft, made in the back (roof) of an underground level to reach a level above.

REM. A measure of the dose of any radiation to body tissue, in terms of its estimated biological effect relative to a dose of 1 roentgen (R) of X-rays (from Roentgen Equivalent Man). One millirem (mrem) = 0.001 rem.

RESTRICTED AREA (CONTROLLED AREA). Any area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.

ROCK. Geologically, any naturally formed aggregate of mineral matter constituting an essential and appreciable part of the earth's crust.

ROCKFALL. The relatively free falling of a newly detached segment of rock of any size from a cliff, steep slope, or underground opening.

ROENTGEN. The unit of exposure. The quantity of X- or gamma radiation that produces ions carrying 1 electrostatic unit (esu) charge of either sign (+ or -), in 1 cubic centimeter of dry air at standard temperature and pressure.

ROOM. A wide working place in a flat mine (corresponds to a stope in steep vein).

ROOM AND PILLAR MINING. Method of underground mining where drifts are driven on a regular pattern leaving pillars to support the overburden. The pillars are usually removed at the end of mining in that area.

SAFETY FACTOR. The ratio of forces available to resist slope failure and the forces tending to cause this failure.

SCALE. The proportionate size relationship between an object and the surroundings in which the object is placed. Also, to remove surface loose rock from excavation faces.

SCALED DISTANCE. A factor in blast design, equal to the actual distance from the blast in feet divided by the square root of the explosive weight in pounds.

SEEPAGE. See Percolation.

SEISMIC. Pertaining to, characteristic of, or produced by earthquakes or earth vibration (as from blasting).

SET. A frame for supporting the ground around a shaft, tunnel or other excavation.

SHAFT. A vertical or steeply inclined excavation or opening from the surface down through the strata to the mineral to be mined.

SILL. An igneous intrusion that parallels the planar structure of the surrounding rock (See Dike).

SINUOSITY. The ratio of a river's channel length to the length of its valley.

SLIDE. A relatively deep-seated failure of a slope, also called a landslide or slope failure. Slides are considered to have large lateral displacement in contrast to slumps, which are local or restricted displacements.

SLUMP. Material that has slid down from high rock slopes; to slip down en masse.

SOIL PROFILE. The characteristic features of the soil, as seen by a vertical cut through the weathered soil mass into the relatively unweathered material, and finally to bedrock.

SPECIFIC (UNIT) WEIGHT. The dry weight per unit volume, measured in pounds per cubic foot.

STOPE. An underground excavation from which ore has been extracted. In New Mexico uranium mines, the terms "room" and "stope" are used interchangeably.

STRATA. Sedimentary rock layers.

SUBSIDENCE. A sinking down of a part of the earth's crust. The lowering of the strata, including the surface, due to underground excavations.

SUBSTRATE. The subsoil.

TEXTURE. The interplay of light and shadow created by the variation in the surface of an object; the visual result of the tactile surface characteristics.

THRESHOLD (COSMETIC) BLAST DAMAGE. The most superficial type of damage to structures caused by blasting, being of the type that develops in all homes in the absence of blasting (e.g., loosening of paint, small cracks in plaster, lengthening of old cracks).

TOE. The bottom of a slope.

UNCONFORMITY. A surface of erosion or nondeposition that separate younger strata from older strata.

UNDERFLOW. The ground water flowing beneath the bed of a surface stream generally in the same direction but at a much slower rate than the surface drainage.

UNDERGROUND OPENINGS. Natural or manmade excavations under the surface of the earth.

UNRESTRICTED AREA (UNCONTROLLED AREA). Any area to which access is not controlled to protect individuals from exposure to radiation and radioactive materials.

URANIUM. A naturally radioactive, silvery-white, metallic element of the actinide series of the periodic system.

URANIUM ORE GRADE. The percentage of uranium in an ore.

URANIUM OXIDE (U_3O_8). A chemical compound made up of three atoms of uranium and eight atoms of oxygen, used as the measure of refined uranium. For uniformity and comparison, weights of other forms and compounds of uranium and uranium ore are usually converted to the equivalent weight of uranium oxide.

VISUAL RESOURCE. The land, water, flora, fauna and other features that are visible on all lands (scenic values).

WALL. The side of an underground level or drift.

WASTE. The barren (non-ore-bearing) rock in a mine.

WORKING(S). A working may be a mine shaft, level or stope. Usually used in the plural.

WORKING LEVEL (WL). A unit of measurement peculiar to the underground mining of uranium; a measure of the concentration of radon 222 daughter products in air. One Working Level is that concentration of radon daughters that will deliver 1.3 x 10^5 mev (million electron volts) of alpha energy per liter of air.

WORKING LEVEL MONTH (WLM). Exposure to 1 working level for 173 hours. The U.S. Mine Safety and Health Administration's limit for uranium miners is 4 WLM per year.

YELLOWCAKE. The final precipitate formed in the milling of uranium. Usually considered to be ammonium diuranate [$(NH_4)_2U_2O_7$] or sodium diuranate ($Na_2U_2O_7$), but the composition is variable. Measured in the equivalent weight of U_3O_8.

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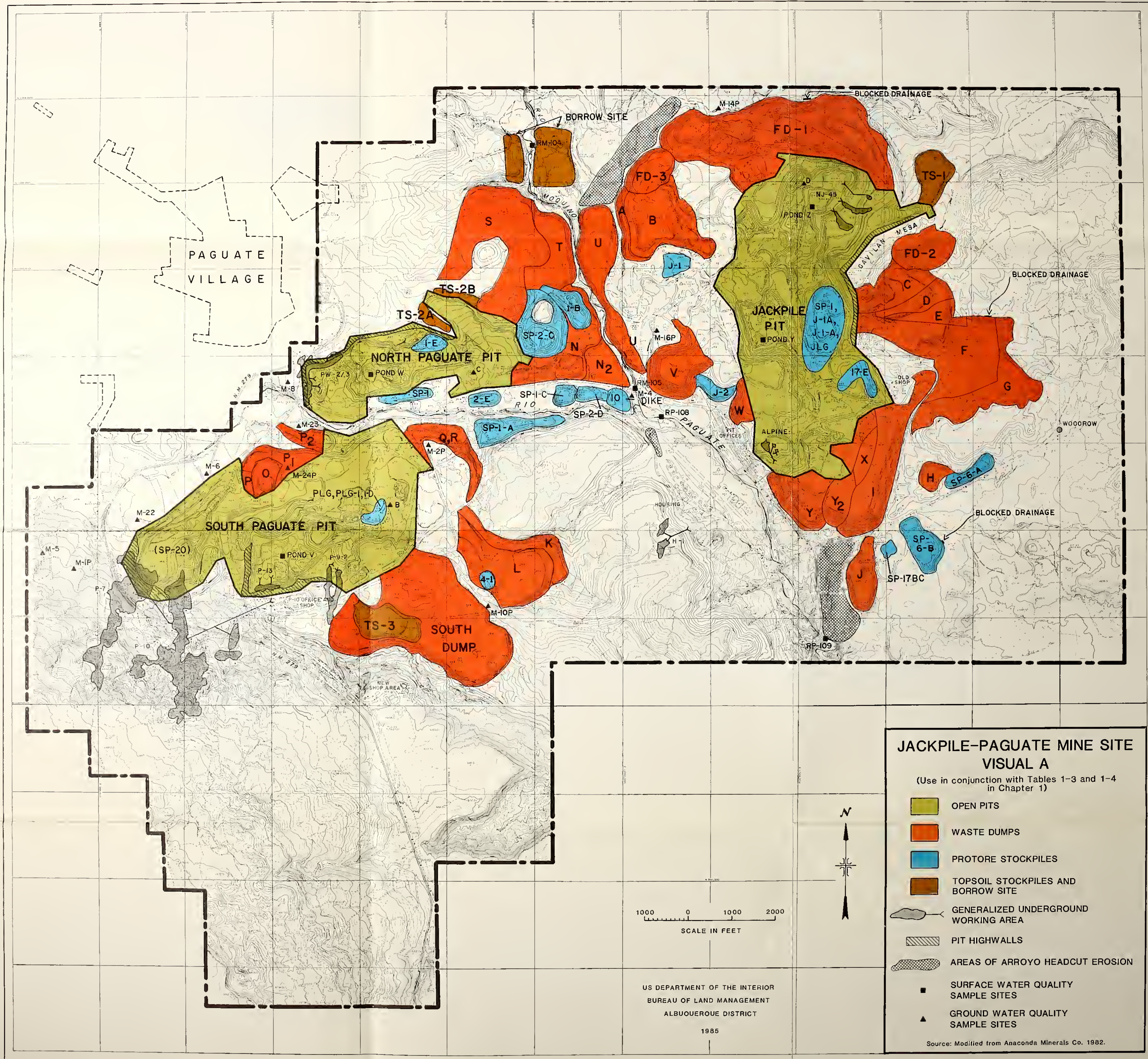

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