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Station

Environmental Assessment and FONSI for the Joint United States/Republic of Korea Research and Development Study for Improved Underground Ammunition Storage Technologies Tests, Magdalena, New Mexico

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Prepared for U.S. Department of the Army
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CONTENTS

PREFACE

The Joint United States/Republic of Korea Research and Development Study for Improved Underground Ammunition Storage Technologies Test Program is sponsored by the Office of the Secretary of Defense (OSD) and the Department of the Army (DA) and is managed by the U.S. Army Technical Center for Explosives Safety and the U.S. Army Engineer Waterways Experiment Station (WES). Mr. Gary Abrisz, Technical Center for Explosives Safety, Savanna, IL, is the Program Manager for the Underground Ammunition Storage Technologies (PMUAST), and Mr. Landon K. Davis is the WES Program Manager. The test program was conducted at WES.

This research effort is being conducted under the direction of Dr. Jimmy P. Balsara, Chief, Geomechanics and Explosion Effects Division (GEED), and Mr. Landon K. Davis, GEED, Structures Laboratory (SL), WES, and Mr. C. E. Joachim, GEED, the WES Project Officer. Mr. Bryant Mather was Director, SL.

This Environmental Assessment was prepared by Mr. D. W. Murrell, GEED, and Ms. Patricia Irick, Dr. Ron Kneebone, Mr. Christ Dewitt, and Mr. William Deregon, U.S. Army Engineer District, Albuquerque (CESWA). It was reviewed at WES by Messrs. Joachim and Davis and by PMUAST for submittal to CESWA. The Finding of No Significant Impact was published as a legal notice in news media in Albuquerque, NM, and surrounding area for public review and comment.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

ENVIRONMENTAL ASSESSMENT FOR THE JOINT UNITED STATES/REPUBLIC OF KOREA RESEARCH AND DEVELOPMENT STUDY FOR IMPROVED UNDERGROUND AMMUNITION STORAGE TECHNOLOGIES TESTS MAGDALENA, NEW MEXICO

1 PROJECT DESCRIPTION

1.1 PURPOSE AND NEED FOR THE PROPOSED ACTION

The U.S. Army Engineer Waterways Experiment Station (WES), in conjunction with the Ministry of National Defense, Republic of Korea (ROK), has developed a research program to evaluate techniques for the reduction of external airblast, ground shock and fragment/ejecta hazards from accidental detonations of munitions stored in underground magazines (Reference 1). The Linchburg Mine complex located in the Kelly Mining District of Socorro County, New Mexico has been selected as the test site after evaluation of geotechnical and environmental factors (see Section 2.2.2). The purposes of the test program are to:

- Confirm or modify the fundamental relations between blast effects and tunnel/chamber geometries that have been established by small-scale experiments.
- Refine these relations based on tests performed under more realistic conditions (e.g., chambers and tunnels in actual rock environments).
- Obtain blast effects scaling measurements that cannot be made at small-scale.
- Confirm blast effects scaling relations for large explosive yields (and large loading densities).
- Examine performance of blast and/or debris control techniques at large (and more realistic) scales.

The results of these experiments will be used to develop new designs and predictive techniques for reduction of hazards to ammunition stored underground and to above-ground personnel and structures in the vicinity of the underground munitions storage magazine complex.

The proposed action consists of a series of approximately 32 underground explosive tests simulating accidental detonations of munitions stored in underground magazines. All tests will be conducted in the Mississippian Kelly limestone formation. The first test is scheduled for mid-November 1993 and is designed to consist of a single 66.3 kg detonation of Composition B explosives. The remaining tests will consist of single charge detonations with charge weights of 66.3, 331.5, 994.5, and 2784.6 kg (Composition B). This series of tests will be conducted over a four month period.

1.2 DESCRIPTION OF THE PROPOSED ACTION

1.2.1 General. The proposed action, referred to hereafter as the Intermediate-Scale Test Program, will involve detonations of explosive charges in adits and chambers excavated off the main drift of the Linchburg Mine. The Linchburg Mine is located near Magdalena, in Socorro County, NM, on the west flank of the Magdalena Mountains (Figure 1). The detonation chambers will be located in an interval of the Kelly limestone exposed in the main Linchburg drift between 215 and 275 m from the portal at depths of approximately 122 m beneath the ground surface. Measurements of airblast pressures, ground shock, thermal effects, and rock structural response will be made at numerous locations.

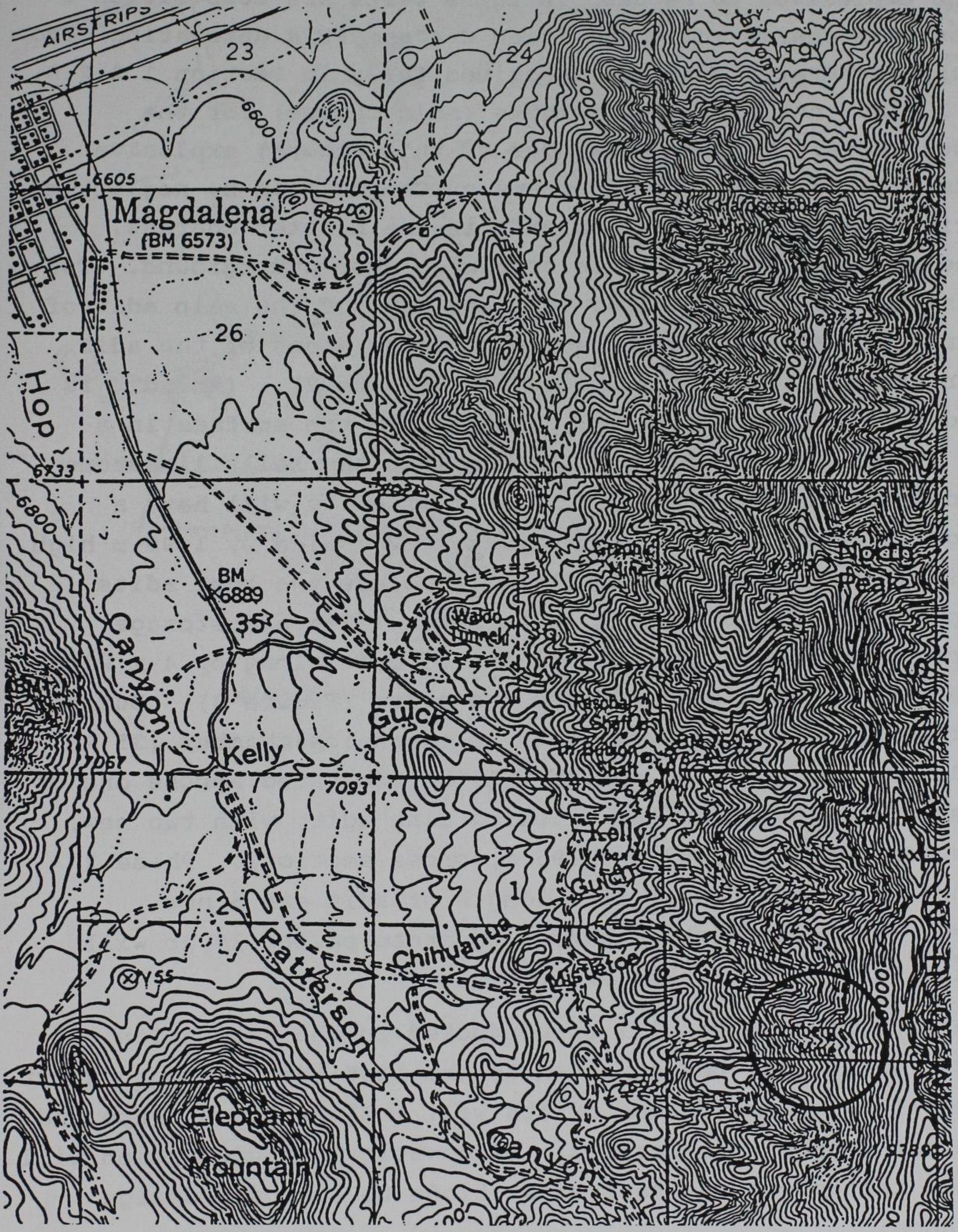

Figure 1. Linchberg Mine, site for Intermediate-Scale Test portion of JOINT U.S./ROK R&D STUDY FOR IMPROVED UNDERGROUND AMMUNITION STORAGE TECHNOLOGIES

The explosives to be used in these tests are Composition B for the main charge and Composition C-4 and PETN detonating cord for the boosters. These are described fully in Section 1.2.2.5. Table 1 lists net explosive weights (main charge) for the proposed tests. For the remainder of this report, explosive weights will be stated in kilograms of Composition B, neglecting the trivial amounts of C-4 and PETN in the booster charges.

The proposed tests will be conducted deep underground. Two test drifts will be excavated into the wall of the main adit of the Linchburg Mine at locations on opposite sides of the adit between 215 and 275 m from the portal (Figure 2). (An adit is defined as a nearly horizontal passage from the surface in a mine.) These test drifts will extend into the Kelly limestone perpendicular to the main adit. The test adits will have a rectangular cross-section, approximately 2 m wide by 1.95 m high. The initial excavation (Phase 1) will include two test adits, each approximately 100 m long, with seven 1/3-scale storage chambers, with approximate dimensions of 8.5 m long by 4 m wide by 1.95 m high, excavated off the two adits (Figure 3). During the second phase of the excavation an expansion chamber (35 m wide, 3.5 m deep and 1.95 m high will be excavated across one of the test adits 10 m from the existing mine adit, with two new, short access drifts (2.67 by 1.95 m, cross-section). Phase 2 will include an additional 50-m length of adit and 5 new chambers. A 10-cm thick (minimum) concrete paving layer will cover the floor of all test excavations.

The explosive tests will be conducted in the detonation chambers, which will be connected to the test adits through short access drifts. These access drifts will include blast traps and other blast suppressive designs. Diagnostic instrumentation will be placed throughout the test excavations to evaluate design performance.

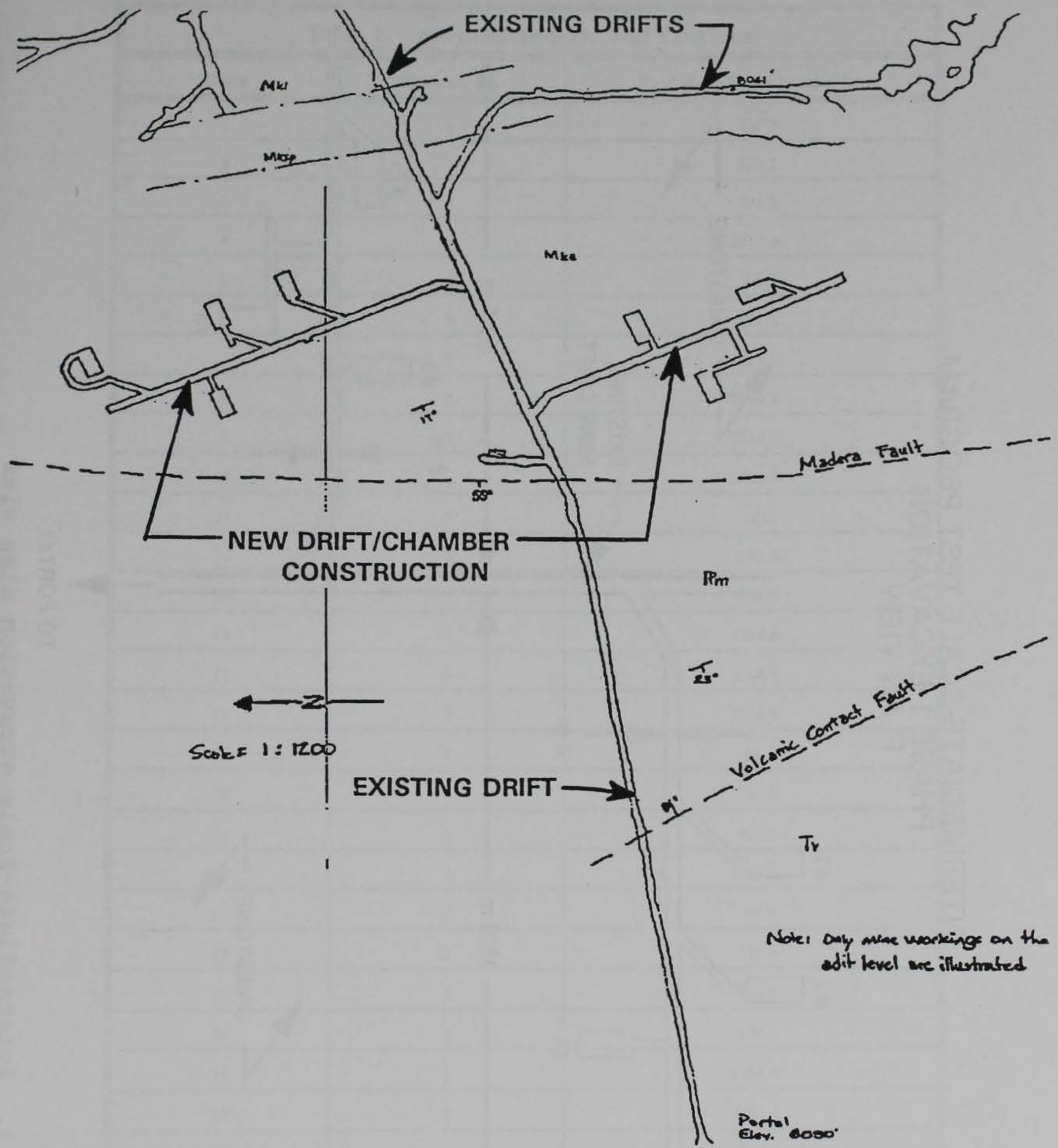

Figure 2. Conceptual layout for Intermediate-Scale Test at Linchburg Mine site, JOINT U.S./ROK R&D STUDY FOR IMPROVED UNDERGROUND AMMUNITION STORAGE TECHNOLOGIES

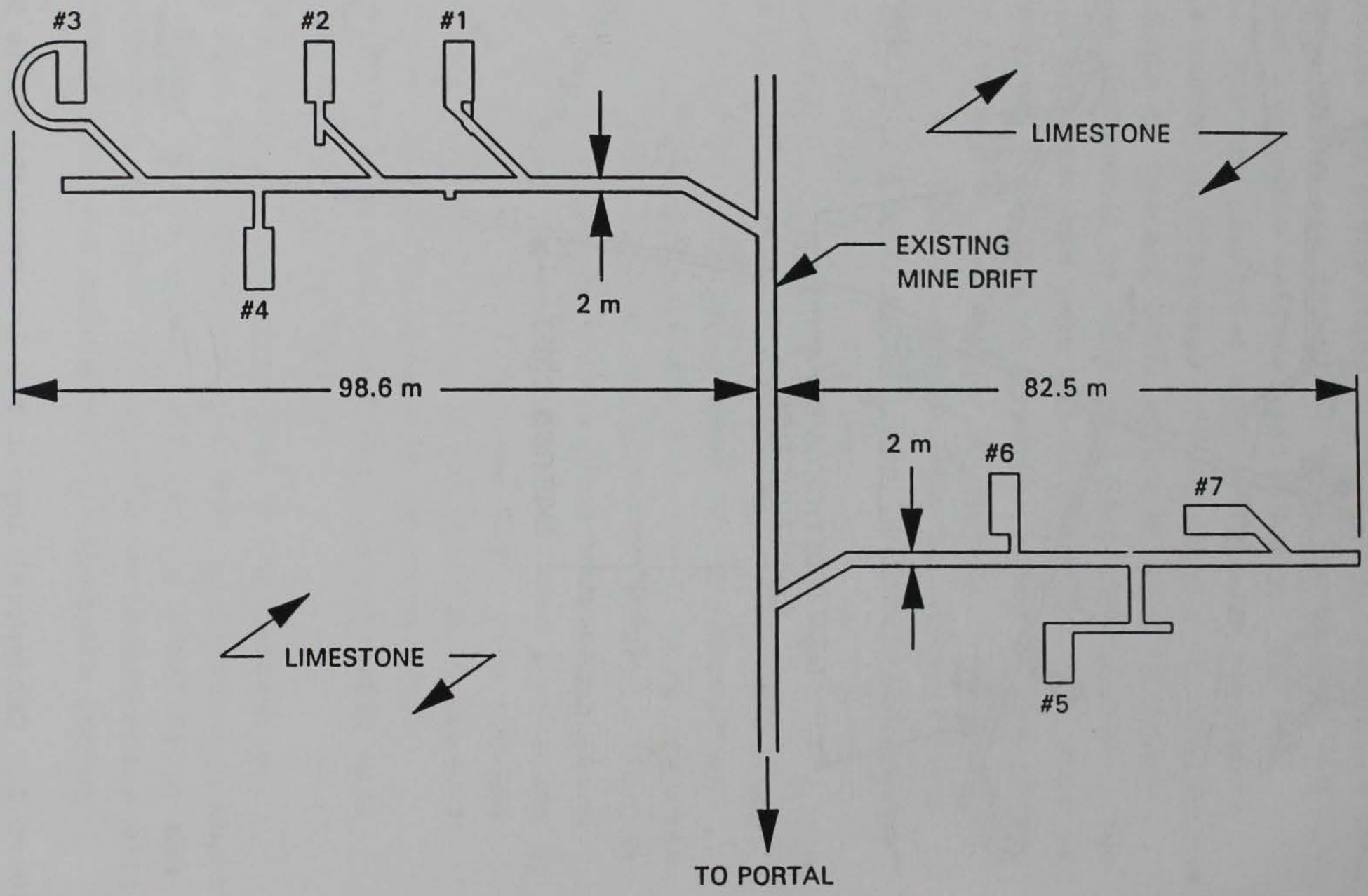

Figure 3. Intermediate-Scale excavation plan view

Table 1. Intermediate-Scale Test Program		
Event	**Chamber No.**	**Explosive Charge Weight, kg**
1	4	66.3
2	4	331.5
3	4	994.5
4	4	2784.6
5	2	66.3
6	2	331.5
7	2	994.5
8	2	2784.6
9	3	2784.6
10	1	2784.6
11	5	66.3
12	5	331.5
13	5	994.5
14	5	2784.6
15	6	2784.6
16	7	2784.6
17	1	66.3
18	1	331.5
19	1	994.5
20	1	2784.6
21	2	66.3
22	2	331.5
23	2	994.5
24	2	2784.6
25	8	2784.6
26	9	2784.6
27	10	2784.6
28	11	2784.6
29	12	66.3
30	12	331.5
31	12	994.5
32	12	2784.6

The Intermediate-Scale Tests will each involve the detonation of a Composition B explosive charge (66.3, 331.5, 994.5, or 2784.6 kg) and a booster charge of 1.8 kilograms of C-4. For each test, the explosive charge will be placed midway between the floor and roof of the chamber and centered along the axis of the 8.5-m chamber length.

Approximately 50 airblast pressure and 10 thermal effects transducers will be placed in the test chambers and adits. Additional airblast pressure gages will be installed outside the mine portal to monitor the external pressure environment. Six self-recording devices with capability to measure sound pressure (micro-barograph) and seismic motions will be placed at greater distances to measure nuisance level disturbance along roads and trails further removed from the portal.

Approximately 40 instruments to measure ground shock will be placed at various locations around the test chambers and adits. Some gages will be placed in vertical holes drilled from the center of each chamber through the overburden to the surface of the ground. A total of 8 vertical 20.3-cm-diameter boreholes are planned. Additional ground shock instrumentation will be placed in horizontal 20.3-cm-diameter boreholes. Instrumentation holes will be filled with a rock-matching grout.

Cables from instruments installed in vertical boreholes will be carried uphole to the ground surface and over the surface to the recording van. The remaining cables will extend through the drifts to a junction box located in the main adit of the mine, and thence along the main adit to the recording van located about 50 m away from the portal. Portable power will be utilized for all electrical needs.

Test control and detonation functions will be performed in the recording van.

1.2.2 Construction and Testing Activities.

1.2.2.1 Site Operations. Site operations in connection with the Intermediate-Scale Tests will be performed in the following activity sequence:

a. Dress-up the existing parking area. Prepare a clear and level area about 50 m from the mine portal on which to park the recording van.

b. Prepare a section of the Linchburg adit between 215 and 275 m from the portal for mining the test adits. During the initial phase of excavation, mine two test adits (on opposite sides of existing main adit), each with approximately 100-m lengths. Mine short access drifts from the test adits to seven chambers and mine these chambers.

c. Distribute mine spoil in existing stopes and cavities deeper in the mine, or along the edge of the existing tailings. If deposited on the tailings pile outside the portal, the total amount of newly excavated material is estimated to increase the volume of material in the existing tailings by less than 10 percent.

d. Drill 20-cm-diameter boreholes for placement of ground shock instrumentation at locations to be specified. Some boreholes will be drilled upward from the adits/ chambers, and will penetrate the ground surface. Since all cuttings will fall back into the hole, no surface disturbance, other than the presence of the hole, will occur. Drill or wire-saw failure planes for self closing chambers.

e. Install and grout in place ground shock instrumentation. Install cable protection and ventilation pipes in floor of adits. Place concrete floor slab (10 cm minimum thickness).

f. Place airblast pressure and thermal effects instrumentation and run cables from all underground instrumentation to junction box.

g. Locate the instrumentation recording van about 50 m from portal. Route approximately 100 cables from the van to a junction box inside the existing mine adit.

h. Connect free-field (external to mine) instrumentation. Place movie/video cameras for documentary photography of any external effects.

i. Conduct system checks and dry runs as required.

j. Place charge container and load explosives.

k. Place booster/initiator assembly.

l. Conduct the test.

m. Exhaust detonation gas products by forced ventilation of test chamber and adits.

n. Reenter the mine. Repeat steps i-m. until test series is complete.

o. Recover all accessible cable and gages.

p. Remove equipment and restore portal area to original condition.

Clearing and leveling will be the minimum required to accommodate the instrument van area. No removal of or damage to large vegetation will be required. Existing roads in the immediate Linchburg Mine area will be repaired and maintained while preparing for and conducting this test program.

1.2.2.2 Schedule and Manpower Requirements.

Approximately six months will be required to conduct these tests. Figure 4 shows the planned schedule for field operations. Field operations are scheduled to commence about 1 August 1993, with the tests to be conducted during the

ACTIVITIES	1993										1994		
	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
1. Site Characteristics													
2. Explosive Safety Plan Hazard Analysis													
3. Mining Contract													
4. Mining Activities													
5. Gage Installation													
6. Testing													
7. Site Cleanup													

Figure 4. Intermediate-Scale Test Schedule

period November 1993 through February 1994. Site restoration should be complete within one year after completion of the final test.

A government representative will be on site approximately two days each week during mining of the test adits and chambers. When test operations are being conducted, five to ten additional personnel will be on site. The mining contractor will have six to ten people on site to mine the test adits and chambers. Additional persons on-site will mainly be vendors making deliveries; their presence will be temporary and under Corps supervision. Several official visitors from U.S. and foreign government agencies and government contractors may visit the site during the course of the program.

It is expected that the maximum number of personnel on site at any time will not exceed 20 and will generally be less than 15. Traffic increase on the Magdalena-Kelly-Linchburg road will amount to perhaps a dozen total vehicle trips per day.

All project-related personnel will access the site via the existing mine road from the Kelly church. Visitor control and access will be in accordance with regulations and procedures established by WES.

1.2.2.3 Mining Operations. The initial construction effort required to complete the Intermediate-Scale Test Program is the mining of 200 m of test adits and 7 test chambers. The adit cross-section will be 2 m by 1.95 m. A second mining operation (about eight weeks later) will excavate an additional 50 m of test adit and five additional test chambers.

The mining will be done by a mining contractor hired by the Corps of Engineers. This contractor will be a firm regularly engaged in this type of mining, and must document

good safety and environmental records and previous experience. The method of mining will be at the discretion of the contractor, but contract specifications will state that all government and Corps of Engineers regulations pertaining to safety and environmental issues will be followed.

The most probable mining method that the contractor will use to excavate the test facilities is drill and blast. In this method, a sequence of holes is drilled in the rock and explosives are packed into the holes, the holes tamped, and the explosives detonated. The resulting rock rubble is excavated and removed. This process is continued until the desired length of tunnel or chamber size is reached.

If this method is used, water will be required to cool and lubricate the drills. A water source exists within the existing mine and has been used for previous mining operations at this site. The water expelled by the drills will be collected and pumped to settling ponds in the interior of the mine where it will seep back into the strata. The drilling water will not drain into any local surface water sources and does not represent a significant hazard for surface water contamination.

The drill and blast method also requires that some blasting explosives be on site during times of construction. These explosives will be stored in a designated and qualified storage area. The mining contractor will be responsible for bringing the blasting explosives to the site as required for mining operations.

All mining operations will take place underground within the existing Linchburg Mine. The amount of blasting explosives used at any one time will be less than 227 kg, and the mining blasts will not be perceptible outside the Linchburg Mine property.

The mining operation itself will be identical to that typical of underground mining, and which occurred in the Linchburg mine as late as 1972. Only rock in the immediate vicinity of the adit and chambers will be disturbed. The Linchburg Mine is situated well above the water table, therefore the local water table will not be significantly affected. The only seepage noted in the existing mine is found within fault zones, and the quantities of water involved are minimal.

Portable generators will provide electrical power for ventilation, pumping, lighting, etc in the mine. Vehicles used for personnel or equipment transportation in the mine will be electric or diesel as required by mining safety regulations. The air in the mine will be exhausted and replaced by a ventilation system installed by the contractor as the mining progresses.

As in any construction project--especially in mining--a great emphasis will be placed on safety. The mining industry has strict guidelines and the government has strict regulations that work together to help ensure a safe mine. In addition, the Corps of Engineers requires contractors to adhere to those Corps regulations which are more stringent than those of industry or other government agencies. The Corps of Engineers will require that there be supervisory personnel trained in mine safety on site. These personnel will monitor the work areas for indications of unstable rock or other potentially hazardous conditions.

1.2.2.4 Test Bed Instrumentation Procedures. During the construction phase of the Intermediate-Scale Test Program, gages will be installed in boreholes to monitor close-in ground motion from tests in Chambers 2 and 4 (8 tests). These will be free-field measurements of rock stress and strain, and ground motion. In addition, airblast

pressure gage mounts will be placed in the floor of the test adits. There will be up to 100 channels of instrumentation for each test.

All free-field gages and ground motion canisters will be placed in 20-cm-diameter boreholes. The boreholes will be drilled by standard drilling methods using drilling mud (bentonite clay) for circulation, or some other drilling method. Upon completion of the emplacement of a gage, the gage hole will be backfilled with rock matching grout. The constituents of the grout mix will be a combination of some or all of the following: Barite, portland cement, bentonite clay, sand and water. The grout will be pumped into the hole, where the grout will be allowed to set for a short time while the canister or gage position is maintained.

1.2.2.5 Explosives and Explosives Safety. For the test program, the procedures for installing the explosives used in the experiment will be in accordance with DOD and U.S. Army Corps of Engineers explosive safety regulations and will be monitored by designated WES explosives blasters. The site will be manned 24 hours/day when explosives are in place for a test. During non-duty hours, the site will be patrolled by a contract security guard. Storage of explosives will be off-site (see Section 1.2.2.6).

The following is a description of the explosive types to be used in the proposed experimental test program (i.e., excluding the mining excavation work):

a. Composition B: The primary explosive for the the testing phase will be a standard military explosive designated Composition B (Comp B). Comp B is composed of 59.5 percent RDX, 39.5 percent TNT, and 1 percent wax (Reference 2).

b. C-4 Explosive: Standard, military-grade Composition-4 explosive will be used in the charge booster

assembly. Approximately 2 to 4 kg of C-4 will be used in each of the ammunition storage tests.

c. PETN Explosive: PETN, in the form of detonating cord, will be used in the charge ignition and booster assembly. Military-grade detonating cord containing 50 grains per foot (10.6 g/m) of PETN will be used. Approximately 70 m will be used per test, for a total weight of 0.74 kg of PETN.

d. Exploding Bridge Wire Detonators (EBW): A high-voltage, extremely safe detonator will be used to initiate the explosive reaction. The EBW to be used contains 70 mg of PETN, and 994 mg of C-4 as initiating explosive.

In the undetonated state, these explosives are environmentally benign. Due to their solid form, a spill of explosives is unlikely. If a test is canceled after the explosives have been loaded, the explosives will be recovered and none will be left in the environment. These explosives are stable in water and will not dissolve.

1.2.2.6 Dry Run and Detonation. A planned schedule of test firings will be provided to the Cibola National Forest Office and local law enforcement agencies at the beginning of field test operations. Following the emplacement of the gages for each test, as much time as necessary will be devoted to a complete system checkout and "dry run". The same procedures will be followed in a dry run as if it were the actual detonation, except for the final explosive placement and arming. Gage recording will be monitored to determine any system malfunctions. When the results of the dry run are determined to be satisfactory, test readiness will be announced to the Cibola National Forest Office and local law enforcement agencies.

Except for the largest charges (2,784 kg), the area will be secured and the explosive loading will begin on the morning of a test day For the largest charges, these

operations will begin on the day prior to the test. The initiation/booster system of the charge will then be placed in the center shortly before the time of firing. A countdown system will be employed which will allow the project manager positive control of the operation, and the ability to abort the detonation up until the instant the firing signal is actually initiated. A Safety Plan will be prepared and approved by the WES Safety and Occupational Health Office before preparing for any explosive testing.

The Composition B, C-4, and detonating cord explosives for these tests will be stored at the Energetic Materials Research and Test Center of the New Mexico Institute of Mining and Technology, near Socorro, NM. Explosives will be delivered to the test site as required for each individual test, and none will be stored on site.

Since all tests will be fired deep underground, meteorological conditions should not be a factor, short of intense thunderstorms at shot time. All explosive operations will be placed on hold whenever a lightning hazard exists. Airspace clearance will not be required.

1.2.2.7 Construction of Support Facilities. No permanent support facilities will be constructed at the test site. A small area (approximately 25 m x 25 m) will be leveled adjacent to the access road about 100 m from the mine portal. This will provide for a temporary pad for a shop/office trailer and generator, and cable and hardware storage. The trailer and all residual hardware will be removed posttest.

1.2.2.8 Site Cleanup and Restoration. Subsequent to completion of the test program, all equipment, material, and refuse associated with the test will be removed. Any disturbed ground will be recontoured and reseeded with native grasses (see Sections 3.3 and 1.3.8.1).

1.2.2.9 Use of Facilities and Resources of the Area.

WES personnel will be housed in motels and apartments in the Socorro/Magdalena area, and will eat in local restaurants. Local businesses will be utilized for incidental supplies and maintenance. Local contractors will be utilized for equipment rental required in construction and site cleanup, and for sanitation and guard services.

1.3 THE TEST SITE ENVIRONMENT

1.3.1 Location and Description of the Proposed Test Site.

The proposed test site is located within the existing Linchburg Mine in Socorro County, New Mexico, within Section 7 of Township 3S, Range 3W. The Linchburg Mine is owned by Cobb Resources Corporation. The mine is currently inactive and in a caretaker status.

The Linchburg Mine consists of underground workings on four patented mining claims within the Magdalena Mining District of New Mexico. The mine was primarily operated for the recovery of lead and zinc. The Magdalena Mining District includes a large number of inactive and abandoned underground mines. Hundreds of small adits can be found on the west slope of the Magdalenas. The nearby Waldo Mine, operated by the New Mexico School of Mining and Technology, is a teaching facility rather than an active mine. Mining operations at the Linchburg were active until 1972, when, for economic reasons, all mining operations were shut down.

The tests will be conducted entirely within the patented mine areas under lease agreement between WES and the present owner. Land use within the project areas will not be altered as a result of the proposed action.

The spoil areas and associated disturbed areas presently occupy approximately five acres of land near the mine portal. The proposed plan would increase this disturbed area by

perhaps as much as 0.4 hectare as a result of additional spoil, increased work space and additional parking areas.

The nearest incorporated community to the proposed site is Magadalena, New Mexico (pop. 834), 9,600 m to the northwest. Kelly, a small ghost town, is located approximately 2,000 m to the northwest. The nearest inhabited dwellings are private residences in Patterson Canyon, approximately 1,800 m west of the project.

The property is presently leased to the WES. The terms of the lease, dated 14 August 1992, provide for a yearly renewal through 13 August 1995.

The Linchburg Mine is presently in good condition, having recently been mucked out of loose slough and rockfill. A double-door and gate structure has been recently constructed at the portal, and usable 0.46 m track extends well into the workings. The majority of the mined stopes are located further into the mine 60 to 80 m to the east of the proposed project site.

1.3.2 Geology.

1.3.2.1 Geologic Setting. The Linchburg Mine is located on the north end of the Magdalena Uplift, a horst block tectonic feature within the Rio Grande Rift/Depression. The Rio Grande Rift is a narrow, generally north-trending, active rift zone that is an extension of the Basin and Range Physiographic Province. The rift zone separates the Colorado Plateau Province to the west from the Great Plains Province to the east. The Magdalena Uplift is bounded to the north by the Ladron Uplift, to the south by the Mulligan Trough, and to the east by the Snake Ranch Trough, which are also tectonic features within the Rio Grande Rift.

1.3.2.2 Physiography. The Magdalena Mountain Range, approximately 39 km long and 16 km wide, is the topographic

expression of the Magdalena Uplift. Maximum relief within the range is approximately 1,100 m above the base of the range. The Linchburg Mine is located on the western flank of the mountains.

1.3.2.3 Structures. The Magdalena Uplift is a north-northwesterly trending homocline with bedding dipping generally to the west at 20 to 40 degrees. There is also minor folding parallel and perpendicular to the axis of the homocline. Faulting at the site is somewhat complex. There are a number of en echelon, northwest trending faults. These are normal faults that dip steeply to the west. Offset has resulted in "stairstepping" of fault blocks, with each block being lower than the adjacent block moving from east to west. In addition, there are a number of normal cross faults. Offset along these faults is not as significant, but has contributed to the development of large-scale fault blocks. A detailed analysis of joint patterns has not been performed, but it is likely that major joint sets have developed parallel to the faults and along bedding planes in the weaker rock units.

1.3.2.4 Seismicity. The Rio Grande Rift is the most seismically active area in New Mexico. Most of the seismic activity occurs between Albuquerque and Socorro, 48 km northeast of the project. Approximately 250 earthquakes have been recorded from 1849 through 1990, often occurring in swarms. This activity is attributed primarily to the injection of magma at depth in the central part of the rift north of Socorro. Earthquakes of up to Modified Mercalli Intensity VIII have been reported. The maximum magnitude measured was 5.1 on the Richter scale for two earthquakes which were part of a swarm in 1966 in the northern portion of the state. At least four earthquakes have been reported within 10 miles of the site since 1942. The largest registered 3.0 on the Richter scale.

1.3.2.5 Stratigraphy. Rocks exposed in the region range in age from Precambrian to Quaternary. A Precambrian complex of greenstone and granite is exposed at the base of the Magdalena Mountains. The majority of exposures, however, consist of Paleozoic marine sediments ranging in age from Pennsylvanian to Permian, and Tertiary intrusive and extrusive igneous rocks.

The majority of the mine workings are located in the Mississippian Kelly limestone where large replacement bodies of sulfide ore developed adjacent to the major faults. In addition to the Kelly limestone, there are exposures of interbedded shale and limestone of the Pennsylvanian Medera and Sandia formation, Precambrian greenstone, Tertiary monzonite porphyry, and Tertiary andesite and rhyolite.

The project will be located in an interval of the Kelly limestone exposed in the main Linchburg adit between 215 and 275 m from the portal. This particular interval is known locally as the Upper Kelly limestone and is approximately 12 to 15 m thick. It is separated from the Lower Kelly limestone by and 2- to 3-m thick shale marker bed known as the Silver Pipe member. At the proposed project location, the limestone strikes north-northwest and dips 15 to 10 degrees to the southwest. Here, the Upper Kelly is composed of a moderately bedded, moderately jointed, dark gray, very hard, dense, crystalline limestone.

1.3.2.6 Surface Drainage. The mine shaft opening at the project site lies at an elevation of approximately 2,460 m above sea level. The opening is in the bottom of a small intermittent drainage which connects to the Patterson Canyon drainage approximately 3,200 m downslope from the mine. Patterson Canyon flows northward into Hop Canyon near Magdalena, approximately 8,000 m downstream from the mine. Approximately 12,900 m downstream from the mine, Hop Canyon

transects Highway 60 200 m west of Magdalena. These surface waters flow into the Rio Salado Basin, which in turn flows north of the Magdalena Mountain range into the Rio Grande Basin.

1.3.3 General Observations and Conclusions. The Upper Kelly limestone is relatively dense and very hard. It has been recrystallized, probably as a result of the intrusion of a number of large stocks in the vicinity. Blasting will likely be required to perform the excavation. Because the limestone is bedded, rock bolts will be required for structural support of the back to prevent fallout after the project is completed. It is anticipated that only three 8- to 10-ft rock bolts in the back of the drifts and chambers will be needed at intervals of 3 to 4 m. Even with the rock bolts, the final grade for the backs will be somewhat irregular with minor stairsteps or sawteeth developing along bedding planes and near vertical joints. It appears that there will be approximately 10 to 15 cm of vertical offset every 3 m of horizontal distance. The sides of drifts and chambers should hold a vertical slope without any need for structural support. A bulk sample of the limestone should be sent to a laboratory for a minimum of tests to include specific gravity, hardness, and resistance in order to provide important physical characteristics to prospective bidders.

The project will have to be carefully located to accommodate for the column thickness and dip of the Upper Kelly limestone. It is possible to situate the adits and chambers entirely within this member and avoid the Silver Pipe shale member and faults. This will help assure that homogeneity of the foundation materials is maximized, and zones of weakness and poor quality rock are avoided.

Solutioning of the Upper Kelly limestone should not be a problem. This exposure is distant from the faults and

associated mineralized zones exposed elsewhere in the mine. Only very minor solutioning was observed in the existing adit, and all joints were tight and/or healed. There is the possibility that the distal ends of each chamber group may encounter a cross fault with some subsequent alteration and solutioning of the limestone, but it is not anticipated. There is, however, no way of predetermining this without a preliminary (as well as costly and time consuming) exploration drilling program.

For future considerations, there are additional exposures of the Upper Kelly limestone in the mine that may be extensive enough for additional testing in material similar to the foundation material for this project. In addition, current mine workings extend into the Precambrian greenstone. Much of the exposed greenstone is highly fractured and altered, but, away from the major faults, this material would likely provide a good quality, homogeneous medium for additional tests. At the far south end of the mine, adit level workings extend into the Grand Ledge Stock, a large monzonite/quartz monzonite porphyry intrusion. Field observations of this material indicate that it could be high quality, homogeneous rock mass ideal for future tests in a different rock type. It is located at a substantial distance from the portal, but the owner has indicated that existing mine stopes could be used for the disposal of material excavated for this project

Figure 2 is a plan view of the project. This configuration best utilizes site geology.

1.3.4 <u>Climate</u>. The climate in this portion of New Mexico is semi-arid with mild summers and moderate winter snows. The average highest temperature for Magdalena each summer is 35.6°C, while the average coldest winter temperature is -16°C. The frost-free season varies from 120 to 180 days

long. Annual precipitation at the project area ranges from 25 to 38 cm per year, approximately sixty percent of which falls as rain from July through September. The U.S. Forest Service reports that the average date of last frost for Magdalena is 21 April.

The west facing slope of the Magdalenas will be slightly warmer than the regional temperatures. The project area is dissected by a drainage that runs from east to west. The south-facing slopes have a very arid aspect, with a xeric vegetation community and very little soil development, while the colder north-facing side of the drainage supports a much more mesic community with deep humic soils.

1.3.5 Air Quality. Magdalena is in the State of New Mexico's Air Quality Control Region 8 (Reference 3). The region is in attainment status for National Air Quality Standards for priority pollutants (particulate matter, sulfur oxides, nitrogen dioxide, carbon monoxide, ozone, and lead). Ambient air quality in the Magdalena area is excellent. In the State's Prevention of Significant Deterioration program administered by the New Mexico Environment Department, the region is designated Class II, which allows for moderate development and its associated air emissions.

The planned action would not result in any permanent or significant short-term degradation of air quality, although some highly-localized and ephemeral increases in concentrations of dust and combustion emissions would be expected during construction and the operation of vehicles and equipment. All stockpiles, permanent or temporary access roads, and waste areas would be maintained to limit dust. Dust control measures, such as surface watering, would be performed as the work proceeds and whenever a dust nuisance occurs. These measures would minimize the short-term impacts to air quality.

1.3.6 Ambient Noise Level. Existing noise levels on the project site are typical of isolated areas in the region. Major sources of ambient noise are occasional planes flying over head. Some localized increase in ambient noise levels would be expected during construction; however, this increase would remain far below State and Federal standards for public safety and would not persist beyond completion of the planned action.

The planned action includes up to 32 detonations. Fourteen of these would be large charges of 2,785 kg, while the others would be 66.3, 331, and 994 kg. Consultation with the NM Department of Mines and Minerals indicates that these are small blasts compared to those used in normal pit mining operations, and that the force will be dispersed because the charges are decoupled, viz., not packed against the mine walls (J. Goravich, conversation 22 March 1993). The nearest habitations are about 1,800 m from the project area. At this distance, the noise generated by the largest detonations will be of very short duration (0.5 seconds or less) and will remain well below any levels of concern according to State and Federal standards.

1.3.7 Soils. The project area is located in a region of shallow and very shallow aridisol soils and rock outcrops on hills, knolls and mountains. The rock outcrops consist of exposed tuff, rhyolite, and limestone. The soils in the project area have formed in alluvium and colluvium derived mostly from volcanic tuff, Socorro County soil survey maps do not include lands within the Cibola National Forest; the following soil descriptions are based on extrapolations from the nearest mapped areas south of Magdalena. The Puertecito soil series (Lithic Ustollic Haplargids) is found on the south-facing slopes of hills and mountains. These soils are very shallow, well drained and moderately slowly permeable. Motoqua soils (Lithic Arguistolls) are generally on the

north-facing slopes of the mountains and are shallow, well drained and moderately slowly permeable.

1.3.8 Ecology.

1.3.8.1 Vegetation. The principle natural plant community in the area is characterized by sideoats gramma (*Bouteloua curtipendula*), blue grama (B, *gracilis*), muttongrass (*Poa fendleriana*), and pinyon pine (*Pinus edulis*) on the south-facing slopes and New Mexico locust (*Robina neomexicana*) and scrub oak (*Quercus gambelii*) on the north facing slopes. The vegetation present is representative of an ecotone between the Great Basin Woodland and the Petran Conifer Forest (Reference 4). The elements of the Petran Montane Conifer forest, including New Mexico locust (*Robina neomexicana*) interspersed with widely scattered Ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menzesii*), dominate the north slopes. The more xeric Great Basin Woodland community is represented by mixed grasses (primarily *Bouteloua curtipendula, B. gracilis and Aristida sp.*), pinyon pine (*Pinus edulis*) and junipers (*Juniperus monosperma and J. deppeana*). This type of mixed community is common in this area at these elevations. A list of plants encountered during a February field survey is attached as Appendix A.

The proposed action may disturb the natural vegetation on approximately 0.4 hectare of the project site. The disturbance area would be adjacent to presently disturbed sites, near the mine portal or along the roads. Preservations of the landscape would be an imperative consideration in the determination of configuration of operations. The contractor would be required to develop site work plans which minimize damage to the landscape, including a restoration plan. The plan would also indicate the location of any necessary guard posts or barriers to protect

trees and shrubs from damage by vehicular traffic. The plan would provide for the obliteration of construction scars and would provide for a reasonably natural appearing final condition of the area. The disturbed area would be reseeded with a mixture of native species such as Arizona fescue (*Festuca arizonica*), squirrel-tail (*Sitanion hystrix*), side-oats grama (*Bouteloua curtipendula*), sheep fescue (*Festuca ovina*), tall wheatgrass (*Agropyron elongatum*) and mountain mahogany (*Cercocarpus montanus*).

1.3.8.2 Wildlife. Suitable habitat exists on the project area for several mammals including mule deer (*Odocoileus hemionus*), porcupine (*Erethizon dorsatum*), desert cottontail (*Sylvilagus audubonii*), rock squirrel (*Spermophilus varigatus*), cliff chipmunk (*Tamias dorsalis*), Aberts's squirrel (*Scuirus aberti*), white-throated woodrat (*Neotoma albigula*), deer mouse (*Peromyscus maniculatus*) (References 5 and 6). Bird species likely to breed in this area include Common Raven (*Corvus corax*), Pinyon Jay (*Gymnorhinus cyanocephalus*), Steller's Jay (*Cyanocitta stelleri*), Scott's Oriole (*Icterus parisorum*), Pine Siskin (*Carduelis pinus*), Brown Creeper (*Certhia americana*), Yellow-rumped Warbler (*Dendroica coronata*), Townsend's Solitaire (*Myadestes townsendi*), Western Tanager (*Piranga ludoviciana*), Broad-tailed Hummingbird (*Selasphorus platyercus*), Western Bluebird (*Sialia mexicana*) Pygmy Nuthatch (*Sitta pygmaea*), Warbling Vireo (*Vireo gilvus*), Solitary Vireo (*Vireo solitarius*), and Chipping Sparrow (*Spizella passerina*) (References 4 and 7). Reptiles potentially occurring in the vicinity include tiger salamander (*Ambystoma tigrinum*), blacktail rattlesnake (*Crotalus molossus*), many-lined skink (*Eumeces multivirgatus*), short-horned lizard (*Phrynosoma douglassi*), Sonoran gopher snake (*Pituophis catenifer affinis*), and the prairie lizard (*Sceloporus undulatus*) (References 8, 9, and 4).

Vehicular use in the project area may have some minor adverse impact on the wildlife in the area due to an increase of roadkills.

Spoil removal may require additional space beyond the extant 0.4 hectare tailings pile, even though tailings would be confined to the mine as much as possible. Some individual animals of small non-game species may be incidentally killed during earth and rock moving activities in the handling of these tailings.

The largest magnitude detonations proposed are small compared to normal mining operations. They would take place in mid-winter thereby avoiding disturbance during the breeding seasons of most animals. The detonations may startle wildlife should they be in the immediate area; however, the charges would be in chambers at least 900 feet from the surface. The loudest noise effect would occur directly in front of the portals of both the Linchburg and the Patterson Mines. Although wildlife may be momentarily startled by the sounds, there is little chance of the detonations causing any loss of wildlife or presenting a significant disturbance.

1.3.8.3 Endangered Wildlife Species. Three agencies have primary responsibility for the conservation of animal and plant species in New Mexico: the U.S. Fish and Wildlife Service (USFWS), under authority of the Endangered Species Act of 1973 (as amended); the New Mexico Department of Game and Fish (NMDGF), under the authority of the Wildlife Conservation Act of 1974; and the New Mexico Energy, Minerals and Natural Resources Department, under authority of the New Mexico Endangered Plant Species Act and Rule No. NMFRCD 91-1. Each Agency maintains a list of animal or plant species which have been classified or are candidates for classification as endangered or threatened based on present status and potential threat to future survival or recruitment.

Endangered, threatened, and review species with potential to occur in the project area are discussed below/in Table 2.

Table 2. Federal and State of New Mexico Species of Concern with Potential to Occur Near the Linchburg Project Site.

ANIMALS	Federal Status[1]	State Status[1]
American Peregrine Falcon (*Falco peregrinus anatum*)	E	E
Bald Eagle (*Haliaeetus leucocephalus*)	E	E
Mexican Spotted Owl (*Strix occidentalis lucida*)	T	E
New Mexican jumping mouse (*Zapus hudsonius luteus*)	C1	E
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	C1	E
Northern Goshawk (*Accipiter gentilis*)	C2	E
Cave myotis (*Myotis velifer*)	C2	E
Spotted bat (*Euderma maculatum*)	C2	E
Occult little brown myotis (*Myotis lucifugus occultus*)	C2	.
Common Black-Hawk (*Buteogallus anthracinus*)	.	E
Common Ground-Dove (*Columbina passerina*)	.	E
Gray Vireo (*Vireo vicinior*)	.	E
PLANTS		
Rock fleabane (*Erigeron scopulinus*)	C2	.

[1] E = endangered; T = threatened; C1 = Notice of Review, Category 1; and C2 = Notice of Review, Category 2. Category 1 species are those for which the USFWS has sufficient information to support their listing as endangered or threatened and for which publication of proposed rules is anticipated. Category 2 species are those for which data on biological vulnerability and threat are not conclusive and for which specific plans for Federal protection have not been proposed and are not likely to be proposed unless additional information becomes available.

The endangered species, the **Peregrine Falcon** and the **Bald Eagle**, have a slight potential to occur on the Linchburg Mine site. The value of this site as potential breeding habitat for both of these species is limited by the lack of water resources in the area.

The American Peregrine Falcon, *Falco peregrinus anatum*, potentially may use the general locality for resting or foraging during spring and fall migration. Its preferred habitat is open country and steep rocky cliffs in close proximity to water, containing dense bird populations in

conjunction with steady strong air currents. The aridity of Milligan Gulch and the adjacent mountain slopes may limit the value of the area as Peregrine breeding habitat (Reference 10).

The Bald Eagle, *Haliaeetus leucocephalus*, occurs along riparian and lacustrine habitat of the Rio Grande and other major rivers in New Mexico between mid-November and mid-March. In migration, it can also be found in mountains and open country. In New Mexico, breeding birds are known only from San Juan County (Reference 10).

The proposed activities would not alter habitat features which could potentially be used by the American Peregrine Falcon or Bald Eagle. In light of their low probability of occurrence at the project site, the short duration of construction activities and minor extent of disturbance, no adverse impacts to these species are foreseen as a result of implementing the proposed plan.

The Federally-threatened Mexican Spotted Owl, *Strix occidentalis lucida* was listed as threatened on 15 April 1993 (Federal Register, Vol. 58, No. 49 (14248-1471). This species is known to occur in biotic communities similar to those present at the higher elevations of the Magdalena Mountains. The Mexican Spotted Owl, *Strix occidentalis lucida*, ranges from central Colorado and southern Utah south through Arizona and New Mexico into central Mexico. It has been recorded in New Mexico National Forests at elevations of 1,128 to 3,048 m. The preferred habitat for this species is mixed conifer forests, but it is sometimes also found in pinyon-juniper, pine-oak, and ponderosa pine woodlands. It may be found in caves, cliff ledges, witches'-broom, and stick nests of other species in mature and old growth forest. Occasionally, it is found in steep rocky-walled canyons. The Linchburg Mine site has sub-optimal breeding habitat for the

Spotted Owl in containing no closed-canopy forests and no steep rocky canyons. The small area of disturbance would pose little affect on foraging habitat for this species. This proposed action would not significantly affect habitat significant to the recovery of this species.

Two State-endangered/Federal Category 1 species have the potential to occur in Socorro County; however, neither is currently known to be present near the project area. The Southwestern Will Flycatcher, *Empidonax traillii extimus*, breeds in riparian areas of perennial streams which include relatively dense shrub cover (Reference 10). Preferred habitat of the New Mexican jumping mouse, *Zapus hudsonius luteus*, consists of permanent streams, moderate to high soil moisture, and dense and diverse stream-side vegetation consisting of grasses, sedges, and forbs, including the edges of permanent ditches and cattail stands in the Rio Grande Valley (Reference 11). The proposed project area lacks habitat features which are important to these species, and therefore would not adversely affect either of these species.

The Northern Goshawk is a Category 2 candidate species which could occur in the vicinity of the Magdalena Mountains. The preferred habitat of the Northern Goshawk, *Accipiter gentilis*, consists of mature coniferous and deciduous forests, especially in mountains and along forest edges. Nest sites are usually found in forest stands with a high density of large trees and canopy closure, conditions which do not exist in the project area. Stands of ponderosa pine and Douglas fir on the east facing slopes of the Magdalena Mountains may be included in Goshawk foraging areas. Project construction and the small area of disturbance would not be likely to affect the quality of foraging habitat for this species. Implementation of this proposed action would not affect this species or its habitat.

There are three Federal candidates, Category 2, species of bats that are known from Socorro County. These species were believed to have high potential to occur in the Linchburg area in the many nearby abandoned mines. Records of the Spotted bat, the Cave myotis and the Little Brown bat being netted over water in Socorro County, indicated that there was some potential for them to either use the caves as summer roosting areas, maternity caves or winter hibernacula (Reference 5).

The Spotted Bat, *Euderma maculatum*, ranges across the desert southwestern United States, having been observed in montane forests, woodlands, and in desert situations, (Reference 6). Its preferred habitat is crevices in rock cliffs and occasionally has been observed in buildings and caves (Reference 12). Evidence suggests that caves are used as hibernacula (Reference 5).

The Little Brown Myotis, *Myotis lucifugus occultus*, ranges across the northern United States and Canada. It roosts in caves, tunnels, hollow trees or buildings (Reference 12). This species is a water bat and is usually seen in the vicinity of large bodies of water, especially major rivers, but is also seen near forests (Reference 6). These bats are colonial, and are believed to hibernate near their summer range, although no hibernacula are known from the state (Reference 5).

The Cave Myotis, *Myotis velifer*, ranges across the northern United States and Canada. it roosts in caves, tunnels, hollow trees or buildings (Burt & Grossenheider, 1964); in New Mexico it is most common in the drainage basin of the lower Pecos River, near the San Francisco or Gila rivers, or in southern Hildago County (Reference 6). It roosts in caves and mine tunnels, usually in crevices or on vertical surfaces. It is colonial (Burt & Grossenheider,

1964) and may migrate to Mexico or hibernate in southwestern New Mexico (Reference 5).

Concerns for the possible presence of rare bats were addressed by field surveys in the Linchburg and adjacent mines. Consultation with biologists of the Abandoned Mines Lands Bureau indicated that disturbance to bats during hibernation can affect their probability of survival over winter. Little information was available as to the magnitude of ground motion that would be required to disturb bats during hibernation. Ground motion could potentially affect bats in nearby abandoned mines as well as within the Linchburg. A radius from the Linchburg was determined in which the ground motion would be high enough to produce a "startle" affect (unpleasant/disturbing) in humans. Maps from the Bureau of Mines and Minerals were used to identify mines within that radius and they were surveyed on 13 April 1993 by the U.S. Army Corps of Engineers personnel and Dr. Scott Altenbach (University of New Mexico), a recognized expert in bat research.

The Linchburg Mine was surveyed extensively. The Patterson Mine was accessed through its underground connection with the Linchburg Mine and briefly surveyed. Tests of the atmospheric conditions in these two mines showed the temperatures to be higher (15°C) than those needed for successful bat hibernation (1-10°C). No evidence of bat presence or usage was found within these mines.

The Enterprise mines are a system of adits in various stages of collapse located approximately 1,500 feet from the portal of the Linchburg. These mines are much older, probably dating from late 1800's. Two portals were located from that system and the associated tunnels were surveyed for bats. The uppermost tunnel had traces of bat guano, indicating occasional summer use. No evidence was found to

indicate that those tunnels were used either as maternity roosts or hibernacula.

The Young American tunnel, another older tunnel, was surveyed in its entirely. It contained a large bird nest near the entrance and evidence of use by woodrats. Like the other mines surveyed, the tunnel was too warm for bat hibernations. No evidence was found of bat presence or usage in the Young American.

The proposed action would have no adverse effect on any populations of bats in the area, since bats do not use any mines in the immediate area for hibernacula. The explosive tests would be performed during the winter when bats would normally hibernate. If the blasting should be rescheduled for spring or summer, then the Enterprise Mine should be resurveyed to determine which species of bat, if any, is using that mine as a roosting site. The opening of that mine would be protected from complete closure by installation of a 24-inch diameter corrugated metal pipe in the portal prior to blasting.

Three species with potential to occur in the Linchburg vicinity, the Common Black-Hawk, the Common Ground-Dove and the Gray Vireo, are protected by the State of new Mexico and not by federal agencies.

The Common Black-Hawk, *Buteogallus anthracinus*, ranges from the southwestern United States to Ecuador. It breeds in central and southern Arizona and southern New Mexico in the Gila National Forest. It is usually found along wooded stream bottoms. This preference for riparian habitats makes it unlikely to be found in the project area.

The Common Ground-Dove, *Columbina passerina*, ranges from the southern United States through Costa Rica and northern South America. Most New Mexico records are from the extreme southern edge of the state. It is found on farms, in

orchards, woodland edges and roadsides. Suitable habitat for this species does not occur within the project area.

The Gray Vireo, *Vireo vicinior*, ranges from the southwestern United States to central Mexico. It prefers habitats of brushy mountain slopes, mesas, open chaparral, scrub oak and junipers (Reference 10). It the Gray Vireo were to be in the area, it would be during the summer breeding season.

1.3.8.4 Threatened and Endangered Plants. Several threatened, endangered or rare plants exist within Socorro County, however, only one of them occurs in habitats similar to those present on this project. The rock fleabane, *Erigeron scopulinus*, is listed on the New Mexico Rare and Sensitive Plant Species list, where it is recognized as rare, but not endangered. This species is a federal candidate, C2, for listing as a threatened or endangered species. It is considered sensitive by the U.S. Forest Service.

The rock fleabane grows in crevices in cliff faces of rhyolitic rock at elevations of 6,000 to 9,000 feet in the Rocky Mountain Mixed Conifer Forest. The range of this species includes Catron, Sierra, and Socorro Counties and adjacent Arizona. No suitable habitat for this species exists on the Linchburg Mine properties.

1.3.8.5 Cultural Resources. An archaeological survey of the project area was conducted on 22-23 April 1993 to identify any National Register eligible properties. The Linchburg Mine, and the Young America and Enterprise Mines, turn-of-the-century mines on the mountain above the entrance to the Linchburg Mine, were the two sites recorded during the survey. No prehistoric sites or isolated artifacts were recorded in the project area. Features which were recorded at the Linchburg Mine included several refuse dumps, the talus pile, concrete pads marking former building locations,

two wood-frame buildings currently used for storage, an ore bin and a munitions building. The existing talus pile is sufficiently large to accommodate work trailers and vehicles without modification to it or to any currently undisturbed land.

The Young America and Enterprise Mines consist of three open pits, one adit and several small talus sites. Cultural materials include several building foundations of unshaped locally-available rock; the remains of door and window frames; stove parts; scatters of 'solder dot" tin cans, tobacco cans, milk cans; broken glass (including brown, clear, amber, purple and milk), bottles, jars and china. A small wooden ore chute was also recorded.

The survey report is being prepared and the New Mexico State Historic Preservation Officer and the Advisory Council on Historic Preservation will be asked for a concurrent determination of No Adverse Effect. These letters of concurrence will be available to be included in the final environmental assessment.

2 ALTERNATIVES TO THE PROPOSED ACTION

2.1 GENERAL

The objectives of the proposed action have been reviewed with respect to national defense requirements, and have been judged important and of high priority. The proposed test will use high explosives to generate shock effects in a method that is least disruptive to the environment, yet meets the requirements/objectives of the test program.

During the test planning process, a number of possible alternatives were considered, including changes in the explosive weights and scale, in order to reduce environmental impact. The criteria used to help evaluate the acceptability of a particular alternative and to assist in balancing the potential environmental harm against national defense interest included:

a. Maximize the attainment of required national defense objectives.

b. Minimize the socioeconomic consequences.

c. Minimize the environmental consequences.

d. Minimize the test cost.

The social variables considered were physical damage to man's structures, activities, or heritages, loss of recreational facilities, and/or aesthetic qualities. The major environmental variables evaluated were (1) permanent changes in the physical environment which would affect human health or welfare, and (2) direct or indirect effects on animals, plants, or ecosystems, especially changes which would temporarily or permanently alter the land

characteristics. Economic variables related to the actual cost of the proposed test program include the direct costs of logistics, construction test support, and data analysis.

2.2 EVALUATION OF ALTERNATIVES

The following alternatives to the proposed action as summarized in Table 3 were analyzed but are not recommended.

2.2.1 No Action. The proposed action is vitally needed by defense agencies concerned with explosive and munitions storage hazards, and with reduction of these hazards without reduction of security, operational readiness or logistical support. Not conducting the tests would leave serious and detrimental voids in the data base which validates new developments in alternative methods of munitions storage. No environmental impact would occur if no action is taken.

3.2.2 Conduct Test at Other Locations. The munitions storage program developed a set of siting criteria in order to meet test objectives. These are:

a. Prior or current land use consistent with test program operations, i.e., mining and blasting, to minimize possible environmental disruption.

b. An existing adit of roughly 3 m by 3 m and at least 300 m long, abandoned or currently inactive, in hard rock, easily accessible from improved roads.

c. A stand-off distance of more than 6 km to the nearest community.

d. Adequate logistical support for a crew of up to 10 people within 50 km.

A survey of potential sites was conducted, and potential sites in the Ophir Canyon, UT, mining district, the Silver City, NM, area, and the Magdalena, NM, area were investigated. The Linchburg Mine, near Magdalena, NM, was the only site found which met the criteria fully.

Table 3
Alternatives Considered, Subjectively Related to the Proposed Project

Alternative	Test Objective	Social Disruption	Ecological Disruption	Cost	Overall Evaluation
No action	Cannot be met	Less (none)	Less (none)	Less (none)	Unacceptable due to national defense need.
Reanalysis of existing data	Cannot be met	Less	Less (none)	Unknown - probably less	Unacceptable. No data exists in the required configuration at high stress levels.
Conduct tests at other location	Cannot be fully met	Similar (site dependent)	Similar (site dependent)	Much greater	No other site currently meets test objectives.
Reduce scope and/or size	Cannot be fully met	Possibly less	Possibly less	Probably less	Size of tests now a minimum to meet program objectives.
Simulate in a laboratory	Cannot be met	None	None	Unknown	Unacceptable. Lack of confidence in exaggerated scaling or non-representative geology

2.2.3 Reanalysis of Existing Data. These tests are required for the validation of empirical predictions of the adequacy of new munitions storage technologies, upon which strategic decisions will be based. No high-level explosion shock, stress or motion data exists for this or similar test configurations. Extrapolation of data from greatly different configurations and/or much lower stress levels would not be a technically valid approach. No environmental impact would occur as a result of reanalyzing existing data.

2.2.4 Reduce the Scope of the Project. The explosive size has already been scaled down to the minimum required to meet the project requirements. Further reductions in simulator size would not provide a reliable answer to the questions posed. Reducing the scope of the project would reduce the environmental impact.

2.2.5 Simulate in a Laboratory. The explosive size is at a minimum to meet the program requirements and is far too large for laboratory testing. No other simulation techniques will meet the program objectives. No environmental impact would occur as aresult of simulating the tests in a laboratory.

3 ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION

3.1 ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED CONSTRUCTION (EXCLUDING EXPLOSIONS).

3.1.1 General. On the surface, the proposed test site will occupy an area of approximately 25 m by 25 m (0.06 hectare) to be used for an instrumentation trailer park and equipment storage. An additional small area at the mine portal will be used for a staging area and will occupy an area roughly 50 m by 50 m (0.25 hectare). The portal area was cleared and leveled during previous mining activity and will not be substantially altered by the proposed activity. The trailer area will be located approximately 50 m from the portal along the existing access road, and will involve a minor amount of clearing and leveling. Disturbance of existing surface drainage and vegetation will be kept to an absolute minimum.

Approximately 800 m^3 of muck will be removed during mining activities. The muck will consist principally of the Kelly limestone with some shale, monzonite, andesite, or rhyolite possible (Section 1.3.2.5). Muck will be dumped in abandoned vertical shafts or stopes inside the mine, or added to the existing tailings pile adjacent to the portal.

Approximately 300 m of 15 to 20-cm diameter holes will be drilled for instrumentation purposes. The instrument holes will be backfilled with a grout which matches the mechanical properties of the in situ material. This grout will contain Portland cement and naturally occurring soil materials (bentonite clay, sand, barite, etc.).

A previously established gravel road will be used for site access. Some minor improvements may be required due to deterioration since the last mining activity. Vehcile traffic will be restricted to existing roads or designated parking areas.

The area proposed for use on this program which is outside the adit lies within areas used for previous mining operations. Disturbance of vegetation and topography will be kept to a minimum, and will be far less than has occurred during previous mining activities.

3.1.2 Air Quality. There will be minor localized increases in airborne dust due to the movement of vehicles transporting equipment and personnel from the hard surface highway to the test area by gravel and dirt roads, and by grading and leveling the proposed trailer-parking area. Natural rainfall will result in some dust suppression. It is expected that the construction activities will be very localized, and the resulting dust will be insignificant when compared to natural dust phenomena, especially since most construction activities will take place in the underground adit.

Vehicles and equipment which will be involved in the test operation will produce minor amounts of gaseous emissions, but the small number of vehicles and equipment in use at any one time is expected to cause only trivial changes in air quality.

3.1.3 Noise Impact. The impact of noise is a function of the presence of people who might be affected. Because of the semi-remoteness of the test area, it is not expected that the noise impact will be significant.

Noise will result from vehicle and equipment usage. Because of the limited amount of vehicle or equipment usage and because all vehicles and equipment have exhaust mufflers, it is expected that noise impact will be minimal.

3.1.4 Geology and Soils. During the construction of the new adits, a total of approximately 800 m^3 of rock will be mined from the adit. All underground excavation will be conducted in limestone that is not mineralized. The project will not be located in that portion of the mine containing lead-zinc ore. As a result, detectable amounts of metals are not anticipated to be in the materials excavated. Approximately 40 to 60 percent of the materials excavated will be wasted inside the stoped portions of the mine. The remaining material will be deposited onto the existing spoils. The existing material in the spoil dump consists almost exclusively of barren rock excavated from access and/or development drifts. There is virtually no potential for the contamination of soils by heavy metal leaching as a result of this project.

Construction activities will be confined as much as possible to disturbed areas or to spoil areas. At the onset of necessary additional disturbance, the topsoil from the area will be saved for use in the restoration of the area. Any areas disturbed by construction will be graded and filled as required, then covered with suitable soil for the growth of grasses. The entire area will be seeded with native vegetation.

The proposed action will have no significant impact to the soil resources.

3.1.5 Hydrology and Water Quality. All underground excavation will take place in limestone that is not mineralized. The spoil material is not expected to contain appreciable amounts of metals. For this reason,

precipitation and surface runoff filtering through the spoil materials is not expected to contribute metal contamination to either the ground water or the surface water.

Relatively minor amounts of water will be utilized during the drilling for this project. This water will be obtained primarily from water from fault-line seepages which are located in isolated areas within the old mine workings. Some water may also be imported. Waters from the Patterson Mine to the south will not be used in this proposed action. All water used will be drained back into the limestone and will not be allowed to exit the portal. Drilling operations in the limestone will not contribute any hazardous material to the water used. Potable water would be imported to the site to make cement. There should not, therefore, be any ground or surface water contamination resulting from this proposed action.

Section 402 of the Clean Water Act regulates discharges of pollutants into the waters of the U.S. including non-point sources associated with stormwater discharge on construction sites. The planned action will not result in disturbance of five or more total acres nor result in any modification in the location, quantity or quality of discharged waters and thus will not require permitting under Section 402.

3.1.6 <u>Hazardous Materials</u>. No hazardous wastes will be produced by this construction effort.

Fuels will be stored in above ground tanks and precautions will be taken to avoid spills. The fuel storage area will be constructed in such a way that if an accidental spill should occur, the fuel would be confined and clean-up procedures could take place quickly with minimal environmental effects. Excess fuels will be returned to the fuel supplier.

The blasting agents that will be used in mining operations will pose little environmental threat if an accidental spill should occur. The explosives are nearly insoluble in water, and since they are very stable and nonsensitive, cleanup can be accomplished safely and quickly. This construction will not limit future land use in the affected area.

3.2 ENVIRONMENTAL CONSEQUENCES OF EXPLOSION PHENOMENA

3.2.1 General. The explosion phenomena (e.g., airblast, noise, ground shock, cratering and ejecta, dust, and explosion detonation products) are evaluated in this section for the proposed detonation.

Human health and safety will not be compromised in any way. The airblast and noise levels at the nearest inhabited locations will, at worst, be roughly equivalent to the sound of thunder, due to the complex, and deep underground, geometry of the proposed tests. The ground shock will not be of sufficient magnitude to be perceptible to humans beyond about 1 km from the detonation, and will not pose a potential structural damage threat beyond a range of 100 m. Some detonation products will be released to the atmosphere, but hazardous products will be oxidized or released in insignificant quantities. No adverse effects on surface geology in the form of cracking, spalling, or rock slides will occur. The dust cloud created by the explosions will be negligible to non-existent, and will quickly dissipate and settle. Dust will cause no threat to human health or safety.

The phenomena of large yield high-explosive detonations has been discussed in great detail in previous environmental assessments of large HE test events. These include tests at Ft. Knox, KY (References 13-16), and the HARDPAN I (Reference 17), HAVE HOST (Reference 18), MISERS BLUFF Phase II (Reference 19), DISTANT RUNNER (Reference 20), MILL RACE

(Reference 21), DRY CARES (Reference 22), and Deep Underground (Reference 23) test programs. The following summary of the explosion phenomena utilizes the above references and other sources.

3.2.2 Airblast and Noise.

3.2.2.1 Airblast and Noise Predictions. Due to the deeply buried configuration of these experiments, and the tunnel and chamber geometry, conventional prediction methods relating airblast pressures to charge size and distance are not applicable. A methodology does exist, however, which takes into account such additional parameters as direction from the portal, tunnel dimensions, and chamber size. This method, presented in Reference 24, is used here, and the results for a 2,800 kg test are plotted in Figure 5 for two angles, 0 degrees (on-line with tunnel axis) and 90 degrees (perpendicular to tunnel axis). Of particular note on Figure 5 is the large (a factor of nearly 4) reduction in airblast as the azimuth increases from 0 to 90 degrees. For angles greater than 90 degrees, additional reductions would follow.

The existing mine axis has a bearing of 265 degrees, exiting the portal slightly south of due west. The nearest dwelling lies roughly in this direction, at a range of about 1,800 m. The town of Magdalena lies on a bearing of 320 degrees, at a range of about 9,600 m. Magdalena thus is at an angle of 55 deg from the mine axis.

3.2.2.2 Environmental Effects of Airblast and Noise. Table 4 summarizes an extensive review of the threshold levels of the vulnerability of biota and structures to airblast. Both Table 4, and much of the following analysis, are drawn from Reference 13 and Figure 5. Damage or injury by airblast is generally related to the peak overpressure of the incident shock wave. It should, however, be noted that

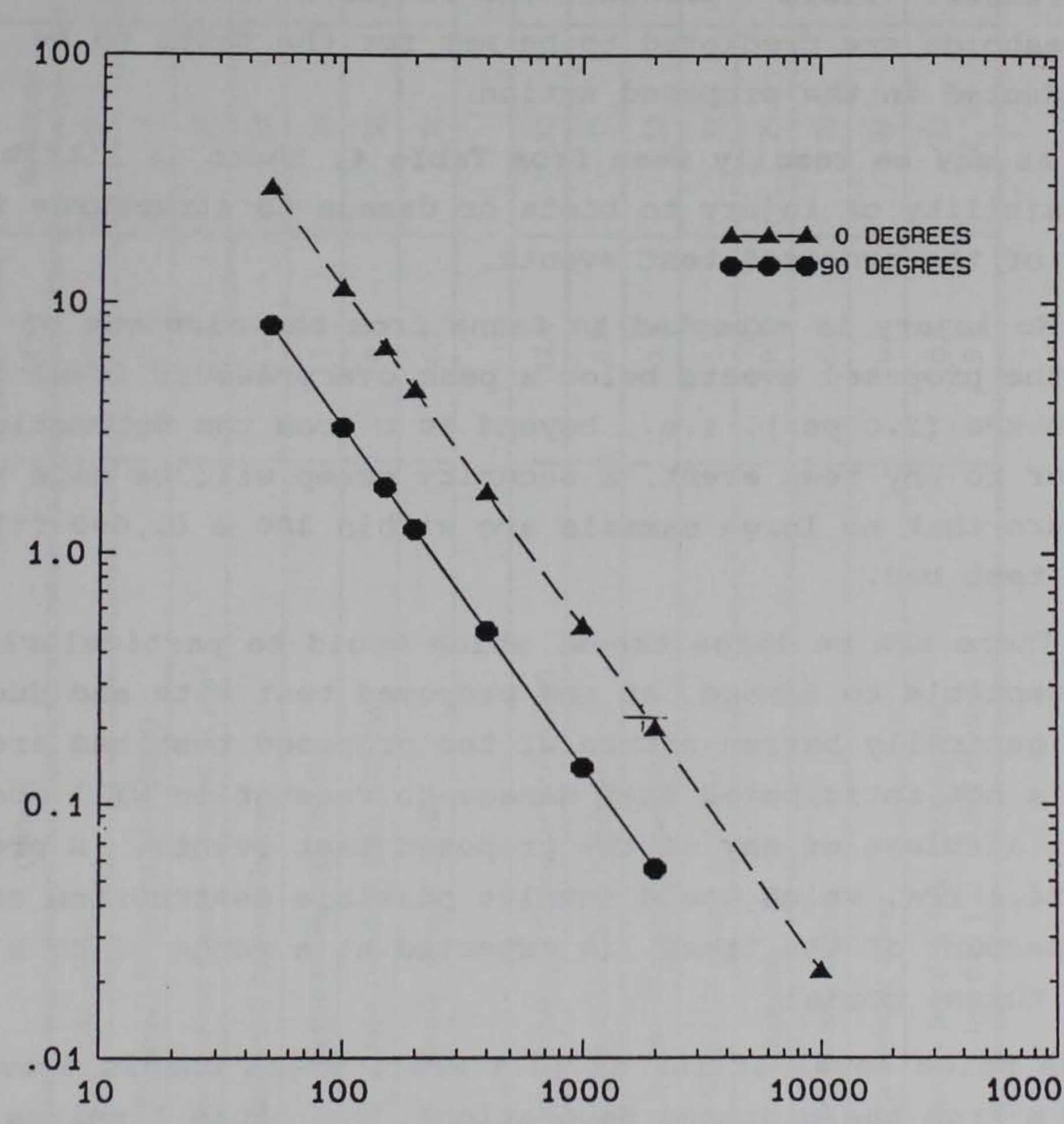

Figure 5. Predicted airblast magnitudes for a 2,800-kg detonation.

the duration of the blast wave and the impulse are also very important in determining the thresholds of damage or injury. The threshold values presented in Table 4 are for short duration blast waves, i.e., positive phase duration less than 0.5 sec. In general, the threshold damage or injury value from the peak incident overpressure will increase as the positive phase duration of the blast wave (and impulse) decreases. Table 4 presents the ranges at which these thresholds are predicted to be met for the tests to be conducted in the proposed action.

As may be readily seen from Table 4, there is little possibility of injury to biota or damage to structures from any of the proposed test events.

No injury is expected to fauna from the airblast of any of the proposed events below a peak overpressure level of 13.8 kPa (2.0 psi), i.e., beyond 80 m from the detonation. Prior to any test event, a security sweep will be made to insure that no large mammals are within 300 m (1,000 ft) of the test bed.

There are no large trees, which would be particularly susceptible to damage, at the proposed test site and due to the generally barren nature of the proposed test bed areas, it is not anticipated that damage to vegetation will occur from airblast of any of the proposed test events. A pressure of 24.1 kPa, which would involve possible destruction of 10 percent of the trees, is expected at a range of 55 m from the tunnel portal.

A noise level of 163 dB (2.4 kPa), which should occur at 310 m from the proposed detonations, can cause tinnitus (ringing of the ears) with a temporary impairment of human hearing.

Table 4. Airblast Damage Criteria and the Distances at Which the Criteria are Met.

Target	Criteria	Peak Over-pressure Level, kPa[1]	Reference	Range at Which Criteria are Met, m
Biota	Birds in flight injured	68.9	25	25
	Tree breakage (10 percent trees down)	24.1	26	55
	Human eardrum rupture (1 percent of pop)	20.7	27	65
	Incipient small mammal damage	13.8	28	80
	Noise - Tintinitus (ringing) (162 db)	2.4	29	310
	Noise - OSHA impulsive limit (140 db)	0.2	30	2,000
	Noise - Thunder sound (134 db)	0.1	31	3,200
Structures	Chimney breakage (10 percent probability)	12.4	32	90
	Major structural damage threshold	6.9	32	140
	Roof failure (10 percent probability)	2.8	32	280
	Door failure (10 percent probability)	1.0	32	600
	Broken bric-a-brac	0.7	29	790
	Broken tile and mirrors	0.6	29	890
	Wall and plaster cracks	0.4	29	1,200
	Windows - less than 1 in. 1,000 cracked less than 1 in. 10,000 cracked	0.4 0.2	33 34, 35	1,200 2,000

[1] For direct "line-of-sight" exposures. Does not include mitigating factors, such as terrain shielding.

These distances are well within the control of the on-site test controllers and no personnel shall be in the open within the 163 dB range of any of the proposed test events.

Persons within the 134 dB (0.1 kPa) sound pressure level may be subject to "startle' effects of the airblast-generated acoustic wave. This startle threshold, roughly equivalent to the rumble of thunder, is predicted to occur out to a maximum range of 3,200 m from the proposed test events. This is less than one-half the distance to the population concentration in Magdalena, where the tests may well be inaudible.

Table 4 summarizes the peak incident or the peak-to-peak (for very low overpressures) overpressure thresholds at which damage occurs to man-made structures, and the maximum ranges at which these effects are predicted to occur. The threshold for major structural damage is 6.9 kPa, which is predicted to occur at a range of 140 m from the proposed detonations.

The nearest inhabited structures outside the Linchburg Mine property are located 1,800 m west of the mine. At this location, airblast from the largest charge is predicted to be 0.21 kPa (0.03 psi). This is well below the level associated with structural damage, and is at the lower limit of remote possibility (1 in 1,000) of cracked window panes. Reference 42 states that, for common practice, 0.7 kPa (0.1 psi) can be taken as a safe limit for window glass, further emphasizing that the possibility of cracked windows is extremely small.

Note: The thresholds and critical distances given in Table 4 and elsewhere in this report do not mean that the effects referred to will actually occur at the distances cited. Rather, these are the <u>maximum</u> distances at which such effects have been observed to occur for explosion events in the past. For any single case (such as the Linchburg tests), the <u>probable</u> levels of these effects, at the distance

indicated, will be much less than the values given in Table 4.

It is not expected that any humans or large animals will be injured by the airblast of any of the proposed detonations, nor is any structural damage anticipated.

3.2.3 Ground Shock.

3.2.3.1 Ground Shock Predictions. Numerous methods have been developed for predicting long range ground shock produced by explosions. Nearly all of these are empirical, and most are derived from data from confined, or fully coupled, explosions. For the decoupled experiments of this program, long range ground shock predictions were derived from equations developed by the Swedish government (Reference 36). Particle velocities thus derived are plotted versus distance in Figure 6 for a 2,800-kg test.

Two human perception thresholds are shown in Figure 6 for reference purposes. These are the normal perception (0.1 cm/sec), and the unpleasant threshold (2 cm/sec). Additional reference is shown by motion levels obtained at a distance of 30 m from various construction and transportation activities.

3.2.3.2 Ground Shock Effects on Structures. Damage, or potential damage, to structures is properly a major concern of explosive blasting operations. Accordingly, it has received a great deal of attention, and numerous studies have produced sets of damage criteria, usually taking peak particle velocity as the significant parameter. These are remarkably consistent, and several of them are summarized in Table 5 for residential-type structures. These are drawn from References 37 through 42.

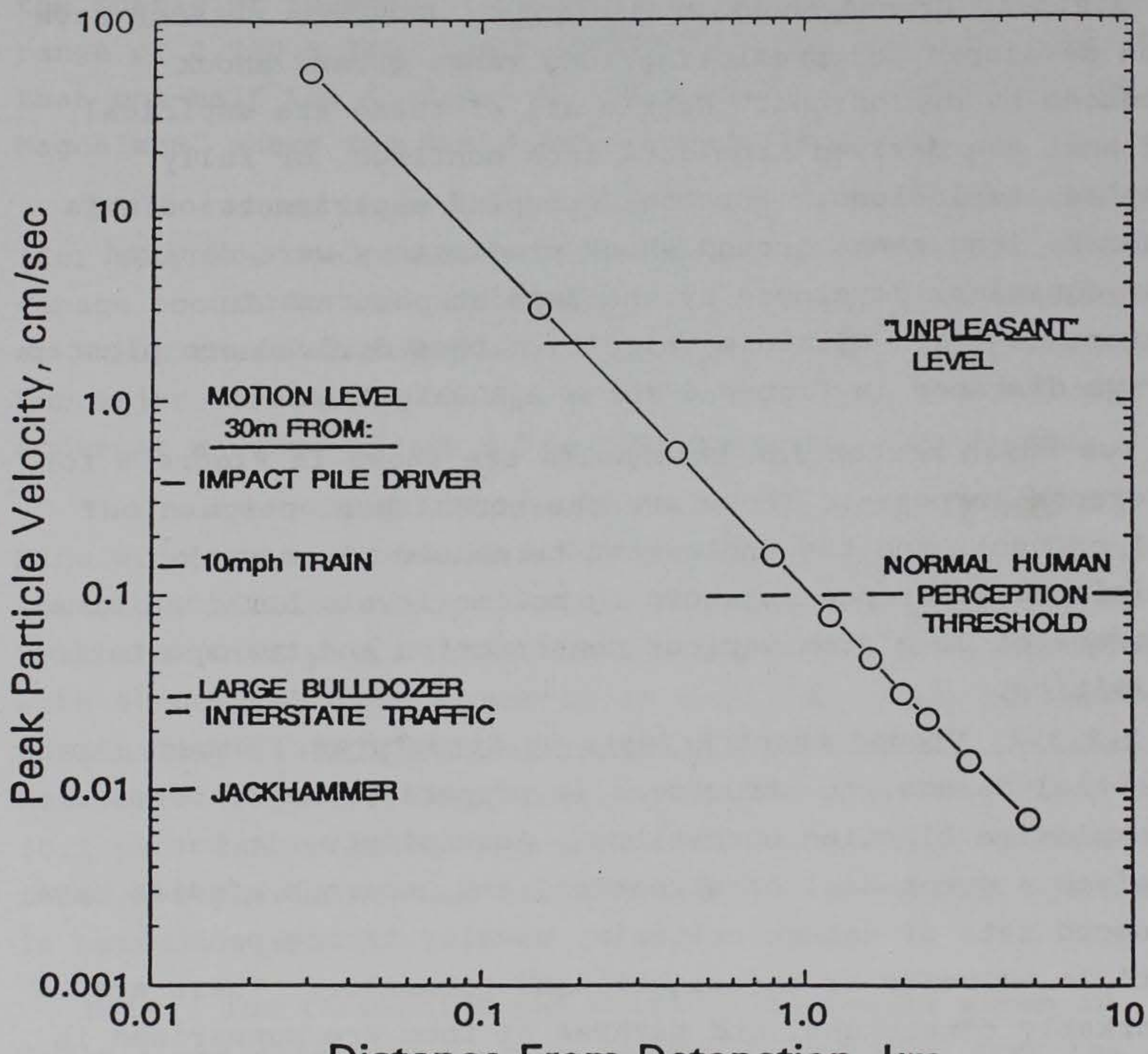

Figure 6. Predicted ground shock magnitudes for a 2,800-kg detonation.

Table 5. Damage Thresholds from References

Damage Type	Damage Threshold, cm/sec				
	Ref. 37 and 38	Damage Ref. 39	Threshold, Ref. 40	cm/sec Ref. 41	Ref. 42
None	4.4	2.5	<5.1	<5.1	>5.1
Opening of old plaster cracks	5.1	-	-	-	-
Fine plaster cracks	7.6	-	10.9	5.1-10.2	-
Plaster and masonry wall cracking/minor structure	-	-	16	10.2-17.8	13.7
Major structural damage/serious cracking	11.4	-	23.1	>17.8	19.3

From the data in Table 5, a composite summary has been constructed and is presented in Table 6, together with the ranges at which several damage criteria are met for the 2,800-kg event (from Figure 6). Table 6 predicts no damage to residential structures beyond 180 m. The nearest residential structure is located at a range of 1,800 m west of the mine. No damage is expected at this range, where a peak velocity of 0.04 cm/sec is predicted. The Kelly Church, located at about 2,000 m northwest of the site, is at a predicted velocity level of 0.03 cm/sec, which is far below the damage threshold for even cosmetic damage.

Table 6. Composite Damage Criteria and Ranges at Which Criteria are Met for Planned Test Events.

Damage Type	Threshold, cm/sec	Range at Which Criteria are Met, m
None	2.5	180
Cosmetic	5.1	110
Minor structure	12.7	70
Major structure	17.8	60

An instrumentation trailer will be located about 250 m from the nearest test at a predicted velocity level of 2 cm/sec. This trailer will be a highway-worthy trailer,

with rugged frame and suspension system. Reference 43 suggests a damage threshold of 300 cm/sec for such trailers when parked on styrofoam or other shock mitigation systems. Reference 38 reports that "trailers" have withstood up to 15 cm/sec with no damage. Similar trailers have been used on previous tests at similar scaled ranges, and have withstood airblast shock impacts of nearly 7 kPa with no damage.

A number of studies have addressed the important area of the vulnerability of subsurface structures, such as basement walls, water wells, and pipelines, to ground shock. Reference 42 indicates that wells sustain no loss of capacity after being subjected to shock velocities as high as 7.6 cm/sec, based on a study of blasting effects on water supplies in Appalachia. Reference 37 includes a study of shock wave effects on uncased wells at the Nevada Test Site, and shows that such wells are undamaged at velocities of 3.8 cm/sec. The 7.6 cm/sec and 3.8 cm/sec levels occur at 90 m and 120 m, respectively, from the test site.

Taking a different approach, Reference 57 suggests using $D = 4.76\ W^{1/3}$ for a safe range for cased boreholes, when both hole and explosion are in alluvium, and D is in feet and W in pounds of explosive. This equation gives a safe distance of 86 ft, or 26 m , for a 2,784 kg explosion. A confined explosion of 2,784 kg would be expected to produce a velocity of about 30 cm/sec at this range in alluvium. Thus, the lack of susceptibility of wells to damage from ground shock is emphasized.

The MISERS BLUFF experiments, conducted in an alluvial valley in western Arizona in 1978, consisted of a single 120-ton detonation, and a detonation of six 120-ton charges simultaneously. Detailed studies of the effects of the explosions on water quality and water levels in nearby wells were conducted (Reference 54), and concluded that no

degradation occurred. Several wells were within 400 m of the 120-ton test, and included small (~10 cm) PVC-cased wells and a large (~40 cm) steel-cased well. No change in water level could be attributed to the test. Subsequent to the 120-ton test, the 40-cm well was used successfully to drive a 15-cm main supplying an irrigation system for dust suppression over an area of nearly one hectare.

Based on the above, it is concluded that there is no significant risk of damage to wells or (by inference) springs, beyond 200 m from the Linchburg Mine tests.

Mechanical equipment, such as engines, pumps, compressors, generators, etc., mounted on skids and tied down, have damage thresholds of 100 cm/sec (References 44 and 45). This level will occur at a range of about 20 m. No equipment of this type will be closer than 250 m.

Communications equipment, electronics, and computers with solid state components can withstand acceleration levels of 5 g (Reference 46). Substantial amounts of these types of equipment will be located in the instrumentation trailer where ground accelerations of 1 g are expected. Since such equipment will be mounted in shock-isolated racks, no damage will occur.

3.2.3.3 Ground Shock Effects on Humans. The threshold of human perception of ground vibration is significantly lower than the levels associated with the onset of structural damage. Subjective human response to vibratory ground motion, based on earthquake studies, has shown that amplitudes of less than 0.1 cm/sec are rarely perceived for short-period, explosion-produced motions (Reference 44). These thresholds are indicated on Figure 6, and show that the limit of normal perception (0.1 cm/sec) for the Linchburg Mine tests should occur at a range of about 1,000 m.

Reference 44 suggests a threshold of 2 cm/sec for motions perceived as "unpleasant," and Reference 45 gives 1.8 cm/sec as the level of "discomfort," or producing a "startle" effect. The 1.8 cm/sec threshold is attained at a range of 200 m from the site.

Reference 45 lists thresholds of 5.6 cm/sec and 11.2 cm/sec for onset of interference with activity or proficiency, and health limit, respectively. These levels occur at 80 m and 100 m from the site.

Table 7 summarizes these thresholds, together with the ranges at which they will occur from the largest (2,800 kg) test. From this table, it can be seen that human perception is unlikely at ranges exceeding 1,000 m.

Table 7. Motion Thresholds for Human Tolerance

Subjective Criteria	Velocity, cm/sec	Range at which Criteria Met, m
Normal perception limit	0.1	1,000
Unpleasant/disturbing	1.8	200
Proficiency/activity interference	5.6	100
Health/safety limits	11.2	80

A significant mitigating factor is the fact that the test events will be conducted during the day. Reference 45 indicates that human tolerance increases dramatically during periods of normal activity at home or in the workshop or office. For example, the tolerance increases from 0.02 cm/sec at night to 1.27 cm/sec during the day, an increase of more than 60-fold. As a result, the test events may not be noticed outside a 1,000 m radius.

Disturbance complaints from people not expecting the ground motion are possible at levels of 0.25 cm/sec (Reference 45) and likely at levels >0.5 cm/sec

(Reference 42) even though no damage would occur. These criteria are met at 600 m and 400 m, respectively.

No humans other than those directly involved in the tests will be within the radius of "unpleasant" ground motion (200 m). None will be within the radius of health safety limits (80 m). Those persons at the recording trailer, at a range of 250 m, will be controlling and expecting the detonation and, hence, the "startle" effect will not be a factor. Suitable precautionary measures, such as stowing loose objects, will preclude any safety hazards at this location.

3.2.3.4 Ground Shock Effects on Biota. Studies specifically designed to determine the effects of ground shock on subsurface animals, plant roots, and soil microbes show no damage by shock fronts whose peak particle velocities are less than 11.4 cm/sec (References 47 and 48). This level will be reached at a range of 70 m from the tests. There exists some possibility of subterranean damage to root systems of flora within this radius, although for non-cratering tests significant permanent damage is unlikely. Reference 49 reports no important damage to tundra grasses for the CANNIKIN and MILROW tests on Amchitka Island, Alaska, at surface particle velocities of nearly 900 cm/sec. Peak surface velocity for these tests will be on the order of 8 cm/sec.

Subjective summaries of the effects of ground motion produced by underground tests on large mammals (deer, cattle, and horses) indicate no physical injury at peak velocities of up to 41 cm/sec (Reference 50). This velocity is predicted to occur at a range of 40 m from the test, and no large animals will thus be subjected to dangerous motions.

3.2.3.5 Ground Shock Effects on Surface Geology. There will be no significant effects on surface geological features

in the vicinity of the Linchburg Mine in the form of cracking, spalling, or cratering. Explosive detonations have been shown to be fully contained, i.e., do not produce ejecta craters, at scaled depths of burial ($D/W^{1/3}$) greater than 1.6, where D is in meters and W is the charge weight in kilograms. For these tests, the nominal depth of burial will be about 122 m, and the maximum charge weight will be 2,800 kg. This gives a $D/W^{1/3}$ of 8.7 or more than five times the fully contained situation. No surface crater will therefore be produced by the tests.

Since there will be no crater formation, there will be no ejected material in the sense of particles thrown out by expanding detonation gasses. There is a remote possibility of dust and small, loose particles being lofted slightly (perhaps a meter) in the region immediately above the shot point. However, no surface mounding, cracking, or spallation will occur.

3.2.4 DETONATION PRODUCTS

The gaseous products of detonation of high explosives or blasting agents generally contain, to various degrees, small quantities of substances known to be hazardous to the environment. The explosive of choice for this series of experiments is reclaimed military-grade Composition B, a composite explosive consisting of 59.5 percent RDX (Cyclonite, formula $C_3H_6N_6O_6$), 39.5 percent TNT (formula $C_7H_5N_3O_6$), and 1 percent wax. The decision to use Composition B was made on the basis of its energetic detonation properties, its ready availability, and its cost effectiveness.

3.2.4.1 Prediction of Detonation Products. Two methods, laboratory tests and computer calculations, are used to determine the chemical products of detonation. Limited laboratory test data exists for a few explosives, such as

TNT, HMX, and nitromethane. For the most part, however, reliance has been on the results of thermodynamic/hydrodynamic equilibrium calculations (References 51 and 52). These calculations use thermodynamic/hydrodynamic equilibrium codes, such as TIGER, developed by the U.S. Army Ballistics Research Laboratory, Aberdeen Proving Ground, MD, and are relied upon heavily by the U.S. Bureau of Mines (USBM), and the Department of Defense (DOD). TIGER code calculations performed by the U.S. Navy were used herein to determine the detonation products for Composition B (Reference 52).

Table 8 lists the calculated detonation products, both as a percentage (g/kg), and total amounts predicted for a 2,800-kg charge. Also listed are reportable quantities (RQ) specified by the Comprehensive Environmental Recovery Compensation, and Liability Act (CERCLA) for three hazardous substances (ammonia, hydrogen, cyanide, and formaldehyde). The amounts of hydrogen cyanide and formaldehyde are seen to be trivial, amounting to 3 percent and 0.01 percent of the RQ's, respectively. Ammonia is anticipated to be 38 percent of its RQ.

3.2.4.2 Detonation Product Effects on Groundwater. All of the detonation products listed in Table 8 occur naturally in the earth's environment. Extensive literature searches and contacts with personnel from the Bureau of Mines, WES, U.S. Geological Survey, U.S. Army Corps of Engineers, Naval Weapons Center, and other organizations involved in the use of high explosives indicate that significant contamination of groundwater by detonation products has never been observed. However, the amount to measured data is small, and none applies directly to contained underground detonations. Nevertheless, the existing data is encouraging. Measurements of specific chemical compounds (for which water standards exist) were made from water and soil samples taken during

other test programs. These include the PACE program, a series of explosive tests on a coral atoll over a fresh-water

Table 8. Detonation Products for Composition B

Compound	Formula	CERCLA RQ (kg)	Amount Produced by:	
			g/kg	2,800 kg
Water	H_2O	-	84.40	236.32
Nitrogen	N_2	-	293.0	820.4
Carbon Dioxide	CO_2	-	343.0	960.4
Carbon Monoxide	CO	-	175.2	490.56
Ammonia	NH_3	45	6.128	17.16
Hydrogen	H_2	-	1.139	3.189
Ethane	C_2H_6	-	53.56	149.97
Propane	C_3H_8	-	17.84	49.95
Hydrogen Cyanide	HCN	4.5	0.049	0.137
Methane	CH_4	-	1.747	4.892
Formaldehyde	CH_2O	45	0.003	0.008
Carbon (Solid)	C	-	23.34	65.352
Methyl Alcohol	CH_3OH	-	0.018	0.05
TOTALS:	-	-	999.4	2,798.4

Gyben-Herzberg lens (Reference 53) and the MISERS BLUFF test program at Lake Havasu, AZ (Reference 54). In these tests, water and soil samples were collected and analyzed following the explosion of three 1,000-pound TNT charges which were partially buried in the coral soil and six 100-ton ANFO surface charges (MISERS BLUFF) over desert soil. EPA ground water contamination standards exist for cyanide, ammonia, and nitrates. No significant concentrations were introduced into the groundwater by the explosion.

Analysis of both soil and groundwater samples from the 100-ton ANFO craters of the MISERS BLUFF test program show that the levels of cyanides were well within the concentrations permitted for drinking water (Reference 54).

Chemical analysis for explosive product contamination in the soil from the MIDDLE GUST crater (Reference 55) were performed without finding any chemical species which exceeded the levels found in control samples. However, analysis was performed only for total carbon, carbonate, organic carbon, sulfur, phosphorus, and nitrogen.

Analyses by the U.S. Geological Survey of the possible effects of the HAVE HOST test program on local groundwater resources (Reference 46) concluded that any possibility of groundwater contamination was extremely remote. Due to the extremely small amounts of hazardous products anticipated for these tests, no groundwater contamination will occur.

3.2.4.3 Detonation Products Effects on Air Quality. Due to the nature of the proposed tests, i.e., in unsealed tunnels, a minor amount of detonation products and dust will escape the tunnel portal within a few seconds after the detonation.

It should be noted that the products listed in Table 8 are those that are produced by the chemical reactions of the detonation. The quantities shown are the amounts present in the early-time fireball. In unconfined detonations, most of the gaseous products within the rapidly expanding fireball react with available air, resulting in greatly reduced concentrations within the first seconds following detonation. As the autoignition temperature of carbon monoxide, formaldehyde, methyl alcohol, methane, ethane, propane hydrogen, and cyanide are below the fireball temperatures, significant oxidation occurs during fireball growth as result of reaction with the atmosphere. The products of these reactions are water, carbon dioxide, and nitrogen compounds (Reference 44). The remaining concentrations of gaseous products will diffuse into the atmosphere, through natural tunnel aspiration and forced ventilation. No degradation of

air quality will occur for more than a few minutes after the detonation, and only within a few tens of meters of the portal.

3.3 ECOLOGICAL CONSEQUENCES

Vehicular use in the areas investigated will have a temporary, minor adverse effect on the environment. A small amount of vegetation and wildlife habitat may be destroyed or damaged along vehicle pathways. A few individuals of some wildlife species may be killed as a result of traffic through these areas. This loss will not result in any long term reduction in population levels.

Posttest, any disturbed ground caused by construction will be recontoured, and construction debris removed from the test site; large vegetation will be allowed to re-establish naturally, and disturbed areas will be reseeded with native grasses (see Section 1.3.8.1).

Preparation of the site will displace or possibly kill some burrowing rodents which inhabit the area. Nonburrowing animals will move to undisturbed areas, and larger animals will shun the test area until after the test. Care will be taken to ensure that apparent animal trails are not blocked.

Human activity and machine noise associated with the construction will disturb wildlife and will alter the distributional pattern of some species for a short period. However, no long-term effects will occur.

No animals will be injured due to airblast, directly or indirectly. Burrowing animals will probably have been displaced by construction operations during site preparation.

The proposed action will not result in any adverse effects to those endangered or threatened species of fauna or flora discussed in Section 1.3.7. Airblast will not reach pressures high enough to present a threat to animal safety.

The detonations will produce a "startle' effect from the noise and ground shock levels at distances up to perhaps 3,200 m. There exists a small possibility that the detonations will be audible in Magdalena, but airblast levels will be well below any threat to health or safety.

3.4 SOCIOECONOMIC CONSEQUENCES

Effects on the socioeconomic environment due to construction and operations will not be significant. The site is remote. The work force is small, not expected to exceed 15 people at any time, and the total construction effort is not large. The quartering of work force personnel will provide additional income to local motels in Socorro, NM. Local purchases of food, gasoline, hardware, building supplies, and services will provide a temporary increase in income for local businesses. The estimated total economic impact for the duration of the project will be the expenditure of roughly $50,000 in the local area (excluding contractual work).

3.5 GEOLOGIC CONSEQUENCES

The major geologic consequence will be a slight increase in erosion potential due to the surface disturbance near the tunnel portal. Because of the small surface area involved and the use of engineering methods to control erosion due to surface disturbance, the increase in erosion potential will not be significant.

3.6 HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL CONSEQUENCES

There are two known historic properties within the area of the proposed test (see Section 1.3.8.5). The proposed test is consistent with the existing use of the Linchburg Mine and will have no adverse effect on the qualities that contribute to its historic significance. Field survey confirmed that the Young America and Enterprise Mines are

located outside of the area of potential impacts by the test and, therefore, the project will have no effect upon the site.

Kelly, a ghost town of the mining district, has a single standing building of historic importance. The Kelly Church, which still sees occasional use, is located at a range of about 2,000 m from the Linchburg Mine, and is well beyond the range of any potential damage.

Although unlikely, should an archaeological site be discovered during construction, the test plans will be altered to avoid any disturbance to the site. This modification would be subject to the approval of the land administrator.

3.7 CONSEQUENCES OF THE PROPOSED ACTION WHICH CANNOT BE AVOIDED

Consequences which cannot be avoided during the construction phase or as a result of the proposed detonation include:

a. Temporary destruction or alteration of terrestrial ecological habitats in an area of less than 0.5 hectare.

b. Temporary displacement of burrowing animals.

c. Temporary and minor increase in erosion potential.

d. Temporary, minor, and extremely local deterioration of air quality due to construction activity.

e. Temporary and minor increases in ambient noise levels due to construction activity.

f. Temporary disruption of animal activity due to "startle factor" of ground shock from the detonations.

g. Consumption of explosives and fuel oil with associated detonation and combustion products.

The construction activity and detonation may alter the short-term productivity of some ecological habitats. This will not have a long-term impact on the productivity over the

region because of the extremely small area affected. The net effects to the environment will be restricted to the immediate tunnel portal area. After the test program is completed, the area will be restored to as near its former condition as reasonably possible. All test construction will be dismantled and removed, and the entire test site will be cleared of debris. The test area will be recontoured to former topographic contours. Shallow buried cables will be removed.

The proposed tests will not foreclose any future options on use of the area. There are no short-term environmental gains associated with this project at the expense of long-term losses. The area will be disturbed for an estimated two-year period, after which the biota will begin its recovery cycle.

4 AGENCIES AND PERSONS CONSULTED

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APPENDIX A
PLANT SPECIES FOUND ON THE Linchburg MINE
MARCH 1993

TREES

Juniperus deppeana	Alligator juniper
Juniperus monosperma	One-seed juniper
Pinus flexilis	Limber pine
Pinus ponderosa	Ponderosa pine
Pinus edulis	Pinyon pine
Pseudotsuga menziesii	Douglas-fir
Quercus gambelii	Gambel oak
Quercus grisea	Gray oak

SHRUBS

Yucca baccata	Datil yucca
Clematis ligusticifolia	Western virgins'-bower
Opuntia erinacea	Grizzlybear prickly-pear
Opuntia imbricata	Cholla
Fendlera rupicola	Cliff fendlerbush
Ribes sp.	Gooseberry
Cercocarpus montanus	Mountain magogany
Fallugia paradoxa	Apache-plume
Robinia neomexicana	New Mexico locust
Rhus trilobata	Squawberry
Symphoricarpos sp.	Snowberry
Artemisia tridentata	Big sagebrush
Gutierrezia sarothrae	Broom snakeweed
Pericome caudata	Pericome
Verbesina enceliodes	Golden crownbread

GRASSES

Aristida divaricata	Povery three-awn
Avena sp..	Oatgrass
Bouteloua curtipendual	Side-oats grama
Bouteloua gracilis	Blue grama
Koeleria cristata	Junegrass
Lycurus pheoides	Wolftail
Stipa comata	Needle and thread

FORBS

Eriogonum jamesii	Wee Mary buckwheat
Sphaeralcea sp.	Globemallow
Erysimum capitatum	Wallflower
Phoradendron juniperinum	Juniper mistletoe
Verbascum thapsus	Flannel mullein
Verbena neomexicana	New Mexico vervain
Ipomopsis aggregata	Skyrocket
Solidago sp.	Goldenrod

APPENDIX B
A CULTURAL RESOURCES INVENTORY OF THE LINCHBURG, YOUNG AMERICA, AND ENTERPRISE MINING COMPLEXES

Prepared by

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Archaeologist
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ABSTRACT

On April 22 and 23, 1993, two U.S. Army Corps of Engineers' archaeologists conducted a cultural resources inventory of the Linchburg, Yound America, and Enterprise Mines, Socorro County, New Mexico. The survey was conducted in anticipation of underground munitions storage facility research within Linchburg mine. As a result of the survey, the Corps is of the opinion that the mines are of sufficient age and historic importance to the area to be eligible for the National Register of Historic Places. The mines were assigned site numbers by the New Mexico Laboratory of Anthropology (Linchburg: LA 100608; Young America and Engerprise: 100609). The Corps is also of the opinion that the proposed research activities at the complex will have no adverse effect on the elements contributing to the historic significance of the Linchburg mine. The Corps believes that the undertaking will have no effect on the Young America and Enterprise mines.

INTRODUCTION

The Linchburg mine is located in Socorro County, New Mexico, approximately 9.5 kilometers to the southeast of the community of Magdalena (Figure 1, Table 1). The Linchburg mine consists of four patented mining claims within the Magdalena Mining District of New Mexico. During operation, zinc and lead ore were extracted from the mine. The mine is currently inactive and in caretaker status. Two areas may be potentially affected by the research project (Figure 1, Areas A and B). The area adjacent to the Linchburg mine adit, that will be the site of construction and etonation (Area A), may suffer some minor disturbance due to increased traffic from construction activities. A second area of minor disturbance will be at the locations of monitoring equipment placed atop drill holes to the below ground test chambers (Area B). The mine shaft opening at the site lies at an elevation of

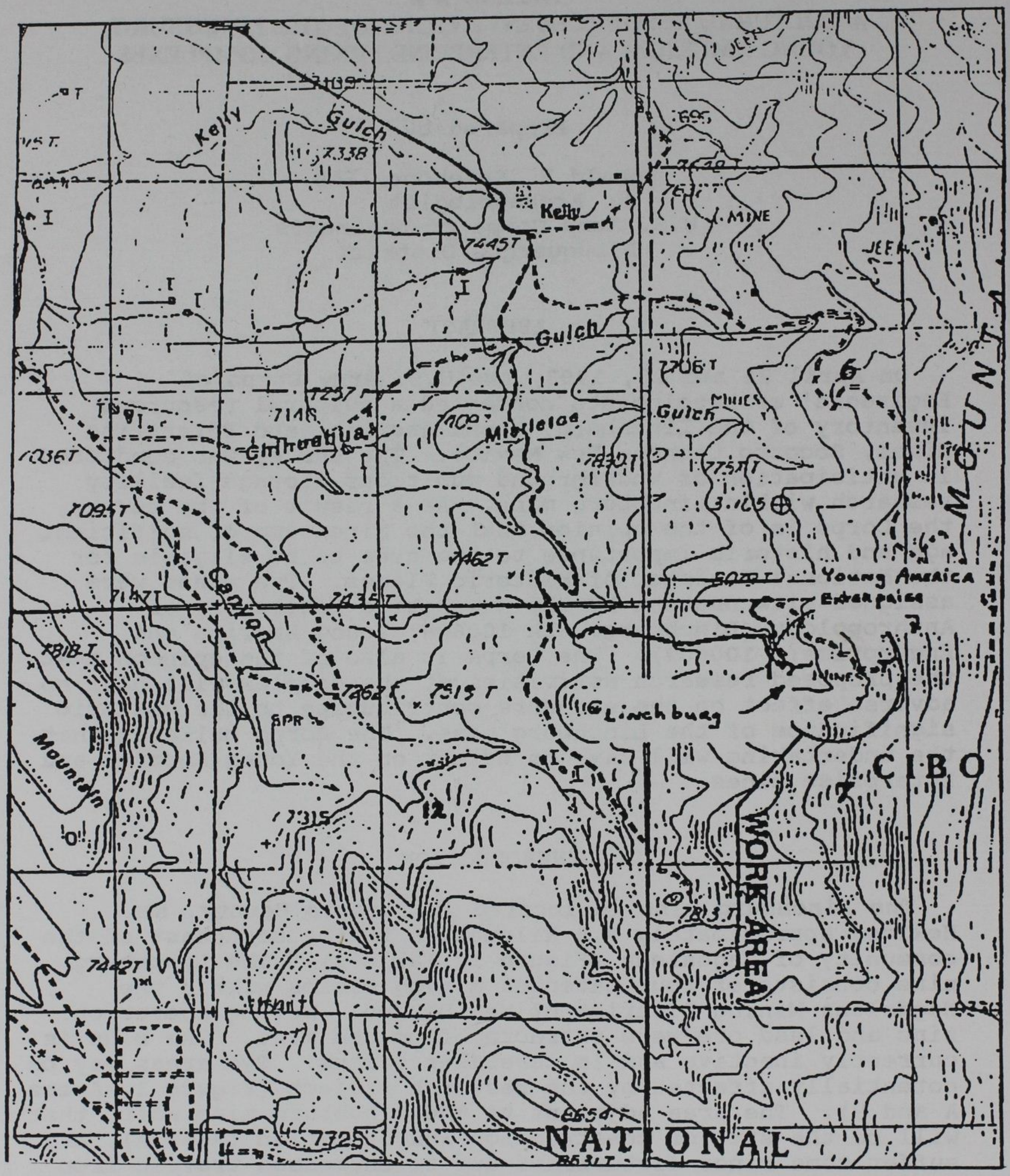


Figure 1. Magdalena, NM, 7.5' USGS Quad Showing Project Area Locations.

Table 1:
Specific Location and Dimension Information for the Project Area(s):

USGS Quad: Magdalena, NM. 7.5'

Legal Description:
T3S R3W Section 7 UTM Coordinates:

Linchburg:	Zone 13; 297585E 3771755N
Young America and Enterprise:	Zone 13; 297885E 3771765N

approximately 2460 meters above sea level. Monitoring sites will be located approximately 300 meters east of the mine shaft entrance at an elevation of approximately 2560 meters.

In order to minimize disturbance to the ground surface and to facilitate drilling holes for instrument cables, the holes will be drilled from the chambers in the mine up to the surface. The only impact to the surface will be the drill bit probing through the ground. A vertical pipe, approximately 60 centimeters high, will be placed in the hole to preclude dirt falling into the chamber. Instruments will be carried by hand to the area of the vertical pipes, there will be no vehicular traffic above the Linchburg mine. There will be only pedestrian traffic in the vicinity of the Young America and Enterprise mines.

The largest magnitude detonations proposed are small compared to normal mining operation. Vehicular use in the project area will be confined to existing dirt roadways. Construction activities will be confined to the defined project area. Research activities will be limited to undertakings less extensive than operation of the mine for ore extraction. No lead or zinc ore will be brought to the surface; spoils will be confined to the mine as much as possible.

ENVIRONMENT

The project area lies in a transition zone between the Basin and Range and the Colorado Plateau physiographic provinces. This zone is considered as the Datil-Mogollon section. This section is noted for extreme relief, high fault block mountains of igneous rock, and broad structural basins. The project area is located in a region of very

shallow and shallow aridisol soils and rock outcrops on hills, knolls, and mountains. Rock outcrops consist of exposed tuff, rhyolite, and limestone. The Puertocito and Motoqua soil series are the dominant soil categories in the project area. Puertocito soils are located on south-facing slopes and are very shallow, well drained and moderately permeable. The Motoqua soil series has characteristics very similar to Puertocito, although it is generally found on north-facing slopes.

The climate in the region is semiarid. The annual average air temperature is 27 to 47 degrees centigrade and the average frost-free period is 120 to 180 days. Average annual precipitation in the area is 251 to 381 millimeters. Approximately 50% of the area's annual precipitation falls between July and September.

The natural plant community in the project area is characterized by sideoats grama, blue grama, muttongrass, and pinyon. The dominant tree species in the project area are Ponderosa pine and scrub oak. Suitable habitat exists in the project area for mule deer, mountain lion, bobcat, ringtail, porcupine, and a variety of small mammals.

METHODOLOGY

Conversations between the Corps of Engineers and the New Mexico State Historic Preservation Officer, conducted prior to the initiation of field work, determined that, due to the age and significance of the mine to the area's historical development, the Linchburg, Young America and Enterprise mines were eligible for inclusion on the National Register of Historic Places. In view of this decision and knowledge of the exact of the location sites, it was decided that an appropriate methodology would be the initial recording of the site on New Mexico Laboratory of Anthropology site forms, including site photos and maps of any components and features of the mine complex. In addition, intensive surface surveys of the road connecting the two sites (Figure 1) and direct transects between them were conducted. The road segment surveyed was approximately one kilometer in length. The direct transects were approximately 500 meters long.

BRIEF CULTURAL OVERVIEW

New Mexican history has been divided into four generally recognized cultural-temporal periods: the *PaleoIndian*, the *Archaic*, the *Formative*, and the *Historic*. The first three time periods are known only from archaeological data and span

the time period between ca. 12,000 years ago (BP) to the arrival of European explorers in the 1500's. The Historic Period postdates European contact and is known from written records as well as archaeological materials.

The PaleoIndian Period (ca. 12,000 BC-5,000 BC) is that era of the first human occupation of the region. The period is primarily known for the distinctive Clovis and Folsom projectile points which date the era. The Archaic Period (ca. 5,000 BC-AD 500), again commonly dated by distinctive projectile point morphological types, represents a time of significant change in the adaptive strategies employed by people in the southwest. It is during this time that the region's inhabitants are believed to have switched from the hunting of large mammals (i.e., mammoth, buffalo) to a more broadly based regime of hunting small game and the collection of wild plant foods.

The Formative Period (ca. AD 500-AD 1500) is probably the most commonly recognized era of New Mexican prehistory. The era symbolizes the shift to settled village life by early Native Americans. A varied array of new technologies (e.g., pottery, semisubterranean pithouses, and ultimately the familiar multiroom pueblos) were introduced at this time. The project area lies at the boundary (Rio Grande Valley) of the Mimbres and Anasazi subregions of the New Mexico culture-historical tradition. The southern Mogollon are distinguished from the northern New Mexican Anasazi tradition by differences in pottery decoration and architectural styles (Sanders 1976).

The Historic Period (ca. AD 1500-present) began with the earliest Spanish explorations of Coronado in 1539. Following early attempts at colonization, the Spanish were ejected from New Mexico during the Pueblo Revolt of the late-17th century. The northern-most extent of the Spanish Empire in the New World was located to the south of the project area at El Paso. The area became part of the United States in 1847, the area remained relatively rural in character. Following the Civil War, a military post was constructed in the region near Magdalena and identified potentially lucrative ore deposits during the civil war (Jones 1904).

The opening of several zinc and lead mines in the surrounding region prompted the founding of the mining town of Kelly three kilometers to the southeast of Magdalena. The town was a booming mining community in the last decades of the 19th century. The arrival of the railroad shifted residence to the modern community of Magdalena around the turn of the century. As new technologies resulted in dropping prices for zinc and lead ores after World War II,

most of the mines in the area were closed down in spite of the presence of additional rich mineral deposits. Kelly has since been abandoned and the population of Magdalena has been steadily declining (Stanley 1973).

PREVIOUS CULTURAL RESOURCES STUDIES

No cultural resources inventories have been previously undertaken in the project area.

RESULTS OF SURVEY

No artifacts, features, or sites were identified along the surveyed road or by the direct transects between the two known sites.

Linchburg Mine (LA 100608):

The Linchburg mine was begun by the American Zinc, Lead & Smelting Company in 1910. The property has changed hands numerous times since initial work was done at the site. The works were taken over in 1912 by C. T. Brown, and by the Empire Zinc Company between 1915 and 1916. Operations at the site were interrupted several times by the volatile market for Zinc products. The longest interruption occurred between the mid-1920's and 1942. Just following the start of World War II, the New Jersey Zinc Company acquired the property and reopened the workings to various lessees (Loughlin and Koschmann 1942). Operations again ceased during the mid-1960's. The current lessor, Cobb Resources reopened operations in 1972. Cobb's operations ceased in 1982, and in 1989 Hydro Nuclear Corporation acquired the property from long-time owner New Jersey Zinc. the mine is annually tested for ore to maintain the claim, however, relatively large-scale production has not occurred since the early 1980's.

The central mine adit is approximately 411 meters long, running ENE at an angle of approximately 75° (Figure 2). Side-tunnels, paralleling ore deposits, run north to south beginning at a point approximately 320 meters into the adit. These perpendicular tunnels run approximately 335 meters north and 700 meters south from this point. A raise is located near the end of the main adit. The shaft of the raise extends approximately 30.5 meters above the level of the main tunnel, an adit parallel to the main runs east-west from the raise approximately 12 meters above the level of the main adit.

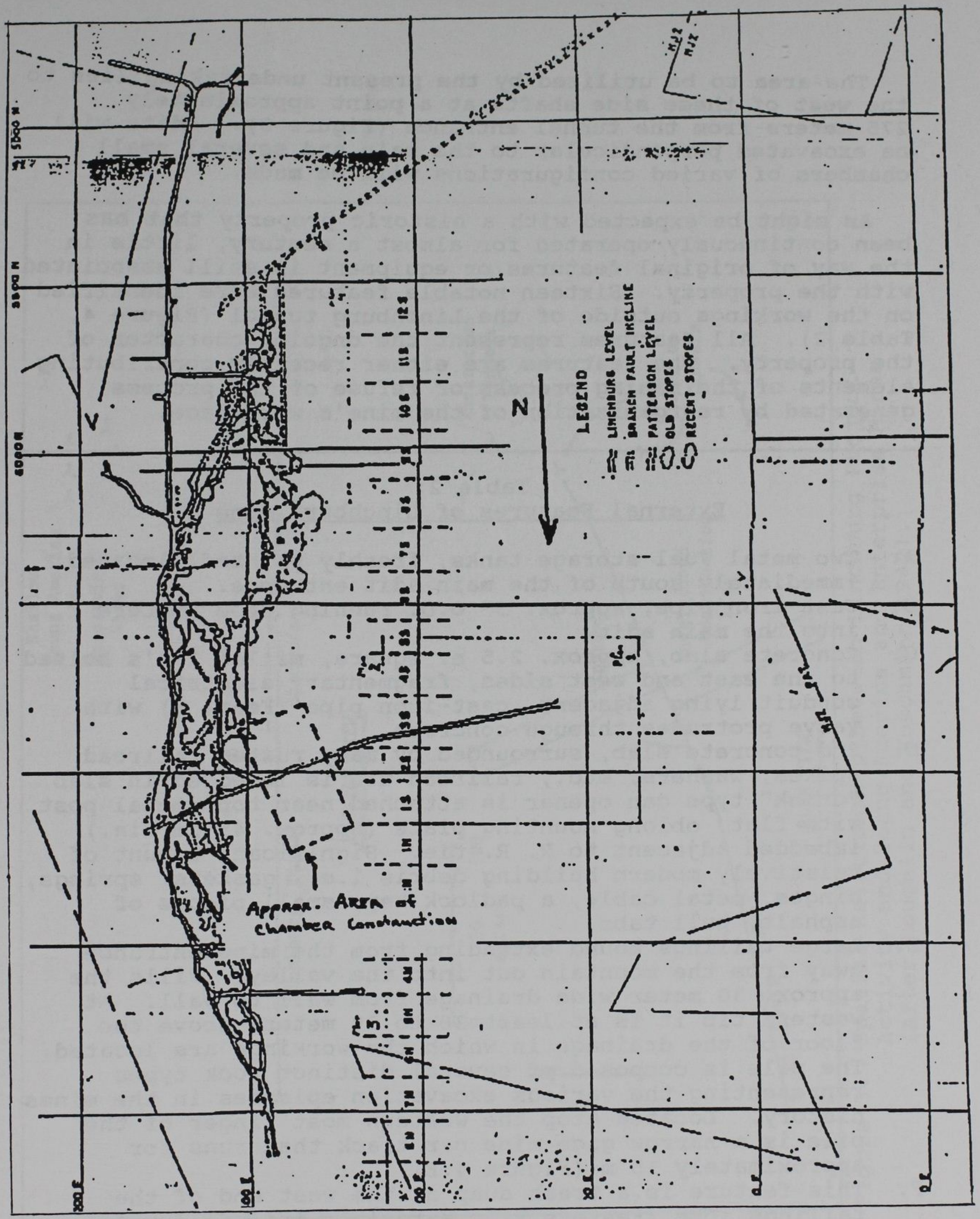


Figure 2. Map Showing Layout of Linchburg Mine Adits (After N. J. Zinc Co. 1959).

The area to be utilized by the present undertaking lies to the west of these side shafts at a point approximately 275 meters from the tunnel entrance (Figure 3). Adits will be excavated perpendicular to the main and several small chambers of varied configurations will be made.

As might be expected with a historic property that has been continuously operated for almost a century, little in the way of original features or equipment is still associated with the property. Sixteen notable features were identified on the workings outside of the Linchburg tunnel (Figure 4, Table 2). All features represent the ongoing character of the property. The features are either recently contributing elements of the mining process or refuse of the process generated by reorganization of the mine's workspace.

Table 2:
External Features of Linchburg Mine

A. Two metal fuel storage tanks, freshly painted, located immediately south of the main adit entrance.
B. Cast-iron pipe, approx. 3" O.D. running from Feature C into the main adit.
C. Concrete slab, approx. 2.5 m. square, milled 2×4's bolted to the east and west sides, fragmentary electrical conduit lying adjacent, cast-iron pipe (Feat. B) with valve protrudes through concrete.
D. 2nd concrete slab, surrounded by many rusted railroad spikes, washers, etc., railroad tie is imbedded in slab "crank" type can opener is attached near top, metal post with flat, oblong mounting plate (approx. 45 cm dia.) imbedded adjacent to R. R. tie. Significant amount of relatively modern building debris i.e., gaskets, springs, hinges, metal cable, a padlock key, small pieces of asphalt, pull tabs.
E. Large tailings mound extending from the mine entrance away from the mountain out into the valley. Fills the approx. 30 meter wide drainage from wall to wall. At western tip it is at least 30 to 50 meters above the floor of the drainage in which the workings are located. The pile is composed of several distinct rock types representing the various excavation episodes in the mines history. Located atop the western most finger of the pile is a narrow gage mine car track that runs for approximately 15 m (Figure 4:E).
F. This feature is a trash dump at the west end of the tailings lobe (Feature E). Materials include 4 × 4 timbers, "church key" opened tin cans, a barrel stove with pipe, faded yellow corrugated fiberglass, plastic jugs, barrels, lubricant cans, krylon spray cans, metal

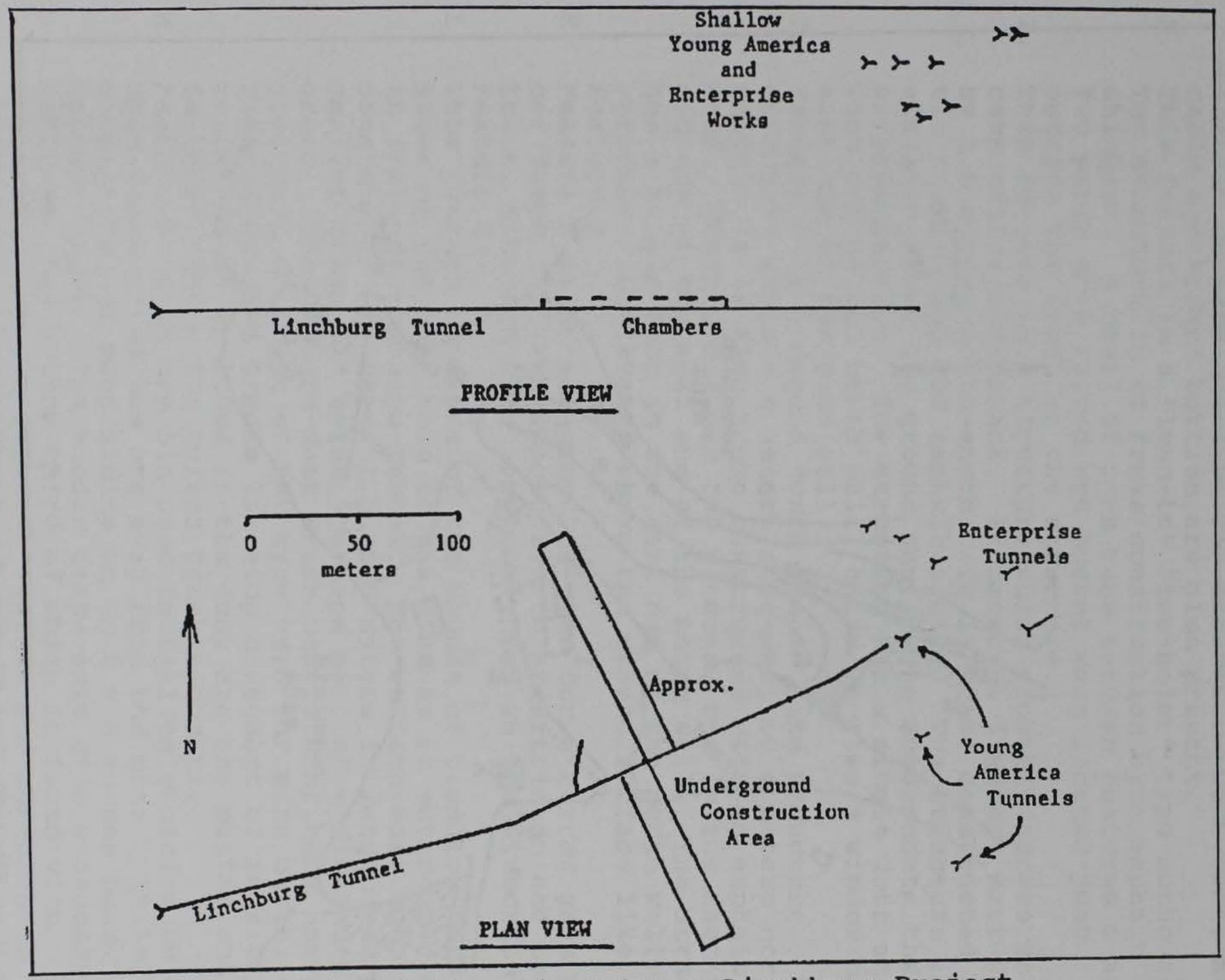


Figure 3. Spatial Relationship Between Linchburg Project Activity and Young America and Enterprise Mines (After Loughlin and Koschmann 1942).

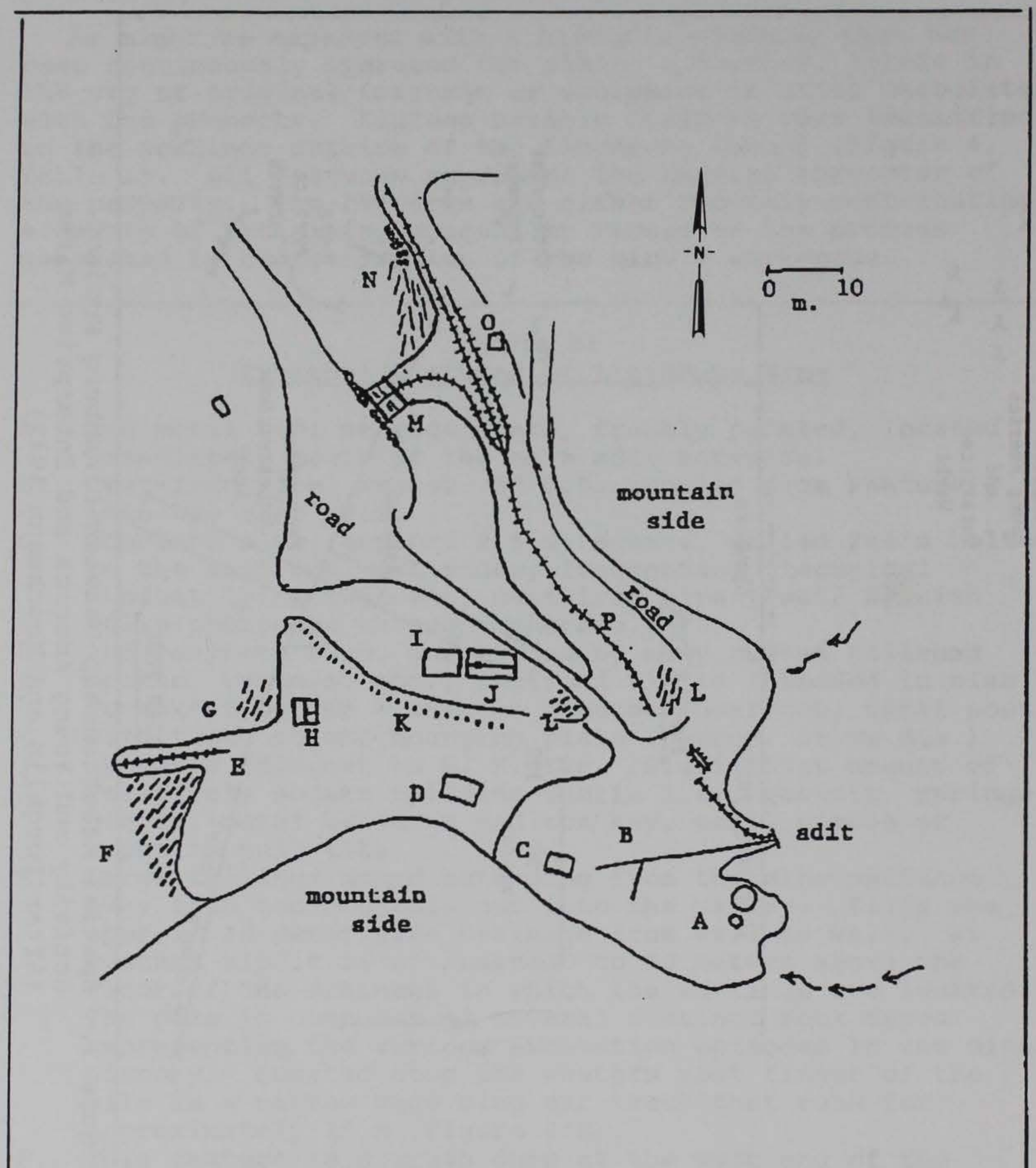


Figure 4. Sketch Map of the Linchburg Mine, LA 100608.

cable, wire-mesh screens, plastic pipe, and Coke and Shurfine juice cans. The configuration of the material especially the timbers, gives the impression of a pushed over building.

G. This feature is a trash dump consisting primarily of more than 30 cylindrical type air cleaners. Some cans, metal cable and broken bottles are also present.

H. This feature is a "lean-to" "two-holer" type outhouse. The structure is of frame construction with asphalt shingles. A trail of cans runs between Features G and H. Two parts of a rusted ore bucket were located just outside the front of the structure.

I. This feature is a structure which probably serves as a camp office/work shack. It measures 5 meters east-west by 3.5 meters north-south. It is frame constructed with tin roofing and red asphalt siding. The structure is elevated above the ground surface to accommodate the sloping terrain. The structure has a single door at the west end of the north wall, there is also a window on the east end of the same wall.

J. Feature J is a second "work shack" like structure. The structure extends 6 meters east-west by 4 meters north-south. It is also frame constructed with an asphalt tile roof. Structure J has two windows, one in the east wall and one at the west end of the north wall. The structure has a single door in the east end of the north wall. The structure is elevated above the ground surface like Feature I.

K. Feature K is an alignment of ties for a narrow gage mine car track. It was impossible to ascertain an end to the track, although they apparently ran in the direction of Feature G.

L. This feature consists of two mounds of trash on both sides of the main road to the mine as it enters the area in front of the mine tunnel. The western-most dump consists of "I" beams 1.5 to 5 meters in length and smaller green "I" beams, perhaps part of a discarded iron grate. The eastern-most trash consists of bent narrow gage rail or track of the type used for mine carts. These discarded tracks lie atop a segment of *in situ* track. Also included in the dump are the plates and fastener plates for switch track segments.

M. Feature M is an ore bin used in filling vehicles which then transported the ore away from the mine. It is constructed of wood siding on an 8 × 8 wooden beam upright frame. The wooden frame sets atop a masonry buttress, the bottom third of which is faced with concrete. The bin is built against and conforms to a steep-sided slope. The top half of the structure is hollow and covered with an iron "cattle guard" or heavy gage rail grill. The floor of the interior of the bin

slants to the west to an iron chute and ore bucket supported from a metal beam by chain.

N. This feature, an extensive deposit of discarded timbers, lies to the north of Feature M. Part of this discard forms a low wall which runs parallel to the two track segments mentioned. The remainder is in a tumbled heap down the slope of the hill side. Material other than timber includes metal pipe, sheet metal, several meters of metal cable, and track and switch plates for mine cart track.

O. Feature O is a small (1 × 1 m) structure to the east of Feature M. It is constructed of railroad tie uprights, covered with 2 × 6 planks and has discarded cardboard explosive boxes as siding.

P. Feature P is a narrow gage mine cart track leading to the top of Feature M from the eastern area of Feature L. Just before reaching the bin (Feature M), the track splits into three lines. One line turns to the west and runs atop Feature M, the two others run parallel to the north for approximately 10 meters.

Young America and Enterprise Mines (LA 100609):

These two closely adjacent mining areas are located approximately 415 meters east and 180 meters up slope from the Linchburg mine (Feature 1). The first reports on the Young America and Enterprise claims appeared in the 1907 reports to the U.S. Geological Survey. The owner at that time was one H. W. Russel and Company. Ownership passed to C. T. Brown in 1911 and then to the Empire Zinc Company in 1915 (Loughlin and Koschmann 1942). The southern-most workings are the Young America claims while the northern most are the Enterprise group located on unpatented land. Like the Linchburg, New Jersey Zinc Company acquired these claims in the 1940's. In turn, Hydro-Nuclear Resources acquired most of the property and it is currently leased by Cobb Resources. The workings include several short tunnels. Only two were accessible by 1916 (Loughlin and Koschmann 1942).

The total area of mine workings covers approximately 300 meters southwest to northeast and 70 meters northwest to southeast. Seven distinctive features, other than numerous tailings piles, were recorded (Figure 5, Table 3). The area has not been in use or has seen only very minor activity for some time. Unlike the Linchburg, these mining sites represent more "pristine" archaeological deposits.

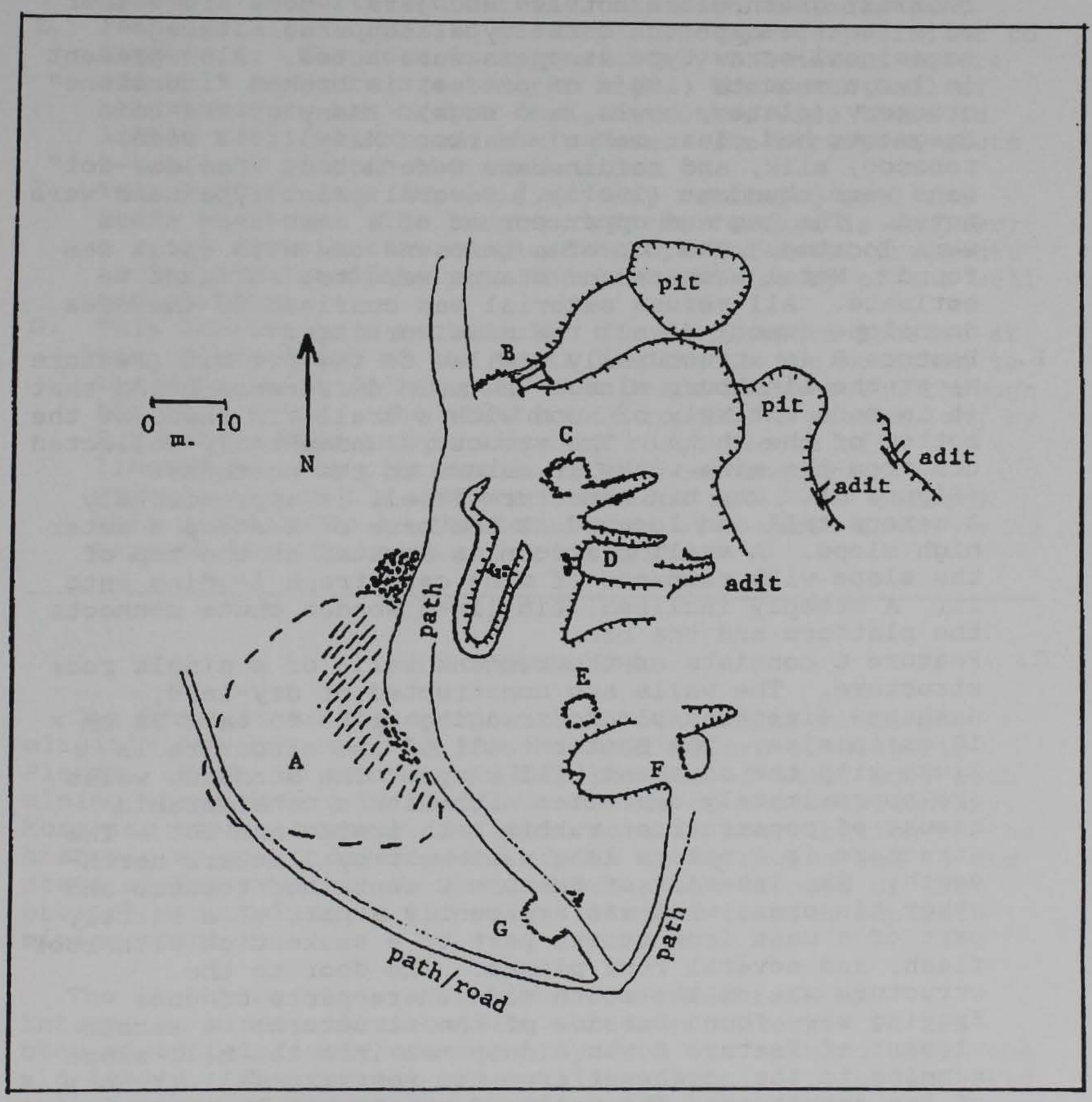


Figure 5. Sketch Map of the Young American and Enterprise Mine Complex.

Table 3:
External Features of Young America and Enterprise Mines.

A. Feature A is an extensive scatter of historic trash. Included are numerous (100's) fragments of purple, amber, brown "carnival glass," and imperfectly blown (contains bubbles) green glass bottles and jars. Most are either of a "bottle-cap" or "cork" type stoppers, although occasional screw type stoppers were noted. Also present in large amounts (100's of pieces) is broken "ironstone" crockery (plates, bowls, and mugs). Many of the base fragments had clear maker's marks. Many (10's each) tobacco, milk, and sardinecans were noted. "Solder-dot" cans were abundant (100's). Several paint type cans were noted. The leg and upper corner of a cast iron stove were located. The top of a kerosene can with spout was found. Metal washers and stamps were too abundant to estimate. All refuse material was confined to the area downslope (west) of all the mine workings.

B. Feature B is structurally similar to the ore bin (Feature M) at the Linchburg mine. The main difference being that it is made entirely of wood with a small tin sheet at the bottom of the chute. The structure undoubtedly collected ore from the mine works 15 meters to the northeast (Figure 5). The bin structure itself is approximately 3 meters tall and located at the base of a steep 6 meter high slope. A small platform is located at the top of the slope with remnants of mine cart track leading onto it. A steeply inclined, tin lined wooden chute connects the platform and the bin.

C. Feature C consists of the remnant walls of a single room structure. The walls are constructed of dry-laid, unshaped limestone blocks, ranging up to 50 cm × 30 cm × 10 cm in size. The eastern wall of the structure is flush with the adjacent hill slope. The standing walls are approximately one meter high with a considerable amount of construction rubble both inside and out. The structure is 4 meters long east-west by 3 meters north-south. The interior of Feature C contained tobacco and other tin cans, what was apparently a part of a barrel, part of a cast iron stove, part of a smokestack with roof flash, and several roof planks. The door to the structure was on the south side where parts of door framing were found outside of the structure. A second element of Feature C was a deep cut into the hill slope running to the northeast from the southern wall (front) of the structure. The walls of this cut were lined with dry-laid masonry identical to that used in the construction of Feature C. It is possible that at one time this cut lead to a mine tunnel.

D. Feature D is a small wooden platform run out from a tailings pile, supported by a 2 meter high wooden frame. Mine cart track leads from a small tunnel to the east of the tailing out onto the platform. The track is incomplete for a space along the top of the tailings pile. Obviously the structure served a purpose similar to that of Feature B, the transfer of ore to some type of ground transportation for the trip down the mountain.

E. Feature E is a dry-laid masonry structure very similar to Feature C. The room is approximately 2.5 meters square and wall remnants are 1 meter high. The south wall of the structure has broken down, but other wise there is little wall fall around their base. The structure abuts a tailings pile on the south side.

F. This Feature is a dry-laid masonry retaining wall and small platform. The function of the feature is unclear; a small distribution of glass bottle and metal fragments is located immediately to the west (in front) of the wall and platform.

G. This feature is a rectangular shaped platform located at the intersection of the trail leading up the mountain to the site and a former path that leads north-south through the mine ruins. The platform is roughly 5 meters long by 2.5 meters wide and is lined by rough blocks of limestone. The platform is only 5 centimeters high principally on the western downslope side. We believe this platform to be the foundation of a cabin shown on maps of the area made prior to 1912.

RECOMMENDATIONS

The Corps is of the opinion that both mining sites are eligible for inclusion on the National Record of Historic Places. They, of course, qualify because of their age, both mining areas dating to the first decade of the 20th century. More important, however, is their notable contribution to the historic economic development of the local region and to the state of New Mexico. We shall discuss the effects of the present undertaking in two parts relevant to each separate mining complex.

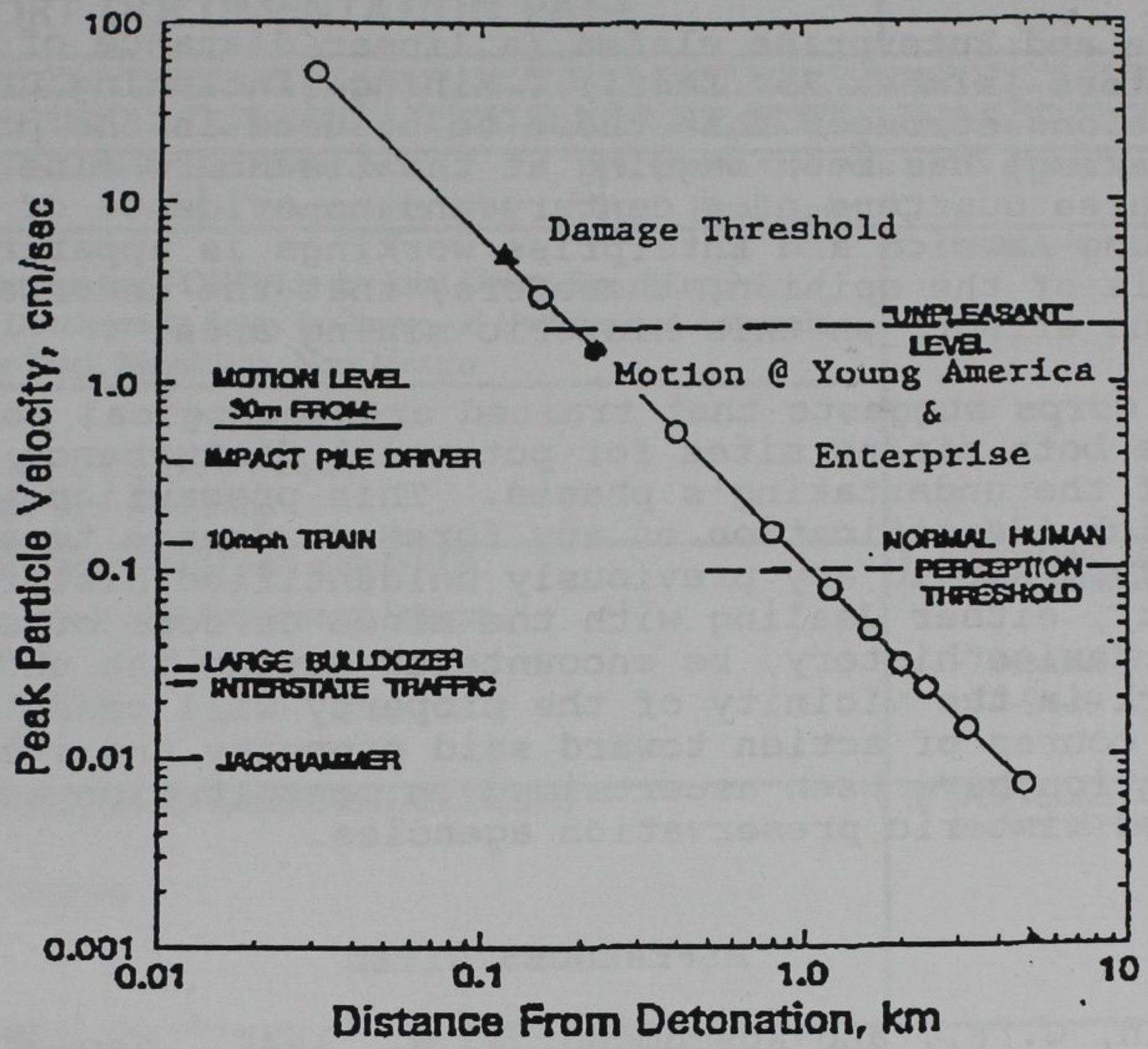
The Linchburg mine, unlike the Young America and Enterprise mines, is an ongoing economic concern. It has been mined relatively consistently from its opening until the mid-1970's. The current owners allow the mine to be unworked only because of recent low market value for the ore it produces. They continue to upkeep the claim in the hope that they will be able to reopen the works. This aspect of the mine's operation adds to its significance as a historic

property, it continues to play an economic role in the community. External feature of the mine are not original structures and have obviously been altered or changed many times. In essence, the location of the mine and its significance to the economic development in the Magdalena Mining District and New Mexico are the elements which contribute to its historic significance.

The action planned for Linchburg mine is no more than would be expected for its routine operation as a mining concern. Tunnels and rooms will be excavated and explosive charges placed and detonated. In fact, the explosive charges to be used in the tests as outlined are considerably weaker than would normally be used in mining the claim. External structures and elements of the mine are not original to the mining claim. No modifications to external structures of the mine will occur in any event. For these reasons, the Corps believes that a determination of "no adverse effect" is appropriate for the undertaking with respect to Linchburg mine.

The Young America and Enterprise mining complex is important to New Mexico history for the same reasons as Linchburg. However, the lack of operations at these mines for many decades has preserved the site as an excellent example of an early 20 the century mining site. Standing structures and the relatively undisturbed nature of associated refuse give the area considerable potential for the recovery of data about this era.

We have examined the Young America and Enterprise claims, not because of any direct threat to these properties due to the undertaking, but to evaluate the potential for secondary effects to them. Comparisons of the locations of the undertaking within Linchburg mine and those of the Young America and Enterprise works indicate that the undertaking will not affect the latter properties. Tunneling and detonations will occur approximately 275 meters from the entrance of the main Linchburg adit. Drill holes for monitoring stations will be made to the surface from this point. These drill holes should, therefore, intersect the surface approximately 40 meters to the west of the Young America and Enterprise complex. No impacts are foreseen for the drilling activity. Detonations at the Linchburg mine should likewise have no effect on the Young America and Enterprise properties. Considerable previous experience with the explosive forces of munitions has allowed the military to very accurately predict the effects of explosions on different structures at varying distances. These predictions are presented in Figure 6. Examination of this table indicates that no structural damage will occur to the Young



Damage Thresholds from References

Damage Type	Damage Threshold, cm/sec				
	Ref. 37 and 38	Damage Ref. 39	Threshold, Ref. 40	cm/sec Ref. 41	Ref. 42
None	4.4	2.5	<5.1	<5.1	>5.1
Opening of old plaster cracks	5.1	-	-	-	-
Fine plaster cracks	7.6	-	10.9	5.1-10.2	-
Plaster and masonry wall cracking/minor structure	-	-	16	10.2-17.8	13.7
Major structural damage/serious cracking	11.4	-	23.1	>17.8	19.3

Figure 6. Estimated Explosive Effects.

America and Enterprise claims (a linear distance of over 230 meters [almost 750 feet]). Mining (including underground detonations stronger than those to be used in the present undertaking) has been ongoing at the Linchburg mine over the past three quarters of a century and no evidence of damage to the Young America and Enterprise workings is apparent. The Corps is of the opinion, therefore, that the undertaking will have "no effect" on this historic mining area.

The Corps suggests that trained archaeological personnel examine both mining sites for potential disturbance following each of the undertaking's phases. This precaution will allow the quick identification of any foreseen damage to either property. Should any previously unidentified historic property, either dealing with the mines or some other phase of New Mexico history, be encountered during the undertaking, all work in the vicinity of the property will cease until the proper course of action toward said property and its ultimate disposition have been ascertained in consultation with all involved historic preservation agencies.

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13. ABSTRACT *(Maximum 200 words)*

An environmental assessment was necessary to investigate the potential impact of the Improved Underground Ammunition Storage Program on the environment. The existing test site environment was reviewed, alternatives to the proposed action were considered, and environmental consequences of the proposed action were analyzed. Environmental consequences included effects of construction activities, excavations, and test explosion phenomena on human health and safety, structures, biota, geology, air and water quality, local ecology, socioeconomic factors, and cultural and historical resources. A Finding of No Significant Impact (FONSI) was submitted.

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