UMTRA-SNL/74 4244
February 1983

ENVIRONMENTAL ASSESSMENT OF REMEDIAL ACTIONS ON THE URANIUM MILL TAILINGS AT THE MONUMENT VALLEY SITE, MONUMENT VALLEY, ARIZONA

U.S. Department of Energy

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ABSTRACT

This document assesses the environmental consequences of a proposed remedial cleanup action at the inactive uranium mill at the Monument Valley site in Monument Valley, Arizona.

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1.1 NEED FOR THE ACTION

The Monument Valley millsite is in Apache County, Arizona, about 5 miles south of the Utah border and just east of the region called Monument Valley (Figure 1-1). The mill, which processed uranium ore from 1955 to 1967, is no longer in use. Remaining at the site are concrete foundations, rubble, and mill tailings, which are the residues of the processing operations. These residues are mostly in the form of crushed rock, much like coarse sand and small gravels; they cover a total area of about 33 acres to varying depths and are contained in two separate piles.

The tailings contain some radioactive materials left from the processing of the ore. These materials produce radon, a radioactive gas that can move through the tailings and into the atmosphere; inhaling radon could cause lung cancer if the concentration of the gas in the air were great enough. Furthermore, natural processes like wind and water erosion can move the radioactive materials now confined to the piles of tailings. If the piles are not properly stabilized, the migrating radioactive materials might contaminate ground and surface water and could become a health hazard to people who live or work close to them.

No one now works at the site, and there are only three households within a 1-mile radius. Although the tailings by themselves, at their present location, are unlikely to cause deaths, a health hazard could occur if people used the sandy tailings in building materials or as fill on land where people live and work. Some tailings in the United States have, in fact, been used in these ways and have exposed people to levels of radiation that are greater than the natural levels to which they are normally exposed. The tailings will remain radioactive for thousands of years; if the piles are left as they are, people in the future may use the tailings or live near them without taking care to avoid the radiation they produce.

In 1978 the U.S. Congress heard testimony about these health hazards of the tailings left at inactive uranium mills. Finding that these tailings "may pose a potential and significant radiation health hazard to the public;" Congress then passed the Uranium Mill Tailings Radiation Control Act, Public Law 95-604. Among other provisions, this law requires that the Secretary of Energy undertake a program of assessment and remedial action to stabilize the inactive tailings piles in a "safe and environmentally sound" manner. It directs the Secretary to do this work in cooperation with other Federal agencies, with state governments, and with any affected Indian tribal governments. It also requires that the remedial actions be carried out "in accordance with general standards prescribed by the Administrator" of the U.S. Environmental Protection Agency (EPA). Among the places at which this action is required is the Monument Valley site.

This environmental assessment is required by the National Environmental Policy Act, which calls for careful attention to the effects that major Federal actions will have on the human environment. Before any such action can begin,

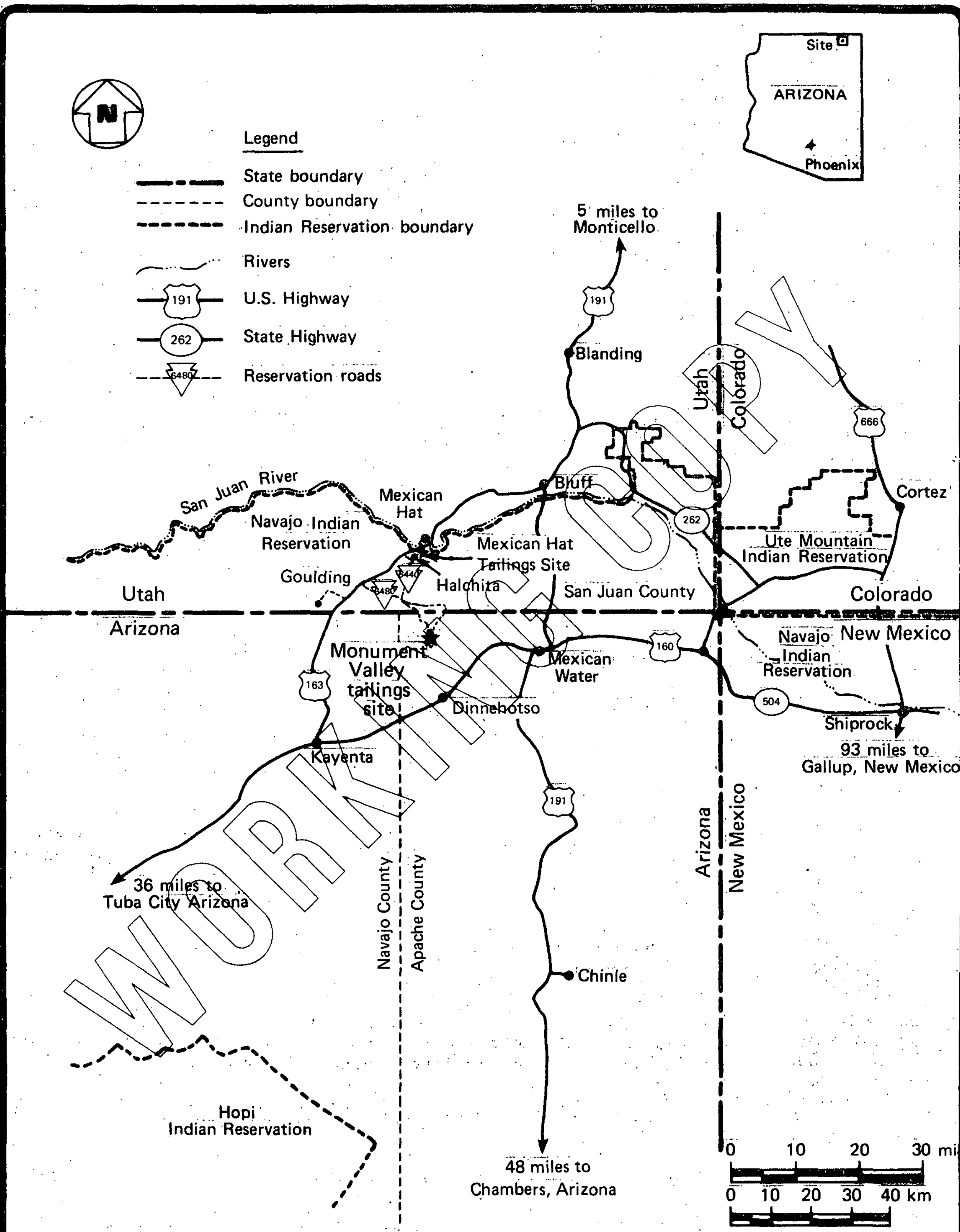

Figure 1-1. Site location.

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the agency that will perform it must study its environmental impacts. This environmental assessment examines the short-term and long-term effects of the action proposed for the tailings at the Monument Valley site. The U.S. Department of Energy (DOE) will use the information and analyses presented here to determine whether the action will have a significant impact on the environment. If the impacts are judged significant, a more detailed document called an environmental impact statement may be required. If the impacts are not judged significant, the DOE may issue an official "finding of no significant impact." These steps and documents are defined and prescribed in Federal law as regulations issued by the Council on Environmental Quality (CEQ) in Title 40, Code of Federal Regulations, Parts 1500 through 1508.

As defined by the CEQ regulations, an environmental assessment is a "concise public document" that "briefly" provides certain kinds of information and analyses. The remainder of Chapter 1 discusses the proposed action and describes alternatives to it. Chapter 2 discusses the present condition of the environment. Chapter 3 predicts the impacts of the project on that environment. Chapter 4 is a brief summary of Chapters 1 through 3. This document does not contain all the details of the studies on which it is based. The details are in the appendixes at the end of this document and in supporting documents referenced in it.

In summary, the need for remedial action at the Monument Valley site rests on the need to eliminate a potential health hazard produced by the radioactive materials in the tailings piles. The U.S. Congress has mandated such action, and this environmental assessment is a step toward carrying out that work.

1.2 THE PROPOSED ACTION

This section summarizes a preliminary plan for the proposed remedial action--onsite stabilization of the tailings--at the Monument Valley site. The preliminary plan describes an action that would meet the interim standards of the U.S. Environmental Protection Agency (Appendix A). The types of permits and licenses that may be required during the proposed action are identified in Appendix B.

A complete, final plan will be developed during the engineering design study that will be required for the project. The final plan will be similar to the preliminary plan, although some of its details may differ. The details presented in this report have been chosen with the intention of overestimating environmental impacts. The preliminary plan, therefore, provides the information that this assessment uses for determining realistic upper limits to the environmental impacts of the proposed action.

On the Monument Valley site (Figure 1-2) are two tailings piles. The old pile, covering 10.6 aces, contains about 165,000 tons of tailings from a heap-leaching process. The new pile, covering 21.7 acres, contains about 935,000 tons of tailings from later batch-leaching and concentration processes. In the former mill area, covering about 10 acres to the west of the old pile, are some concrete foundations, broken pipe sections, and other rubble.

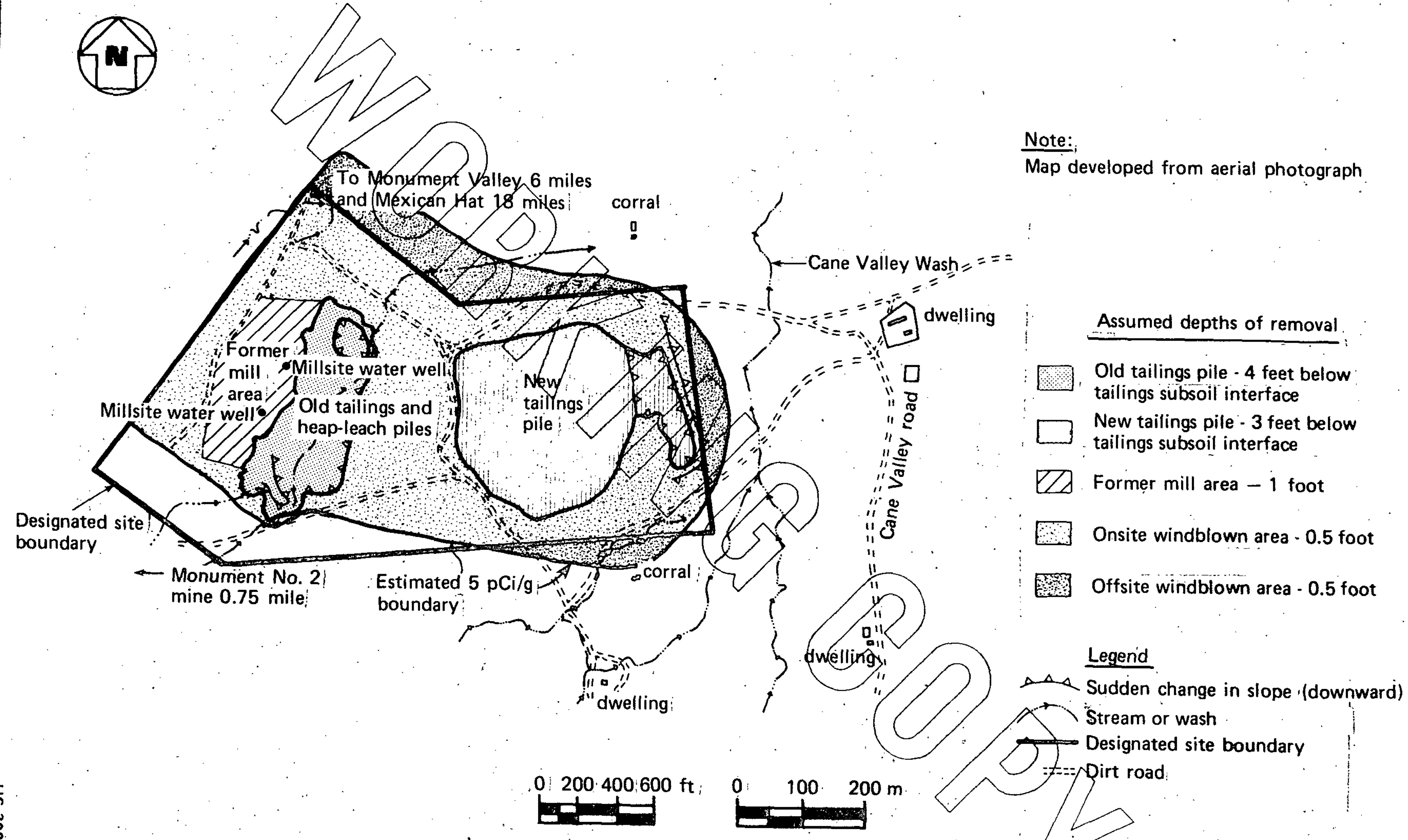

Figure 1-2. Detailed site map and area decontamination plan.

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The proposed remedial action at the Monument Valley site will consist of consolidating the two tailings piles to produce a single pile; cleaning up areas of windblown tailings and about 12 properties in the vicinity that have been contaminated by material from the piles; placing all the contaminated material, foundations, pipes, and rubble in the single pile; and stabilizing that pile.

The old tailings pile is located in an ephemeral drainage (see Figure 1-2). Because the tailings in the old pile were placed on an irregular surface and contain some slimes (FBDU, 1981), special equipment, such as front-end loaders and truck-mounted vacuum loaders, may be needed during the remedial action. If saturated or wet areas still exist within the old pile, the wet material could be mixed with the drier, coarse tailings in the new pile for ease in handling and transportation. When placed on the consolidated pile, the wet slimes could be segregated from the near-surface areas by a minimum of 2 feet of dry, coarse tailings to prevent contact with the fine-grained cover material.

The DOE Office of Occupational Safety, using the results of preliminary gamma-ray surveys, has estimated that 12 properties in the vicinity of the Monument Valley site are recommended for future comprehensive onsite surveys and may require cleanup of tailings and associated contamination. For this assessment, it has been assumed that all 12 properties will require remedial action in order to assess the "worst-case" situation. Estimates of costs and time for vicinity-property cleanup have been based on experiences with such cleanup at Grand Junction, Colorado, and Salt Lake City, Utah. The vicinity-property cleanup, estimated to require 8 days at a cost of $105,600, excluding engineering and contingency costs, will add an additional 1200 cubic yards of contaminated material to the pile (Appendix C, Section C.1.2). The cleanup crew for the vicinity properties will be the same as for the remedial action. The cleanup will be completed early in the remedial-action program at the Monument Valley site.

The final consolidated pile will be shaped to resemble a low, elongated, truncated pyramid with 5:1 side slopes, approximately 50 feet high and covering approximately 31 acres (see Figure 1-3). The pile will be located to avoid the ephemeral drainages in the area. If necessary, a diversion ditch will be placed along the base of the slope above the stabilized pile to reroute any surface drainage. A cover will be placed over the consolidated pile to stabilize it and to reduce the radon exhalation from it. A cover that will meet these objectives can be designed in many ways. The final cover design will be based on detailed measurements of the engineering properties of the soils and other materials to be used in the cover. Some parts of the final design may therefore differ from those in the preliminary design, which has been developed for estimating upper bounds to the environmental impacts of building the cover. For example, the preliminary design described here includes layers of material in order to predict impacts at a large, but realistic, number of borrow sites; it calls for a cover thickness large enough to bound the impacts at the borrow sites and the impacts of hauling the cover material to the site. Both the preliminary design and the final design would meet the EPA standards.

According to the preliminary plan, the consolidated pile will be stabilized with a 2-foot clay layer placed directly on the tailings. The clay will be overlain by 4.5 feet of silty sands. Capping the fine material will be 1.5 feet of minus-6-inch mine-run riprap. The cover will require 81,200 cubic yards of

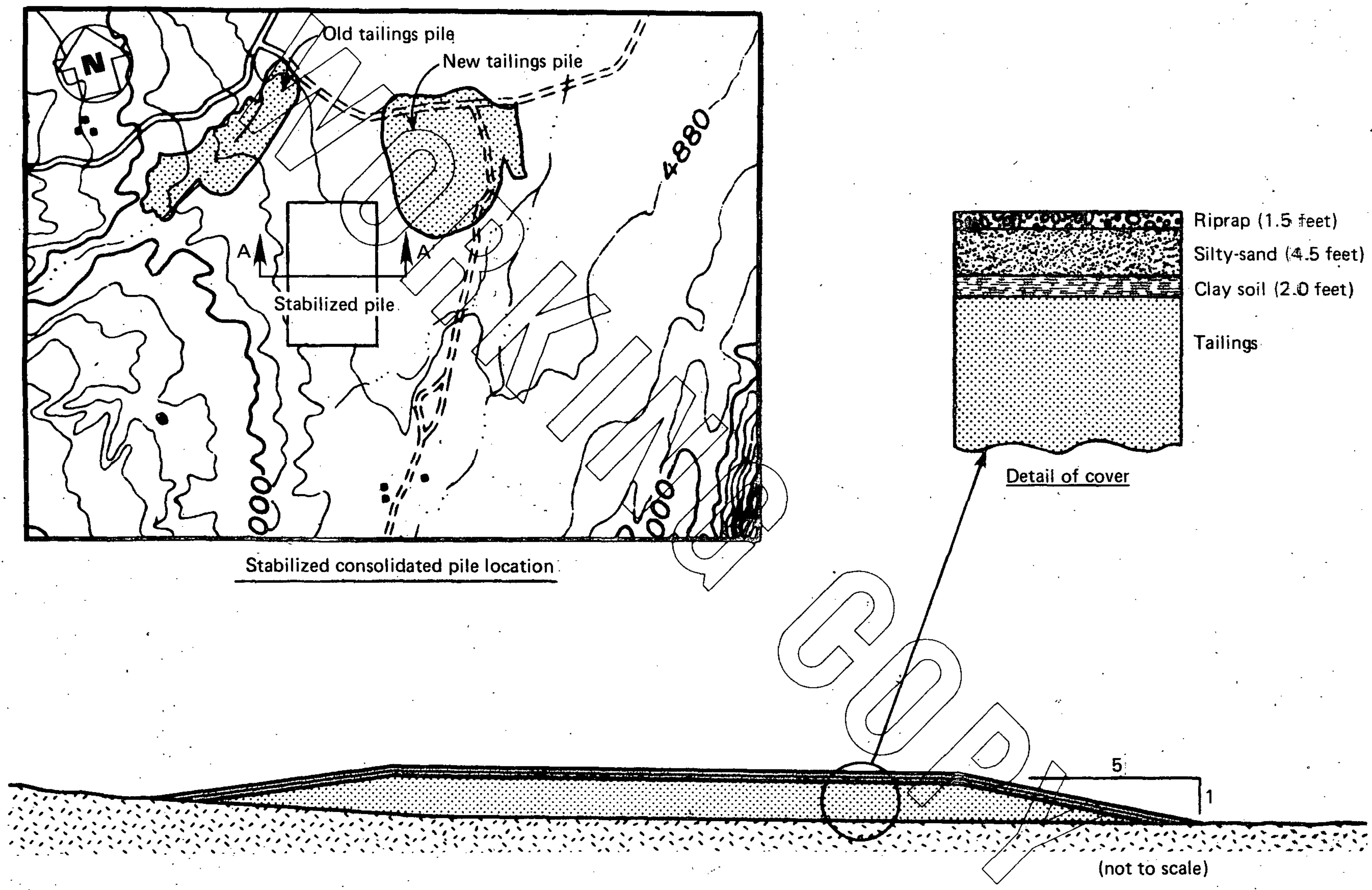

Figure 1-3. Plan and cross-section of proposed stabilized consolidated pile.

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clay, 194,800 cubic yards of silty sands, and 68,800 cubic yards of minus-6-inch mine-run riprap (see Appendix C, Section C.1.3, for details).

Clayey materials will come from the Petrified Forest Member of the Chinle Formation. A potential borrow site is approximately 1 mile east of the site along the base of Comb Ridge, as shown in Figure 1-4. (Another borrow site that can supply clayey material is about 10 miles to the northeast, as shown in Figure 1-4.) The silty sands would be stripped from surficial deposits overlying the Petrified Forest Member adjacent to the site. Minus-6-inch mine-run riprap will come from the De Chelly Sandstone Member of the Cutler Formation, which is exposed within 1 mile of the site. Approximately 2 miles of existing roads will have to be upgraded for use as haul roads. At the completion of the remedial action, the disturbed borrow areas will be reclaimed.

At the completion of the remedial action, a site-control program will be established; the site may be fenced. The site will be owned by the Federal government, probably by the DOE. The U.S. Nuclear Regulatory Commission (NRC) will license the maintenance of the stabilized disposal site and will specify the requirements for inspection and monitoring. The NRC will also evaluate the results of the inspection and make further recommendations.

The estimated cost for the proposed remedial action described in the preliminary plan for onsite stabilization is about $10.4 million in 1982 dollars, including engineering and contingency costs. This estimate does not include the costs of acquiring property or borrow material. An estimated average employment of 49 workers, with a peak of 52, will be required, and the remedial action will be completed in about 65 work weeks of 60 hours each (see Appendix C).

The proposed action is designed to accomplish the Congressional mandate for remedial actions that will meet the standards set by the EPA. As explained in Section 1.1, these actions will reduce the number of health effects that the Monument Valley tailings might cause, prevent their spread by natural forces, and discourage their removal for use elsewhere.

1.3 ALTERNATIVES TO THE PROPOSED ACTION

The alternatives discussed in this section include no action, moving abandoned uranium-mill tailings located near Mexican Hat, Utah, to Cane Valley for stabilization with the Monument Valley piles, below-grade disposal of the Monument Valley tailings in the Monument No. 2 mine pit, and below-grade disposal in shale along the base of Comb Ridge.

The Monument Valley site was specifically designated for remedial action in the Uranium Mill Tailings Radiation Control Act of 1978 (Public Law 95-604). Under this law, the no-action alternative is unacceptable. The radon-exhalation rate and the level of external gamma radiation at the site currently exceed the EPA standards, and Public Law 95-604 requires that remedial action bring the site into compliance with these standards. As discussed in this document, the no-action alternative provides a standard for comparison of the proposed action and other alternatives.

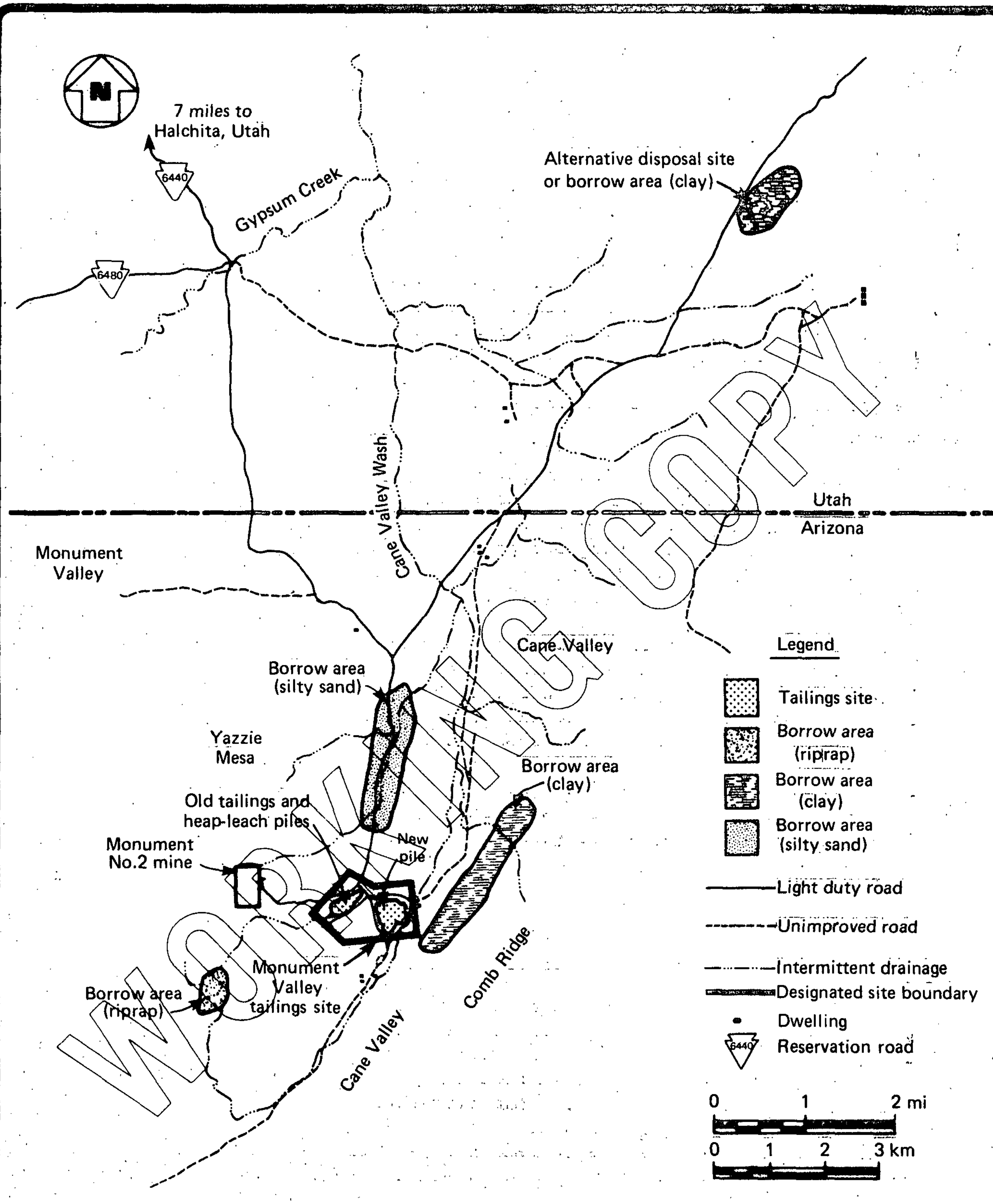

Figure 1-4. Borrow-site map.

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The other alternatives would provide for long-term stabilization of the contaminated materials. As explained in Sections 1.3.2, 1.3.3, and 1.3.4, they would be more expensive than the proposed action and would not provide any additional calculable health benefits. They are therefore less cost-effective than the proposed action. Moreover, the risks of personal injury through vehicle accidents would be increased in the alternatives that involve removing tailings from the site or bringing large volumes of tailings to the site; these risks would be be greater than the risks associated with radiation released during onsite stabilization. For these reasons, the proposed action is preferred over the alternatives, which are presented only in enough detail to document why their impacts are treated only briefly in this assessment.

The costs reported in this section are summaries of more-detailed calculations in Appendix C. They include costs for site preparation, transportation, placement of the materials, and site reclamation required at the alternative locations for surface or below-grade disposal, and reclamation of the original site. They do not include the cost of acquiring the land for disposal sites.

1.3.1 Alternative 1: no action

The no-action alternative means the tailings pile, foundations, vicinity properties, and other contaminated areas would be left as they are. Wind and water erosion would continue spreading contamination off the site. Any contaminated material at the vicinity properties would remain. The foundations and rubble associated with the millsite and tailings piles would remain in much the same condition for many years. It is expected that winds will gradually move the new tailings pile to the northeast as a single large sand dune or a series of sand dunes.

1.3.2 Alternative 2: consolidation on the site with tailings materials from Mexican Hat

Under this alternative, mill tailings from the Mexican Hat site, located 18 miles north (Figure 1-1), would be moved to the Monument Valley site, where materials from both sites would be consolidated and stabilized into a single tailings pile approximately 50 feet high, with 5:1 side slopes, covering approximately 70 acres and containing a total of 3 million cubic yards of contaminated materials. The same sources of cover material described in the proposed action would be used for this alternative.

This alternative would entail a greater risk of vehicular accidents and an increased risk of radiation exposure during the transportation of tailings from Mexican Hat to Monument Valley. The transportation would necessitate improving the haul roads on the reservation. Because of the nearly saturated condition of the Mexican Hat slimes, special transportation methods, such as tank trucks, may be required. This might add to the cost of this alternative. Workers at the site would be exposed to the contaminants for a longer period of time.

The cost for this alternative is estimated to be $51.4 million in 1982 dollars, including engineering and contingency costs (see Appendix C, Section C.2).

1.3.3 Alternative 3: below-grade disposal in the mine pit

This alternative would involve moving all the tailings, foundations, and offsite contaminated materials to the original Monument No. 2 Mine pit, located 0.75 mile west of the site (see Figure 1-4). The mine pit would be prepared for this alternative by excavating the waste overburden material that was left in the bottom of the pit during mining. The pile would be covered with zoned cover material as in the proposed action, and borrow materials would come from the sources indicated in Section 1.2. Overburden could be used as additional cover.

The surface of the stabilized pile would blend with the surrounding topography. The placement of the contaminated materials in the mine pit would allow the area around the existing tailings piles to be used for grazing. Because most of the ore was removed during the previous mining operation, using the pit for disposal would not make any ore reserve inaccessible to mining, nor would it contaminate a previously uncontaminated area.

Compared with the proposed action, this alternative would require an increase of about 1 road mile in the haul distance; it therefore entails a slightly increased potential risk of vehicular accident. The workers would be exposed to higher levels of radiation in the ore pit and would be exposed to the radioactive tailings for a longer time during the transportation.

The cost of this alternative, including transportation, site preparation, and improvement of the haul road, is estimated to be $14.1 million in 1982 dollars, including engineering and contingency costs (see Appendix C, Section C.3).

1.3.4 Alternative 4: below-grade disposal along the base of Comb Ridge

This alternative would involve the excavating of a below-grade disposal pit in the Petrified Forest Member of the Chinle Formation along the base of Comb Ridge. At a potential site 8.5 miles north of the present tailings piles (Figure 1-4) the tailings could be isolated hydrologically, and long-term stabilization could be ensured. Except for the final 1.5-foot layer of minus-6-inch mine-run riprap, cover materials would be available on the site. The contaminants could be placed at the head of a drainage in a badlands area where plant life would not be affected.

Compared with the proposed action, this alternative would increase the possibility of vehicular accidents because it requires hauling the tailings several miles. It would expose the workers to the contaminants for a longer period of time. It would restrict the use of the previously unrestricted disposal area, although the area around the current piles would be cleaned up and released for unrestricted use.

The cost for this alternative is estimated to be $24.3 million in 1982 dollars, including engineering and contingency costs (see Appendix C, Section C.4).

REFERENCES FOR CHAPTER 1

FBDU (Ford, Bacon & Davis Utah Inc.), 1981. Engineering Assessment of Inactive Uranium Mill Tailings, Monument Valley Site, Monument Valley, Arizona, DOE/UMT-0117 (FBDU-360-04), prepared for the U.S. Department of Energy, Albuquerque, New Mexico.

2 AFFECTED ENVIRONMENT

This chapter describes the environment that would be affected by the proposed action. Data used in the preparation of this chapter were obtained from engineering assessments prepared for the U.S. Department of Energy (FBDU, 1977 and 1981), from field visits, and from other published and unpublished sources.

2.1 BRIEF DESCRIPTION OF THE AFFECTED AREA

The Monument Valley millsite and tailings are located in northeastern Arizona, in Apache County (Figure 1-1). They are on the Navajo Indian Reservation just east of Monument Valley, in Cane Valley. The site is 6 miles north of Dinnehotso, Arizona; 12 miles west of Mexican Water, Arizona; 13 miles south of Halchita, Utah; and 14 miles south of Mexican Hat, Utah. No incorporated towns are within at least 30 miles of the site.

The site is in a desert characterized by hills, steep ridges, and mesas. Sandstone cliffs east of the site are exposed on Comb Ridge and along the ridges separating Cane and Monument Valleys. Elevation differences of up to 1000 feet between valley floors and the tops of buttes and ridges are typical. Coarse-grained soils in the area are vegetated by blackbrush, shadscale, rabbit brush, and Apache plume. Fine-grained soils support snakeweed, haplopappus, and rayless encelia. The drainageways are dominated by greasewood. Vegetation is practically nonexistent on the tailings piles.

The area has a semiarid desert climate. Heavy thunderstorm activity occurs in late summer and early fall. The prevailing wind is from the southwest. The site is in a somewhat isolated area of the Navajo Indian Reservation; however, there are residences scattered in the vicinity of the piles. The land in the area is used for low-density grazing.

2.2 DESCRIPTION OF THE EXISTING TAILINGS-PILE AREA

The Vanadium Corporation of America built the Monument Valley mill in 1955. Until 1964, the mill operated as a sand-slime upgrader unit. In 1964, the mill was operated as a batch-leaching process and later as a heap-leaching facility until its close in 1967. Both the original tailings and some ore were treated in this second phase. In 1967, the year the mill was shut down, the Vanadium Corporation of America merged with Foote Mineral Corporation.

About 1.1 million tons of coarse sand tailings are distributed between the two piles on the site. The old tailings pile and the heap-leach piles, covering about 11 acres and containing about 165,000 tons of material, are located just east of the former millsite. They contain tailings from the original upgrader process at the site and the heap-leached ore. The depth of tailings in the old pile is highly variable because of its location on the bank of a drainage. The heap-leach piles are on flatter ground to the northeast of the old pile. Most of the original tailings were reprocessed by batch leaching and discharged to the new tailings pile east of the original pile. The new pile occupies about 22 acres with 935,000 tons of tailings. The new pile and the heap-leach piles are high in sulfates and chlorides from the acid-leaching process. The new pile also contains some of the building material and equipment from the millsite.

The site is not fenced, and no warning signs are posted. The piles have not been stabilized; however, because the tailings are coarse grained, wind and water erosion has been minimal. Windblown tailings partially cover a road to the northeast of the new pile, and wind erosion has contaminated the soil on an additional 59 acres.

Water erosion of the old and heap-leached piles has caused gullying and the spread of contaminated material. Dahlstrom (1982) found evidence of contamination in the drainage extending 1 mile north of the site. Much of this contamination is below the levels that require cleanup; however, the potential exists for continued water erosion to increase the levels of contamination beyond the acceptable standards. This is especially true on the eastern edges of the old pile and in the heap-leach areas, where an ephemeral stream crosses the site.

More information about the Monument Valley site is contained in engineering assessments prepared for the DOE (FBDU, 1977 and 1981).

2.3 WEATHER

Weather stations nearest the Monument Valley site are at Bluff and Blanding, Utah, about 35 and 55 miles, respectively, to the northeast. Precipitation data presented are primarily from these stations (USDA, 1941; USDC, 1960). A 1-year record of wind measurements is available from the White Mesa Project at Blanding (NRC, 1979), but the national weather stations at these towns do not provide permanent wind data.

The climate at Monument Valley is typical of semiarid deserts, with light precipitation, low relative humidity, and large fluctuations in daily and annual temperatures. The winters are cold but usually not severe. The summers are hot, and temperatures of 90 to 100°F occur frequently.

The average annual precipitation in the region is only about 7.5 inches, most of which falls during two separate rainfall seasons. The first main rainfall period occurs during late summer and early autumn, when late afternoon thunderstorms and showers are common. The second main rainfall period occurs during the winter months.

The White Mesa wind record shows an overall average wind speed of 9.2 miles per hour (all directions); the most frequent direction is from the south. The wind speed and frequency for 16 directions are shown in Table D-1 of Appendix D. The distribution of windblown tailings at the Monument Valley site suggests that the predominant winds in the area are from the southwest. In addition, Ford, Bacon & Davis, Incorporated (FBD) personnel collected wind data at the Mexican Hat, Utah, millsite (Figure 1-1) in July and August 1976. They found wind blowing predominantly from the southwest at an average velocity of 5 miles per hour.

2.4 AIR QUALITY

The air-quality sampling stations nearest to the Monument Valley site are at Bullfrog Marina, Utah, about 60 miles northwest (USDH, 1981), and at Page, Arizona, about 85 miles west. In addition to these stations, four sampling stations in Blanding, Utah, about 55 miles northeast, recorded data over a 1-year period for the White Mesa Uranium Project Environmental Statement (NRC, 1979). Data from these sites are summarized in Table D-2 of Appendix D; Federal standards are given in Table D-3.

The measured values for total suspended particulates, sulfur dioxide, and nitrogen dioxide at all these sites are well below State and Federal air-quality standards, and the entire region, including the Monument Valley area, is an attainment area for all air pollutants.

2.5 SURFACE AND SUBSURFACE FEATURES

Cane Valley, where the site is located, is cut into the soft beds of the Monitor Butte and the Petrified Forest, the shale members of the Chinle Formation. Alluvium and windblown sand overlie most of Cane Valley and usually cover the contacts between formations, making interpretation difficult; however, the millsite lies at the edge of the valley where the older Shinarump Member of the Chinle Formation outcrops (see Figure 2-1). The western side of the old pile also lies on the Shinarump Member, while lower portions of the old pile and heap-leach area in the drainage may rest on the underlying Moenkopi Formation (Witkind and Thaden, 1963). The Moenkopi Formation is comprised of interbedded shaley siltstones and sandstones. The rest of the pile lies on dune sand, which covers the contacts between the Shinarump Member and the Moenkopi Formation (see Figure 2-1). Most of the new tailings pile rests on windblown sand and alluvium, with the western edges on outcrops of the Shinarump Member. Judging from nearby outcrops and local dips, the Shinarump Member underlies all of the unconsolidated material beneath the pile, and the contact of the Shinarump with the younger Monitor Butte is east of the pile.

The Shinarump Member of the Chinle Formation, which contains the uranium ore mined from the Monument No. 2 mine, consists of light yellowish-gray fluvial crossbedded conglomeratic sandstones with interbedded conglomerate lenses. Some mudstone lenses are also present, and silicified wood is characteristic of the Shinarump Member, especially in the ancient channels. The Shinarump Member is generally about 50 to 75 feet thick in the site area; however, local variation in thickness can be pronounced because the Shinarump was deposited on an irregular erosional surface.

The Moenkopi Formation consists of chocolate-brown to reddish-brown shaley siltstones and sandstones. The Moenkopi Formation, which is approximately 45 to 50 feet thick beneath the site, varies locally in thickness from 0 to 80 feet (Witkind and Thaden, 1963). This variation in thickness was caused after deposition, when erosion formed broad swales and channels as deep as 275 feet in the formation (Repenning et al., 1969). In the site area, the swales are about 30 feet deep, with channels in the bottom of the swales about 50 feet deep, as at the mine in the Monument No. 2 channel. The Monument No. 2 channel cuts through the Moenkopi Formation 20 feet into the underlying De Chelly Sandstone of the Cutler Formation, the major aquifer in the area. The De Chelly is a poorly sorted, fine-grained sandstone about 550 feet thick locally.

Local dips appear to vary from about 3 to 6 degrees to the east; however, along Comb Ridge the strata dip steeply to the east and southeast, plunging at dips exceeding 13 degrees. Monument Valley is located in a seismic zone where only horizontal accelerations of less than 0.04 g are expected (Algermissen and Perkins, 1976).

Since soils in the immediate area are developed from outcrops of the Shinarump Member, they are quite sandy. The soils have been disturbed by past mining and milling activities on and near the site. Some finer-grained soils can be found east of the site in alluvium eroded from the shale of the Monitor Butte and Petrified Forest Members of the Chinle Formation.

There are no known mineral resources in the immediate site area other than the uranium associated with the Shinarump Member of the Chinle Formation;

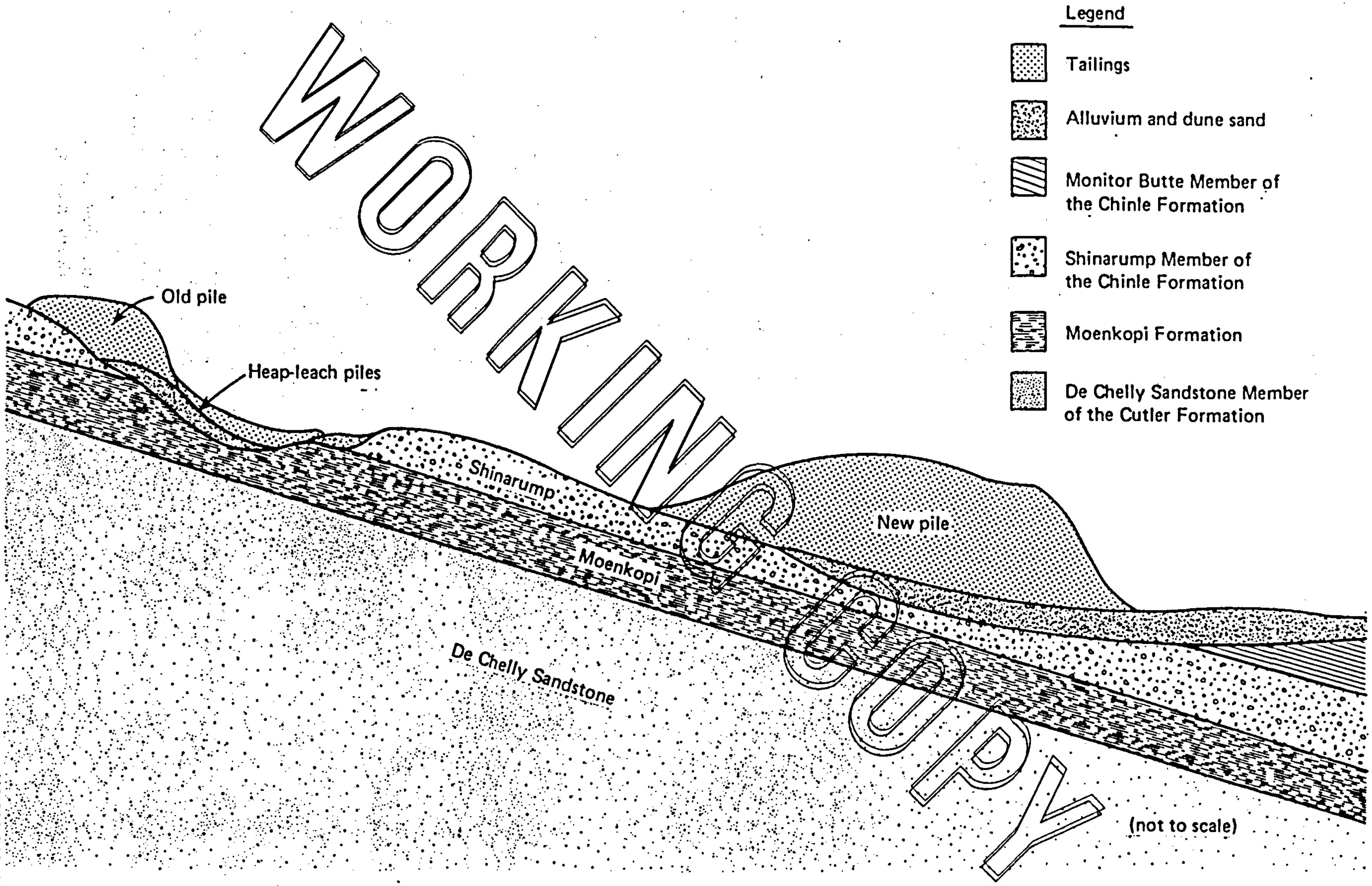

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Figure 2-1. Generalized geologic cross-section.

however, oil and gas deposits have been discovered within 20 miles north of the area and could exist in sedimentary beds below the Cutler Formation (ABGMT, 1965).

2.6 WATER

2.6.1 Surface water

The old Monument Valley tailings pile rests on an ephemeral channel that drains an area of approximately 1200 acres above the pile (see Figure 2-2). This channel is tributary to Cane Valley Wash, which lies east of the site. The watershed upstream from the old pile consists of sandstones and siltstones of the Chinle, Moenkopi, and Cutler Formations (Cooley et al., 1969). These rock outcrops yield runoff readily during a rainfall event, as evidenced by the gullying in the old pile and heap-leach areas.

Runoff from the new tailings pile, although limited in magnitude, flows toward Cane Valley Wash. A portion of this runoff is contained within a diked area located immediately east of the pile.

No streamflow records are available for Cane Valley Wash. However, field investigations suggest that this wash is intermittent in the area of the tailings piles, flowing for short distances in early spring in response to a high water table. High peak runoff events are expected occasionally in Cane Valley Wash as a result of thunderstorm activity.

Because of the general lack of streamflow, very little is known about the quality of surface water in the area. Efflorescent salts in the bottom of Cane Valley Wash indicate that streamflow is relatively saline. The origin of this efflorescence is presumably shallow ground water contained in the alluvium of the wash.

Radiometric analyses have been reported for only two surface-water samples in the area (Haywood et al., 1979). These samples contained radium-226 concentrations of 0.4 picocuries per liter (pCi/l) in Cane Valley Wash about 1 mile upstream from the site, and 0.6 pCi/l about 7 miles downstream from the site. Both concentrations are significantly below the U.S. Environmental Protection Agency interim primary drinking water standard of 5.0 pCi/l for combined radium-226 and radium-228 (as given in 40 CFR 141, assuming the latter exists in negligible quantities). No data are available concerning trace-metal concentrations in surface waters of the area.

Data presented by Dahlstrom (1982) indicate the presence of soil radium-226 concentrations in excess of background for a distance of about 1.1 miles downstream from the site in the unnamed wash crossing through the old tailings pile. Although some of this contaminated soil may have eroded from the drainage upstream of the piles in the area of the Monument No. 2 mine, the data do suggest that the old pile is eroding with subsequent downstream deposition of contaminated material. The area of sedimentation does not appear to extend as far as Cane Valley Wash.

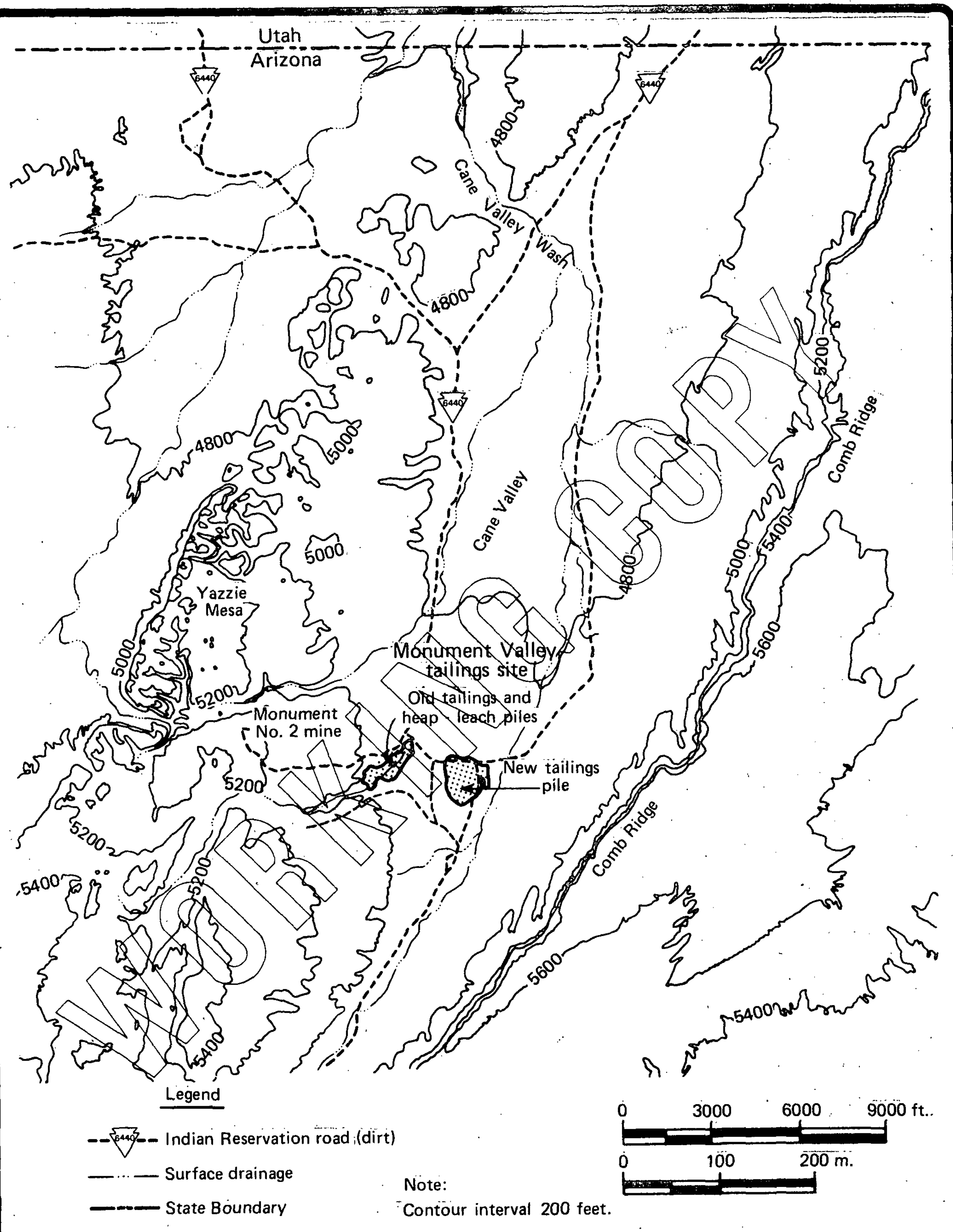

Figure 2-2. Topography.

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2.6.2 Ground water

The De Chelly Sandstone Member of the Cutler Formation is the major bedrock aquifer in the area of the Monument Valley site (Cooley et al., 1969). Water levels in two abandoned wells drilled on the millsite suggest that ground water immediately below the site exists under unconfined conditions. However, because of the dip of the De Chelly Sandstone (Witkind and Thaden, 1963), ground water in bedrock below the valley bottom exists under confined conditions, as evidenced by a flowing well located approximately 3000 feet east of the millsite. Siltstones of the Hoskinnini tongue of the Moenkopi Formation overlying the De Chelly Sandstone probably act as the confining layer.

Local topographic conditions and the water levels in the two millsite wells indicate that the depth to the potentiometric surface (i.e., the level to which ground water would rise in a well) averages approximately 95 feet below the millsite, 70 feet below the bottom of the old tailings pile, and 20 feet below the lowest part of the new tailings pile (see Appendix E for locations of wells). Geologic data presented by Witkind and Thaden (1963) suggest that the Hoskinnini tongue of the Moenkopi Formation may be at such an elevation that ground water below the new pile exists under confined conditions. Whether confined conditions exist below the old pile is uncertain.

The full thickness of the De Chelly Sandstone outcrops west of the site along the eastern edge of Monument Valley. No springs or seeps are known to exist along this outcrop, suggesting that ground water below the site flows eastward and southeastward along the dip of the strata. Along Comb Ridge, the De Chelly Sandstone plunges deeply to the southeast (Whitkind and Thaden, 1963), placing the top of this aquifer below the depths of most water wells (i.e., at a depth of approximately 2000 feet immediately east of Comb Ridge).

Ground water also exists in the alluvial and dune deposits of Cane Valley east of the site. Several shallow hand-dug wells have been constructed along the wash for domestic use by local residents. Sumps and trenches constructed east of the wash during mining and milling operations indicate that the unconsolidated deposits are saturated within a few feet of the surface throughout much of the valley. This area is situated approximately 0.6 mile east of the piles. Siltstones and mudstones of the Moenkopi and Chinle Formations that underlie the alluvial and dune deposits in Cane Valley apparently prevent significant downward movement of ground water in the unconsolidated deposits. The direction of ground water movement in the unconsolidated valley deposits is, therefore, probably toward and along Cane Valley Wash.

Data on the quality of the ground water have been collected in the area by several investigators (Snelling, 1970; Hans and Douglas, 1975; Hans et al., 1978; Haywood et al., 1979; Appendix E). As indicated in Appendix E, ground water in bedrock in the area is high in overall quality, averaging concentrations of less than 200 milligrams per liter (mg/l) total dissolved solids on the west side of the valley and approximately 300 mg/l in the valley bottom. Shallow ground water in the unconsolidated valley deposits tends to be somewhat more saline, especially adjacent to Cane Valley Wash. Bicarbonate is the dominant anion in ground water throughout the area, and calcium, magnesium, and sodium are the dominant cations.

Concentrations of trace metals and radioactive constituents in ground water, reported by several investigators collecting data from the area, are generally well within the U.S. Environmental Protection Agency (EPA) interim primary drinking water standards (see 40 CFR 141). One sample showed a significantly higher natural uranium concentration than all other samples (sample MKL-758, a sample of ground water in the shallow unconsolidated valley deposits collected from a sump east of Cane Valley Wash; see Appendix E). This sample contained a natural uranium concentration of 0.46 mg/l (approximately 153 pCi/l, assuming that 0.03 mg/l is approximately equivalent to 10 pCi/l), compared with a maximum natural uranium concentration of 0.007 mg/l (2 pCi/l) at all other sites. This site also shows an elevated vanadium concentration (see Appendix E); however, as explained in Appendix E, the source of this contamination appears to be associated with a local uranium-ore outcropping (Dahlstrom, 1982) rather than contamination from the tailings pile.

2.7 ECOSYSTEMS

A field investigation of the ecosystem at Monument Valley was conducted in May and August 1982. A summary of the findings is presented in this section, and more details are given in Appendix F.

The Monument Valley site lies within a large vegetation unit termed Great Basin Desertscrub by Brown and Lowe (1980). The lower areas surrounding the site are dominated by greasewood and its associates. Snakeweed, haplopappus, and rayless encelia dominate the higher fine soils; and blackbrush, shadscale, rabbit brush, and others are predominant on rocky outcrops.

The new tailings pile resembles shifting sand dunes, and both piles are practically devoid of vegetation. In May a few specimens of downy chess and Indian ricegrass were found growing on the piles; however, in August no plants were observed. The interface between the piles and native plant communities was dominated by Russian thistle, galleta, and common local shrubs.

Wildlife species are unlikely to use the tailings piles as habitat. There is no food source, and the unstable substrate does not accommodate burrows.

Three potential borrow areas have been proposed: two near the tailings piles and one about 8.5 miles away (see Figure 1-4). The silty-sand borrow area near the site is characterized by rocky outcrops and a desert plant community. Blackbrush, shadscale, and yucca are common. Occasional junipers dot the area. Cover is sparse and low. The clay borrow area adjacent to the site lies in a low drainage. Conditions are somewhat more mesic than at the silty-sand borrow site, and the vegetation is more diverse. Large specimens of greasewood, rabbit brush, and salt cedar are common.

The third potential borrow site, in the Petrified Forest Member of the Chinle Formation, was surveyed in June 1982. Thirty plant species were found, but the types and general scarcity of plant life indicate a harsh, specialized habitat at this location. No threatened, endangered, or sensitive plant species were found.

Small mammals, birds, and reptiles are probably abundant near the tailings piles and on the proposed borrow sites. White-tailed antelope squirrels were commonly seen. Nocturnal rodents such as the Ord kangaroo rat and deer mouse are probably also common. Larger mammalian inhabitants include the black-tailed jackrabbit, coyote, and mule deer.

Several songbirds may nest on the borrow sites. These include the mourning dove, poor-will, loggerhead shrike, and Brewer's sparrow.

Reptiles indigenous to the proposed borrow sites include the lesser earless lizard, Western whiptail, and side-blotched lizard on sandy sites. Rockier areas are populated by the collared lizard, desert spiny lizard, western rattlesnake, and gopher snake.

No plants listed as threatened or endangered are likely to occur on the tailings piles or proposed borrow areas (Kenneth Heil, San Juan College, personal communication, April 1982). Cutler milkweed is known from sandy areas near Rock Point and Mexican Water (both are a considerable distance from the site) and is currently under review for possible inclusion on the Federal list (U.S. Fish and Wildlife Service, 1980). It could occur on one of the borrow sites although no specimen of that genus was collected on any of the sites. All yuccas and cacti are afforded protection under the Arizona Native Plant Law (Arizona Revised Statutes, 1978); however, it is unlikely that the law extends to Indian lands.

No Federally listed threatened or endangered wildlife are known to inhabit the vicinity of the tailings piles or borrow sites (Edward Olson, U.S. Bureau of Indian Affairs, personal communication, April 1982). Comb Ridge could be important for nesting of unlisted raptors.

The only big game species likely to occur near the sites are mule deer and cougar.

2.8 RADIATION

The radiation from the tailings and in their vicinity is of special interest in assessing the remedial actions at Monument Valley. Because some of the basic facts about radiation and its measurement may not be familiar to all users of this document, Appendix H, Section H.1, presents a brief explanation of the phenomena and units referred to in this section and Section 3.1.

Radon concentrations have been measured in the vicinity of the Monument Valley tailings piles using calibrated Wrenn chambers (FBDU, 1977). The concentrations have been reported as 6.8 pCi/l between the old and new tailings piles, 3.2 pCi/l at 0.11 mile downwind of the tailings, and 4.3 pCi/l at 0.6 mile downwind of the tailings. The average radon background in the Monument Valley area is about 0.6 pCi/l. At 10-percent equilibrium and a radon concentration of 6.8 pCi/l, the radon-daughter concentration on the piles would be about 0.007 WL.

Near tailings piles the highest concentrations of radon and its daughters in air typically occur on top of the piles, reaching a maximum on a still, dry day when the tailings are dry. No measurements of radon-daughter concentrations or equilibrium values have been made at the Monument Valley site; however, extensive studies have been carried out by the U.S. Environmental Protection Agency (EPA) at the Vitro tailings site in Salt Lake City, Utah. These studies show that the radon daughters were at 3 to 13 percent of equilibrium with the radon in the air over the pile (Duncan and Eadie, 1974).

Equilibrium ratios similar to those at the Vitro site in Salt Lake City are assumed to exist at the Monument Valley site. The analyses in this assessment assume that the radon daughters at the Monument Valley piles are at 10-percent equilibrium with the radon. In motionless air, the radon-daughter concentration reaches 10-percent equilibrium with the radon present in about 5 minutes (Evans, 1980). On the Monument Valley tailings piles, which together cover an area about 1240 feet wide and 2400 feet long including the area between the new and old piles, the average wind speed would have to be less than about 6 miles per hour to achieve this condition. As noted in Section 2.3, wind speeds in the vicinity of the Monument Valley site average about 9 miles per hour. The assumption of 10-percent equilibrium is conservative (to overestimate the hazard); it therefore provides a calculated upper bound to radon-daughter exposures and health effects. Radon flux emanating from the surface of the tailings has been estimated to be about 50 picocuries per square meter per second at the site (Czarnecki and Langner, 1982). Radon flux is a measure of the quantity of radon emanated from a unit surface area in a unit time period.

Natural gamma background exposure rates in the Monument Valley area vary between 7 and 11 microroentgens per hour (μR/hr), averaging 9 μR/hr, as measured 3 feet above the surface with an energy-compensated Geiger-Mueller detector (FBDU, 1977). Above the surface of the new tailings pile, the gamma-exposure rates measured in 1977 ranged from 39 to 79 μR/hr and averaged 58 μR/hr. At the old tailings pile and former millsite, gamma-exposure rates ranged from 23 to 157 μR/hr, with an average of 63 μR/hr (FBDU, 1981).

An aerial survey of the Monument Valley site was conducted by the EG&G Remote Sensing Laboratory in September 1980. This aerial survey reported gamma levels on the two piles in the range of 50 to 180 μR/hr, with one small area on the new pile where levels were in the range of 180 to 300 μR/hr. This survey did not identify the actual gamma level at any one point on the pile but only gave a range of values. For example, a single reading of 185 μR/hr would be reported as being in the range of 180 to 300 μR/hr, and a reading of 175 μR/hr would be reported as being in the range of 100 to 180 μR/hr. For this reason, the survey levels reported by EG&G are given here to show the general consistency with the earlier surface surveys but are not used in calculations of possible health effects from the tailings. The aerial survey confirms that gamma-radiation levels at the three dwellings near the site are in the range of 9 to 13 μR/hr. This is the natural background level in the Monument Valley area (Dahlstrom, 1982).

2.9 LAND USE

On the reservation, land is owned by the Navajo Tribe rather than by individual Navajos. Navajo families have traditional use of specific areas by "assignment," and, although in many respects assignees treat the land as though it is private property, they have no title to it. The Navajo Tribe makes the decisions pertaining to development on the reservation.

There is low-density grazing, basically by sheep and horses, within the vicinity of the tailings. Three dwellings are visible from the tailings site. To the east of the tailings is the Monument Valley Navajo Tribal Park containing 29,187 acres.

2.10 NOISE

Background noise levels were measured by FBD personnel in May 1982 at the Monument Valley tailings site and in directions toward areas where local residents live. The noise levels at these sites averaged between 45 and 51 decibels on the A-weighted scale. These low levels are typical of rural areas (EPA, 1972).

2.11 SCENIC, HISTORIC, AND CULTURAL RESOURCES

A search of cultural-resource records was conducted at the Navajo Tribal Museum and at the Arizona State Historic Preservation Office (SHPO) in 1982. No proximate cultural-resource sites are listed on the SHPO register or on the Navajo Tribal Museum register. Archaeological surveys performed within a 15-mile radius of the tailings site concern two building sites: one covering 0.5 acre, and one 1 acre. Other surveys conducted east and west of the project area have found moderate to high densities of sites. Records of these sites at the Navajo Tribal Museum indicate a high probability of moderate aboriginal site densities throughout the project area, with high site densities near permanent water sources and major drainages. Archaeological surveys performed east and west of Dinnehotso showed moderately high archaeological site densities, particularly adjacent to major drainageways and permanent water sources (Martin, 1973).

The tailings site is within 2 air miles of the eastern boundary of Monument Valley Navajo Tribal Park; however, the site is not visible from the park.

2.12 SOCIOECONOMIC CHARACTERISTICS OF THE AFFECTED REGION

This section briefly summarizes the more extensive discussion in Appendix G, Sections G.1 through G.11.

The readily accessible communities nearest to the site are Halchita, San Juan County, Utah, about 13 miles to the north; Mexican Hat, San Juan County, Utah, about 16 miles to the north; Goulding-Monument Valley, San Juan County, Utah, about 19 miles to the west; and Kayenta, Navajo County, Arizona, about 20 miles south of Goulding-Monument Valley on Highway 163 (Figure 1-1). Although Dinnehotso is approximately 6 miles southeast of the Monument Valley site, it is about 40 miles away by road (mostly dirt road). The tailings are more readily accessible from Highway 163 in Navajo County, which leads to Goulding-Monument Valley, Halchita, Mexican Hat, and Kayenta. Most of the socioeconomic impacts will be felt in San Juan County, Utah. The communities specifically examined in this section are those that will house the work force: Halchita and Mexican Hat.

Between 1970 and 1980, San Juan County experienced a 27.6-percent increase in population, from 9606 to 12,253 residents. This growth contrasts with the slower growth rate of 6.3 percent between 1960 and 1970. If planned energy developments occur, primarily in uranium and oil and gas production, San Juan County is projected to have over 20,000 residents by 1990 (Burnett, 1981). Given the depressed uranium market, a more likely 1990 estimate is slightly over 15,000 residents.

The predominant racial groups in San Juan County are whites and American Indians. The Navajo Indian Reservation, along the southern boundary of the county, is frequently referred to as the "Utah Strip." Halchita is the largest town (500 people) on the Utah portion of the reservation.

Single-family rental housing is difficult to obtain in the Mexican Hat and Halchita areas. Trailer parks are available, as is dormitory housing, for a total of approximately 80 units.

Unemployment in San Juan County was almost 9 percent for the first quarter of 1982. Mining accounts for 34 percent of the nonagricultural jobs, government for 27 percent, and trades and services for 25 percent (Utah Department of Employment Security, 1982). If planned energy developments continue to lag, unemployment is projected to increase.

San Juan County community services can accommodate some additional growth. The capacity of services in the unincorporated communities of Mexican Hat and Halchita varies. The elementary school can increase in enrollment by 23 students; a new high school will open in the Goulding-Monument Valley area in the fall of 1983. The hospitals in San Juan County are underused, but the Halchita Health Clinic is approaching a maximum patient load. Water and sewer systems can accommodate a significant increase in population.

San Juan County (off the reservation) has nine law-enforcement officers stationed at Blanding for a 0.74 ratio of officers to 1000 population, the lowest in Utah (Utah Department of Public Safety, 1980). In the Utah Strip,

law enforcement is provided by the Navajo Police, stationed at Kayenta, Arizona. The 31 officers in Kayenta are probably sufficient, but a geographic maldistribution exists in that the response time from Kayenta to Halchita would be approximately 30 minutes. Relocating 2 of the 31 officers would improve the distribution of officers.

Fire protection is inadequate because the equipment in Mexican Hat is antiquated and there is no equipment in Halchita.

The existing network of Federal and State highways is adequate for transporting both people and equipment. Federal and State Highway 163 could handle an additional 1000 daily trips. Portions of Navajo Route 6440, from Halchita to the site, are graveled; other portions are dirt. San Juan County has eight airports for light planes. The closest of the airports to the site is at Blanding, 40 miles away.

Fiscally, San Juan County can afford growth. The county can bond an additional $13 million. Data describing the fiscal capacity of the Navajo Nation, and specifically of the Utah Strip, are not available.

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3 ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

This chapter assesses the impacts that the proposed remedial action would have on the environment described in Chapter 2. It briefly describes the ways in which the impacts of the alternative actions would differ from those of the proposed action.

3.1 IMPACTS OF RELEASES OF RADIATION

The radiation from the Monument Valley site may increase the potential for health effects among people who live and work nearby. This section describes the expected impacts of radiation releases during the proposed action. To show the improvement that the action will accomplish, this section also describes the impacts of the radiation currently emitted from the piles; these impacts will continue to occur if no action is taken.

3.1.1 Pathways and mechanisms for the transport of radioactive material to people

There are five principal potential environmental pathways of exposure to man from the tailings radiation:

1. Inhalation of short-lived radon daughters resulting from the continuous radioactive decay of the radium in the tailings. Radon is a gas that can diffuse through the tailings into the atmosphere. This gas decays into a series of daughter products; when these daughters are inhaled, they may be deposited in the bronchi and lungs where they then decay, emitting radiation.

2. External whole-body gamma exposure from the decay of radionuclides in the tailings.

3. Inhalation and ingestion of windblown tailings. The primary exposure is from the alpha emitters thorium-230 and radium-226, each of which deposits in the bones if ingested and in the bronchi and lungs if inhaled.

4. Ingestion of ground and surface water contaminated with radioactive elements (primarily radium).

5. Contamination of food through uptake and concentration of radioactive elements by plants and animals.

The population near the Monument Valley site is exposed to radiation from the piles primarily through inhalation of radon daughters; a minor part of the potential exposure is from gamma radiation. The other potential routes of exposure are much less significant near the site.

3.1.2 Radiation doses during remedial action

The model used to generate the estimates presented in this section does not account for natural variability among people, nor does it distinguish whether a person is a smoker. It assumes that health effects are linearly proportional to exposures, which means that any small exposure to radon daughters is assumed to be capable of producing health effects; making these and other assumptions differently could give rise to a rather large variance in the number of health effects predicted by the model. In this analysis these uncertainties are overcome by using conservative assumptions in the model so as not to underestimate the health effects caused by exposure to radon daughters. Also, the estimated radon-daughter exposure of persons near the Monument Valley tailings is small and well within the range of variability of exposure from natural background sources.

Health effects attributable to such a limited exposure are well below the limits of meaningful calculation. This analysis uses the model, along with conservative assumptions, to estimate an upper limit for possible health effects from radon-daughter exposure to the remedial-action work force and local population.

Approximately 44 weeks will be required to place and contour the contaminated material and to add the first clay cover, using a 52-person crew. It is during this period that exposure to radiation will be greatest. The additional 21 weeks of the project include site preparation, demolition, final covers, and fencing.

3.1.2.1 Radiation doses to the general public

The population around the site is exposed to radiation from the piles mainly through pathway 1 listed in Section 3.1.1. This exposure and the resultant health effects are discussed in this section. The methods of calculation are explained in Appendix H (Section H.2) of this assessment.

Three occupied Navajo residences are located at distances of 1000, 1500, and 1700 feet from the Monument Valley tailings. No others are within 1 mile of the site. In 1975, the latest date for which specific information is available, the number of persons residing in these dwellings was 8, 10, and 10, respectively (Hans and Douglas, 1975). It is assumed that these numbers have not changed since 1975. Appendix H describes the model used to estimate an upper limit to the exposure of these people to radon daughters from the Monument Valley tailings. The model accounts for the locations of persons, wind direction, and atmospheric dilution of the radon daughters.

In one year each person living in one of the three residences near the site presently receives an exposure as follows: for Residence No. 1, 0.28 mile (1500 feet) east of the site, 0.11 working-level month (WLM); for Residence No. 2, 0.32 mile (1700 feet) southeast of the site, 0.007 WLM; for Residence No. 3, 0.19 mile (1000 feet) south of the site, 0.018 WLM. This exposure is estimated to cause no more than 2.8×10^{-5}, or 0.000028, lung-cancer death per year of exposure among the 28 persons. Another way of expressing this is that one

fatal lung cancer due to the Monument Valley tailings might be expected to occur in such a population of 28 persons in about 36,000 years of exposure to the radon daughters from the tailings.

Statistics provided by the Arizona Department of Health Services (Dutton, 1982) indicate a total of 0.012 lung-cancer death per year from all sources in 28 persons living in Arizona, or that one fatal lung cancer from all sources might normally be expected to occur among the 28 persons in about 83 years.

During the 10 months that actual handling of the tailings is in progress, the radon-daughter concentration is assumed to double because of the disturbance of the tailings. Exposure to radon daughters from the Monument Valley tailings during the 10-month remedial-action period is estimated to cause an upper limit of 4.7×10^{-5}, or 0.00005, lung-cancer death among the 28 persons. Another way of expressing this is that one fatal lung cancer due to the remedial action would be estimated to occur among the 15 persons in about 18,000 years if they all could live that long and if the remedial action continued that long.

Because no permanent residents live within 500 feet (0.1 mile) of the piles and because gamma radiation from the site beyond this distance is negligibly small when compared with natural background, no health effects to the general public were attributed to gamma radiation from the piles. Similarly, for the other radiation pathways listed in Section 3.1.1, no exposures to the general public can be attributed to the tailings.

Under the no-action alternative, the tailings would continue to expose the 28 nearby people at the current rate. Consolidating the tailings with those from Mexican Hat would increase the exposure of these people, over the exposure during the proposed action, because the amount of tailings being handled at the site would be greater. Moving to the mine pit or Comb Ridge would also increase the exposure received by these people. The entire pile would be disturbed instead of only the parts that have to be moved; depending on the transportation routes, the tailings might pass by some of the residences.

3.1.2.2 Radiation doses to workers

A worker at the site would receive radiation exposure mainly from pathways 1, 2, and 3 listed in Section 3.1.1. These exposures and resultant health effects are discussed in this section. The methods of calculation are explained in Appendix H of this assessment.

To predict upper limits to the effects of the tailings, the radon-daughter concentration is assumed in this analysis to be 0.01 working level, which is a conservative estimate because it assumes 10-percent equilibrium and because it is roughly 50 percent higher than the level derived from the radon-concentration measurement between the piles (Section 2.8). During a 260-hour work month, rather than the standard 170-hour work month, a worker would receive 0.16 WLM in 44 weeks of direct work on the tailings.

When some of the tailings are moved during the remedial action, the loosening of the disturbed material will allow radon gas to escape more quickly than from undisturbed tailings. No quantitative data exist on the amount of

increase, which would depend, for example, on the method of disturbance and the moisture content and cohesiveness of the tailings. Only a small fraction of the total surface of the tailings will be undergoing disturbance at any time; nevertheless, this analysis, in an effort to bound the effects of the more rapid release, assumes that the average radon concentration over the entire pile and over the 44-week working period will be double the existing concentration. Under this assumption, this analysis predicts that a worker would receive an exposure of 0.32 WLM over the approximate 10-month period of the remedial-action project.

The estimator described in Appendix H predicts that the exposure of an individual crew member to 0.32 WLM would result in a risk of dying from lung cancer attributable to the radiation of 3.2×10^{-5}, or 0.00003. This risk may be compared with the average normal risk, approximately 0.02 (Appendix H, Section H.4) of dying of lung cancer in Arizona. In other words, an Arizona resident normally has about 1 chance in 50 of dying of lung cancer; a worker on the Monument Valley remedial action might theoretically increase this risk by about 1 chance in 31,000.

In a work force of 52 persons, each exposed to 0.32 WLM from radon daughters during the remedial action, an upper bound to the number of lung-cancer deaths attributable to the exposure would be 1.7×10^{-3}, or 0.0017. This number may be compared to the approximately 1.1 deaths from cancer that would normally be expected among 52 people at the current rate prevailing in Arizona.

Since workers on the site would be directly exposed to uncovered tailings during moving and shaping operations and when the cover is first added, gamma-radiation exposures to workers would be greatest then. Once the tailings begin to be covered, gamma-radiation exposure levels would diminish rapidly. The level of gamma radiation on the new tailings pile averages 58 microroentgens per hour (μR/hr) including a background of about 9 ± 2 μR/hr. At the old tailings pile and former millsite, the gamma-radiation level averages 63 μR/hr including background (FBDU, 1981). To determine the highest estimate of the overall hazard, the value of 63 μR/hr is used as the gamma-radiation level on the work area at Monument Valley. It is assumed that a remedial-action worker will be exposed at this level of gamma radiation for 44 weeks before the millsite is cleaned up and sufficient cover is placed on the pile to reduce gamma radiation nearly to background. The worker's exposure to gamma radiation above background from the tailings will be 2640 hours x (63-9) microroentgens per hour, or 143,000 microroentgens (143 milliroentgens) total. According to the risk estimators in the BEIR-III report (National Academy of Sciences, 1980) shown in Appendix H, this one-time exposure of a male aged 20 to 49 will theoretically result in an individual risk of dying from cancer of 1.1×10^{-5} (Appendix H). The average normal risk of dying of cancer in the state of Arizona is much larger, about 0.12 (Appendix H, Section H.4). In other words, the normal risk of about 1 chance in 8 of dying of cancer would be increased by about 1 chance in 91,000.

The estimated upper limit for excess cancer deaths in a 52-person work force because of exposure to gamma radiation during the remedial action is 5.7×10^{-4}, or 0.0006. This number may be compared with the approximately 5 deaths from cancers other than lung cancer that would be expected among 52 persons at the 9-percent rate prevailing in Arizona.

Workers who are not at the Monument Valley site continually during the remedial action will receive even smaller doses of radiation. For example, the driver of a truck hauling typical contaminated material from a vicinity property 10 miles away would receive a dose of less than 0.12 milliroentgen per load (DOE, 1982a).

Remedial-action workers on the Monument Valley site will probably inhale some contaminated dust raised by earthmoving equipment. The degree of exposure they receive will be limited by the use of water-sprinkling equipment and other dust-suppression techniques that will hold the atmospheric concentrations of potential air pollutants below the limits established by Federal agencies. For occupational exposure at 40 hours per week, these limits are 0.33 working level for radon daughters (10 CFR 20, Appendix B), 0.03 picocuries per liter for radium-226, and 5 milligrams per cubic meter for respirable dusts (29 CFR 1910.1000). To verify that these limits are not exceeded, the remedial action will include air sampling during the earthmoving activities.

The inhalation of dust by the workers at Monument Valley would not increase appreciably the estimated exposures calculated in this section. Detailed calculations of workers' exposures from inhaling dust have been carried out for the proposed alternative remedial actions at the Vitro tailings site near Salt Lake City (DOE, 1982b). These actions, especially the alternative of stabilization in place, are similar to the work proposed at the Monument Valley site. The calculations show that the radiation doses from inhaling dust are a small fraction, typically 2 percent or less, of the doses from exposure to radon daughters and gamma radiation.

Under the no-action alternative, no remedial-action workers would be exposed to radiation from the tailings. Under any of the alternatives calling for bringing in more tailings or for moving the tailings, the exposure of the workers would be increased because of the longer time required for carrying out the remedial action and the necessity for handling the tailings twice, once at the present piles and once at the disposal site.

3.1.3 Radiation doses from hypothetical accidents

High winds occurring while the tailings are being moved could blow some of the loose material from the working area into inhabited areas or open rangeland. In principle, the radioactive material could then contaminate vegetation, which ultimately could be ingested by beef cattle. Only a small fraction of the loose material could be picked up, and it would be spread over a large area. No grazing animal would be expected to consume enough contaminated vegetation to deposit hazardous amounts of radioactive material in its flesh. No significant impact in terms of increase in public exposure to radiation is projected.

If a truck carrying contaminated material from one of the 12 vicinity properties were to overturn on a public road, persons who stood near the material would be exposed to a low level of radiation. This exposure would be brief--roughly, no more than a few hours--because the crew from the Monument Valley site would go to the accident scene and reload the material; members of

the general public would be kept at a distance. Someone standing 10 feet away from the truckload of typical vicinity-property material for 3 hours would receive a radiation dose of less than 0.1 milliroentgen (DOE, 1982a). Such a dose would be much smaller than the doses derived for workers in Section 3.1.2.2, and the possibility that it would produce health effects would be so small as to have little meaning.

Under the no-action alternative, no remedial action and, hence, no accidents would occur. Under the alternatives for moving tailings, the spill of tailings from a truck would become more likely because the truck traffic would be greatly increased. The consequences of such spills would remain an inappreciable addition to the exposure normally received from background sources of radiation or from the proposed action.

3.1.4 Radiation doses after remedial action

The remedial-action efforts that have been proposed for the Monument Valley site are designed to reduce radiation doses to meet the proposed standards established by the U.S. Environmental Protection Agency (EPA). At this level the doses received from exposure to radon daughters from the Monument Valley site will be comparable to those from natural background. They will, in fact, lie within the normal range of variation of exposure from natural background levels of radon daughters (EPA, 1980). Radon flux from the tailings will be reduced from the present level of 50 picocuries per square meter per second (pCi/m^2-s) to an estimated 9.0 pCi/m^2-s.

The no-action alternative would allow the present exposure of nearby residents (Section 3.1.2.1) to continue indefinitely. All of the other alternatives would meet the EPA standards.

3.2 IMPACTS ON AIR QUALITY

Preliminary estimates suggest that the equipment in use during the remedial action would consume about 685,000 gallons of fuel over a period of about 15 months (see Appendix C, Section C.1.3).

Emission factors for earthmoving equipment (EPA, 1975) predict that the following amounts of substances would be released to the atmosphere each month for 15 months: carbon monoxide, 4180 pounds; hydrocarbons, 1370 pounds; oxides of nitrogen, 23,900 pounds; sulfur dioxide, 1420 pounds; and particulates, 810 pounds.

In addition to these fuel-consumption emissions, fugitive-dust releases resulting from earthmoving activities and amounting to about 23,000 pounds per month for 15 months would be expected and would be visible in high winds (see Appendix C, Section C.1.4). However, the fugitive dust would not cause a long-term impact. Control measures, such as watering dusty areas and reducing vehicle speed, will help to minimize fugitive dust.

The no-action alternative would not change the air quality. All of the alternatives for moving the tailings would increase the pollutants emitted by vehicles because they require that the tailings be hauled over distances ranging from nearly 1 mile, in alternative 2, to 18 miles, in alternative 3. Under alternatives 3 and 4, fugitive dust would be raised at the disposal site, as well as at the tailings site.

3.3 IMPACTS ON SOILS

Soils at the Monument Valley site have been previously disturbed during milling operations. Under the proposed action, additional areas would be disturbed to obtain cover material; however, as these areas are covered with active sand dunes, they have not developed a true topsoil. Some new road construction may be necessary, in which case topsoil could be disturbed.

The no-action alternative would not affect soils. The alternatives for moving the tailings would require cover materials similar to those needed for the proposed action; they would, therefore, have similar impacts on soils. In addition, the alternative of moving to the site near Comb Ridge would require disturbing the existing soil at a previously undisturbed disposal site.

3.4 IMPACTS ON MINERAL RESOURCES

There should be no impacts on mineral resources because of the proposed action. While the pile is located on the uranium-bearing formation of the area, uranium mineralization tends to occur in the bottom of the troughs, and the site is located on the rim of a trough. Oil or gas deposits could be found in the area, but the pile will not cover a large enough area to interfere with any recovery efforts.

None of the alternatives to the proposed action would be expected to affect mineral resources.

3.5 IMPACTS ON WATER

As noted in Appendix C, the demand for water during remedial-action operations will amount to approximately 8.6 million gallons (7.9 million gallons for dust control and 670,000 gallons of potable water). This water can presumably be supplied by an existing 12-inch diameter well located on the millsite, following the acquisition of appropriate temporary water-use permits. This water will be consumed and will, therefore, be lost from the source. As noted in Appendix E, the withdrawal of this will not adversely affect local water wells in current use.

In addition, the increased population in the area brought on by the remedial-action operations will place an additional domestic-water demand of about 5 million gallons on existing systems (see Appendixes C and G). Water-supply systems in the nearby communities of Halchita and Mexican Hat appear to be adequate to handle this increased demand (see Appendix G).

Assuming that proper sediment and runoff control practices are employed during remedial action, no degradation of local surface waters is expected during cleanup operations. Following remedial action, the source of potential contamination will have been stabilized, thereby eliminating future pollution from the tailings area.

Removal of tailings from the area of influence of the ephemeral wash crossing the old pile will eliminate the possibility that surface water in the wash will reach the tailings. The clay cap covering the stabilized pile will prevent significant infiltration into the tailings following remedial action. As a result, leaching of the stabilized pile should be negligible. Thus, future ground-water contamination by the stabilized pile will be eliminated.

In addition to reduced leaching of the tailings, other subsurface hydrologic conditions exist that should prevent future ground-water contamination. The tailings are resting on unsaturated materials at varying heights above the potentiometric surface (see Section 2.6). Several investigations have shown that the rate of moisture movement in the unsaturated zone is very low (fractions of an inch per year, compared to feet per year in the saturated zone; see, for example, Freeze and Cherry, 1979; Yeh and Ward, 1980). Below the old tailings pile, the depth to water appears to be about 70 feet. Although the depth to water below the new pile is less, ground water at this point appears to be confined (i.e., upward pressure gradients exist). Hence, under either pile, thousands of years would probably be required for moisture to migrate from the tailings to the underlying saturated zone. Sorption, decay, and geochemical interactions would delay the rate of contaminant movement even more (Freeze and Cherry, 1979).

Geochemical conditions at the site should also prevent ground-water contamination. Because the milling and leaching process involved the use of acid (FBDU, 1981), the tailings are assumed to be somewhat acidic. These tailings rest on bedrock that is alkaline in nature, as indicated by the presence of calcium-carbonate cementing agents (Whitkind and Thaden, 1963). Typically, in environments consisting of acidic tailings overlying alkaline-host materials, chemical precipitation levels within a few feet of the

tailings-host material interface (Shepherd and Brown, 1982). These conditions should prevail indefinitely, thereby further reducing the potential for future migration of contaminants from the piles to underlying ground-water systems.

Under the no-action alternative, the tailings would remain isolated from ground water, but wind and water could gradually move some tailings material toward surface waters. The movement of contaminants by erosion would probably remain slow enough that the concentrations in surface waters would not greatly exceed the current values reported in Section 2.6.1. The other alternatives would, like the proposed action, provide long-term isolation of the tailings from ground and surface waters.

3.6 IMPACTS ON PLANTS AND ANIMALS

Only minor adverse biological impacts would be associated with the remedial action. The tailings piles are practically devoid of life; consequently, stabilization of the contaminated materials would improve conditions. The stabilized pile would provide a better habitat for animals, such as lizards, rodents, insects, and ground-nesting birds. During the remedial action, wildlife activities would be decreased because of noise and encroachment. This impact would be eliminated after the completion of the work.

Vegetation losses would occur at each borrow site. This would result in loss of wildlife habitat and some wildlife deaths caused by heavy equipment operation. Once the work is completed the borrow sites can be revegetated, thereby restoring the wildlife habitat.

No threatened or endangered species would be affected. No habitat or vegetation of special interest would be impacted. Impacts to game species would be minimal.

The no-action alternative would leave the piles as they are, supporting few wildlife. Moving the tailings from Mexican Hat to the Monument Valley site would affect the site in much the same ways as the proposed action, except that the temporary disturbances would last longer. The alternatives for moving the tailings would temporarily disturb wildlife at the new disposal site. Because these alternatives would use much the same kinds of wildlife habitat as the present piles and the proposed borrow areas, they would be unlikely to affect any threatened or endangered species.

3.7 IMPACTS ON LAND USE

The proposed action is not expected to have any long-range negative impacts on land use. Grazing will be disrupted in the near vicinity for the short term during remedial action. The site is located in an area with no special qualities that suit it for unusual activities; it is similar to most of the territory surrounding it. There are no communities close to the site that need the area for expansion. The site's only forseeable agricultural use is for low-density grazing, and the few acres associated with it are insignificant in comparison with the amount of rangeland available.

The no-action alternative would not change land use. The other alternatives would affect land use in about the same way as the proposed action.

3.8 IMPACTS ON NOISE LEVELS

Noise impacts during the proposed action would affect the remedial-action workers and people who live nearby or along the haul roads. Each remedial-action activity uses its own particular mixture of equipment items, as shown in the preliminary estimates for the project (see Appendix C, Sections C.2 and C.3). The combined noise levels of the maximum number of equipment items at work at one time at any activity are shown in Appendix C, Table C-10. The approximate noise environment for a remedial-action worker is given under the heading "50 feet," which is the assumed average distance between the worker and the noise source. Residents 50 feet to 1 mile away would experience noise impacts as shown in the other columns of the table.

The maximum sound level to which workers will be exposed is about 110 decibels on the A-weighted scale (dBA). This will occur during the 1.5 months of rock drilling and will come mainly from jackhammer and rock-drilling equipment. Workers using this equipment normally wear ear-protective devices that reduce the sound to levels below 90 dBA.

Residents an eighth of a mile away would be subjected to sound levels ranging from about 60 to 88 dBA, depending on the remedial-action activity and the equipment being used. These sound levels are typical of many industrial activities (EPA, 1972) and will not cause permanent hearing damage to residents during the remedial action; for example, sounds in this range are comparable to the sound of a passing automobile or light truck heard from 20 feet away. A person 50 feet from one of the haul roads would experience noise levels of 82 to 93 dBA during the passage of a large truck.

Blasting of rock will be done during about 1.5 months of the remedial action, producing brief but intense impulse-type sounds. The nearest residents are about 1 mile from the rock-borrow site. The sound levels and frequency of the noise depend on variables such as the kind of rock, the drilling geometry, and the size of charge and type of blasting chemical used. These variables will be determined at the time the work is performed; therefore, sound-level estimates are not offered here.

The no-action alternative would not affect noise levels. The other alternatives would produce noise levels similar to those of the proposed action with the addition of noise from trucks hauling tailings; the workers would be exposed to similar noise for a longer time, and the public along the haul routes would hear more trucks for a longer time.

3.9 IMPACTS ON SCENIC, HISTORIC, AND CULTURAL RESOURCES

No impact is foreseen on the Monument Valley Navajo Tribal Park. As workers commute to the site from Halchita, the increased traffic would not interfere with the activities of the tourists or be visible from the park.

The remedial action at previously undisturbed borrow sites could affect cultural resources because archaeological sites have been found at low to moderate densities in the area. The potential for the existence of such sites will be taken into account by a Class III archaeological survey conducted before the disturbance of the borrow sites.

None of the alternatives would affect scenic resources. Because archaeological field surveys would precede work done under the alternatives for moving the tailings, no impacts on historic or cultural resources would be expected.

3.10 IMPACTS ON POPULATION AND WORK FORCE

This section briefly summarizes the more extensive discussion in Appendix G, Sections G.12 through G.16.

The proposed action would generate 52 direct job slots at peak activity for a period of 1.3 years, assuming a 60-hour work week. With a 15-percent turnover for locally filled direct job slots, the total work-force slots would be 58. The county and the Navajo job market can supply 40 workers; however, 12 managerial and health specialists would need to in-migrate. The 52 direct job slots would generate 16 indirect job slots if the 1.3 multiplier assumed in this analysis is appropriate. Of the indirect slots, 8 would presumably be filled by in-migrants. Thus, of the 74 direct and indirect job slots, 20 would be filled by in-migrants, generating an additional population of 53 people. Of the 53 people, 19 are assumed to be of school age.

The no-action alternative would not affect the local population and would provide no jobs. The other alternatives would take longer than the proposed action and would probably require an appreciably larger crew; the number of in-migrants would be greater.

3.11 IMPACTS ON HOUSING, SOCIAL STRUCTURE, AND COMMUNITY SERVICES

Details of the predictions summarized in this section appear in Appendix G, Sections G.16 and G.17.

At any given time the peak work force (52) and the indirect work force (16) would require a maximum of 68 housing units. In June 1982, Mexican Hat and Halchita had 80 available spaces for mobile homes and dormitory facilities (see Appendix G). Water and sewer facilities are adequate for the increased population.

Because local contractors would be used, disruption of the social system should be minimal.

Service areas that are currently at or below standards would be further strained by the proposed action. These areas include the 19 school-aged children who would fill the remaining physical capacity of the elementary school; fire equipment may need to be procured for Halchita; and two law-enforcement officers may need to be stationed in Halchita rather than Kayenta, Arizona.

The no-action alternative would not exert any of these impacts. The other alternatives would use larger crews than the proposed action, but the 80 available nearby spaces would probably be adequate. The small strains on services that might arise from the proposed action would be made larger by these alternatives.

3.12 IMPACTS ON ECONOMIC STRUCTURE

The proposed action would cost about $10.4 million. The State of Utah and San Juan County would benefit through sales taxes on the goods and services workers purchase off the reservation. The fiscal impact on the Navajo Reservation is not predicted because data describing the current fiscal situation are not available.

The no-action alternative would add no money to the economy. The other alternatives would cost more than the proposed action; the alternative of moving the tailings to the mine pit would add little more money to the local economy; disposal near Comb Ridge would add roughly twice as much. Moving the tailings from Mexican Hat to Monument Valley would have perhaps five times as much fiscal impact.

3.13 IMPACTS ON TRANSPORTATION NETWORKS

State and Federal Highway 163 can accommodate up to 500 additional round trips per day (see Appendix G). The remedial action would not exceed that capacity. Haul roads to borrow sites on the Navajo Reservation would need some upgrading. Navajo Route 6440, a portion of which is a gravel road, would need to be improved at some of the drainage crossings.

The no-action alternative would not affect roads. The alternatives for moving the tailings would increase traffic significantly more than the proposed action will. Most of this increased traffic would move over roads on the reservation; the affected roads would require upgrading to handle the movement of the tailings. The amount of additional traffic can be roughly estimated as follows: to haul 820,000 cubic yards of material in 12-cubic-yard trucks would require about 68,000 round trips. The round trip to the mine pit would be 1.5 miles, requiring more than 100,000 vehicle-miles for moving the material there; the 17-mile round trip to Comb Ridge would require about 1.2 million vehicle-miles. Moving the 2.2 million cubic yards of tailings from Mexican Hat would require more than 6 million vehicle-miles. More detailed estimates might be smaller, but the alternatives would add significantly to the traffic that the proposed action will generate.

3.14 USE OF ENERGY AND OTHER RESOURCES

The proposed action will use about 685,000 gallons of fuel; this total includes both diesel fuel and gasoline. This number has been generated from average-use factors for the equipment types expected to be used (Caterpillar Tractor Company, 1981). (See Appendix C, Section C.1.3, for details.)

Potable-water consumption is expected to be about 670,000 gallons, estimated for the average number of workers (49) at 35 gallons each per day for 390 working days. This water could presumably come from wells located on the millsite. It appears that only one other well, a flowing well near Cane Valley Wash (Appendix E), in the immediate vicinity of the tailings piles is completed in the same aquifer as the millsite wells. Should pumping during remedial action adversely affect this flowing well, some water may also need to be supplied to the local residents. Other wells in the area are completed in the shallow unconsolidated deposits in the valley bottom, with no apparent hydraulic connection to the aquifer tapped by the millsite wells (Section 2.6.2). These shallow wells should, therefore, not be affected by pumping the millsite wells.

Water for dust control and for compacting cover material could also be supplied from local wells. Two 4000-gallon water trucks would be used to haul this water. Each of these trucks would make three trips per day for the 331 days of work for which water would be required, for a total of about 7.9 million gallons. The minor amounts of water for equipment washdown and other minimal construction-site uses are included. About 4.9 million gallons of water will be needed for domestic use (see Appendix C, Section C.1.6).

The no-action alternative would not have these impacts. The other alternatives would require appreciably more fuel because they would require hauling the tailings to a new disposal site; they would require more potable water because they would require workers for a longer time. They would require water for dust control at the disposal site as well as at the present tailings site.

3.15 ACCIDENT IMPACTS NOT ARISING FROM RELEASES OF RADIATION

The remedial action at the Monument Valley site would require the hauling of rubble, tailings, contaminated topsoil, and cover materials. An estimated total of 169,000 vehicle-miles would be required to accomplish this (see Appendix C, Section C.1.3). Accident statistics (DOT, 1980) show an 11-year average of 3.73×10^{-8} fatalities per vehicle-mile for all types of vehicles. Vehicle-related accidents during the proposed remedial action are therefore expected to produce 0.01 death. Truck transportation also produces 7.94×10^{-6} vehicle accidents per mile (NSC, 1980) that do not involve fatalities. Truck transportation during the proposed action will therefore produce one or two (1.3) nonfatal vehicle accidents.

Published accident statistics (AEC, 1972; BNL, 1975) related more specifically to the nuclear-energy industry show that the probability of a nonfatal truck accident ranges from 1.6×10^{-6} to 2.6×10^{-6} per vehicle-mile. According to these estimates, the Monument Valley remedial action would produce about 0.4 vehicle accident.

During the operation of machinery such as trucks, tractors, forklifts, and cranes, about 0.15 accident will occur per man-year (DOT, 1977). The remedial action at the Monument Valley site has been estimated to require about 96 man-years of labor (see Appendix C, Section C.1.3); therefore, about 14 nonfatal accidents resulting in loss of work time would be expected during the remedial action.

The no-action alternative would not cause any of these accidents. The other alternatives would require hauling the tailings to a new disposal site. The rough estimate of the additional vehicle-miles required by the alternatives (Section 3.13) shows that the alternatives would produce more traffic accidents than the proposed action, although they would not be expected to produce any fatalities. The alternatives would require more work with machinery over a longer time; they would, therefore, produce appreciably more accidents than the proposed action.

3.16 MITIGATION MEASURES

The work performed during the remedial action will be conducted in accordance with State and Federal safety rules and regulations.

Monitoring of windblown dust will help in guiding efforts to suppress fugitive dust and prevent the recontamination of cleaned areas by moving equipment. Dust-abatement procedures will keep windblown dust to a minimum. Dust masks and ear-protection devices will be available to workers at the site during stabilization operations. Standard construction practices will be used to isolate work areas and limit the total area of active disturbance.

Total shielding of the workers from gamma radiation while moving and recontouring the contaminated material is not practicable. However, once the application of soil cover is under way, the workers will spend most of their time on top of the soil cover, which will shield them from nearly all of the gamma radiation from the contaminated material.

The borrow sites will require reclamation. The slopes will be shaped to ensure stability. Haul roads will be ripped and scarified.

To prevent access to the site after remedial action, a site-control program will be established; the area may be fenced, and ownership will be transferred to the Federal government, probably to the U.S. Department of Energy. A permanent ground-water monitoring system will be located downgradient from the stabilized pile to determine whether any contamination is migrating from it, in compliance with U.S. Environmental Protection Agency standards. An inspection will be conducted to determine the need, if any, for continued maintenance and monitoring. The requirements for inspection will be specified by the U.S. Nuclear Regulatory Commission (NRC) in their licensing of the maintenance of the disposal site. The NRC will also evaluate the results of the inspection and make further recommendations.

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4 SUMMARY

4.1 THE PROPOSED ACTION

The Monument Valley millsite and tailings are located in northeastern Arizona, in Apache County, about 6 miles north of Dinnehotso, Arizona. The site is about 5 miles south of the Utah-Arizona border just west of Cane Valley Wash, on the northeastern part of the Navajo Indian Reservation.

The proposed remedial action is the consolidation of the tailings and contaminated material to a location near the present "new tailings pile." A 2-foot clay layer, 4.5 feet of silty sands, and a 1.5-foot mine-run riprap cap would cover the pile. All of these materials would be obtained within 1 mile of the site. The pile, in the shape of a truncated pyramid, would be approximately 50 feet high with 5:1 side slopes. Proper contouring of the pile and diversion of surface water would help to minimize wind and water erosion.

The proposed remedial-action program has been developed to meet the standards of the U.S. Environmental Protection Agency for the disposal of tailings and the cleanup of contaminated land.

Standard earthmoving equipment would accomplish the remedial action. The work required by the preliminary plan presented in this assessment would take 65 weeks with an average of 49 workers and a cost of $10.4 million.

4.2 SUMMARY OF THE ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

Table 4-1 summarizes the short-term and long-term impacts (discussed in Chapter 3) of the proposed remedial action. The short term is the period of about 65 weeks when the remedial action is carried out. The long term is the indefinitely long period after the work has been completed.

Table 4-1. Summary of the environmental impacts of the proposed action[a]

Affected part of environment	Short-term impacts (during remedial action)	Long-term impacts (after remedial action)
Radiation	Possible increase in radon-daughter concentration at the site (from 0.01 to 0.02 working level)	Reduction of radon-daughter concentration at the site to background levels (about 0.0006 working level, which is the radon background of 0.6 pCi/l at 10-percent equilibrium)
	Possible increase in radon flux because of disturbance of the tailings surface	Reduction of radon flux to 9.0 picocuries per square meter per second
	Possible intermittent increases in windblown tailings depending on wind velocities during remedial action	Elimination of windblown tailings
	Gamma exposure to workers (143 milliroentgen from the tailings over 10 months compared to natural background of about 66 milliroentgen over 10 months)	Reduction of gamma-radiation levels to background (9 microroentgen per hour or approximately 79 milliroentrgen per year)
Air quality	Increase in air pollutants during operation (quantities vary according to pollutants)	Decrease in windblown fugitive-dust particles
	Increase in fugitive-dust emissions (quantities vary with wind velocity)	
Soils		No impacts expected on topsoils
Minerals		No impacts expected on mineral resources

Table 4-1. Summary of the environmental impacts of the proposed action[a] (continued)

Affected part of environment	Short-term impacts (during remedial action)	Long-term impacts (after remedial action)
Water	Increased demand for potable water (670,000 gallons onsite worker use plus 4,870,000 gallons domestic use over 65 weeks)	Decrease in radioactivity of surface runoff
	Increased use of water for dust control (7,900,000 gallons)	
Plants and animals	Minor disruption of wildlife from machinery noises and encroachment	The stabilized pile will provide an improved wildlife habitat for various animals (i.e., lizards, rodents, insects, and ground-nesting birds)
	Disturbance of plants and wildlife on borrow sites	
Land use	Disruption of grazing	No impacts expected
Noise	Increase in noise on the site (short intermittent periods of 90 to 110 decibels on the A-weighted scale)	
	Increase in noise heard by residents (short periods of 60 to 93 decibels on the A-weighted scale)	
Scenic, historic, and cultural resources	No known impacts	
Population and work force	Increased employment positions (52 at peak)	
	Increased population (53 people at peak)	

Table 4-1. Summary of the environmental impacts of the proposed action[a] (continued)

Affected part of environment	Short-term impacts (during remedial action)	Long-term impacts (after remedial action)
Housing, social structure, and community services	Adequate housing, water, and sewer available	
	Schools may be filled to capacity; additional fire and police protection already needed for area; remedial action may exacerbate existing conditions	
Economic structure	Increased revenue to local area both on and off the reservation (expenditure impact of over $10 million)	
Transportation networks	Additional commuting traffic	
	Upgrade several haul roads	Upgraded road may be left for use of locals
Energy use	Irretrievable use of fuel (685,000 gallons) during remedial action	
Nonradiation accidents	Potential for up to two nonfatal accidents involving vehicles during earthmoving activities	
	Potential for worker accidents on the site during remedial action (14 injuries, all nonfatal)	

[a]Quantitative estimates of impacts are in parentheses.

GLOSSARY

GLOSSARY

alpha particle	A positively charged particle emitted from certain radioactive materials. It consists of two protons and two neutrons, and is identical with the nucleus of the helium atom. It is the least penetrating of the common radiations and hence is not dangerous unless alpha-emitting substances have entered the body.
aquifer	A unit of unconsolidated or consolidated material that is sufficiently permeable to conduct ground water; the source of wells. A confined aquifer is overlain by relatively impermeable material. An unconfined aquifer is one associated with the water table.
A-weighted scale (dBA)	Sound pressure level measured by a standard sound level meter. This scale is most commonly used to measure environmental noise and is often supplemented by the time and duration of the noise to determine the total quantity of sound affecting people.
background radiation	Naturally occurring low-level radiation to which all life is exposed. Background radiation levels vary from place to place on the earth.
BEIR	Biological Effects of Ionizing Radiation. An acronym for a committee of the National Academy of Sciences and a report, The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980, generated by the committee.
beta particle	A particle emitted from some atoms undergoing radioactive decay, identical to an electron. Beta radiation can cause skin burns, and beta emitters are harmful if they enter the body.
Class I to III archaeological surveys	Relates to an archaeological investigation of probable occurrence of cultural resources within a given locale. A Class I survey is a literature search for predetermined archaeological treasures of historic significance; a Class II survey is a combination of a literature review and a partial but cursory excavation of an area to determine the presence of cultural resources; a Class III survey is an in-depth excavation of an area to determine the presence of archaeological materials where the likelihood of their occurrence is high, based on the history of the area.
curie (Ci)	The unit of radioactivity of any nuclide, defined as precisely equal to 3.7×10^{10} disintegrations per second.

daughter product	The nuclide remaining after a radioactive decay. A daughter atom may itself be radioactive, producing further daughter products.
dose	A general term denoting the quantity of radiation or energy absorbed.
emanation	Emission of radon from radioactive materials within the earth.
exposure	In a strict technical sense, a measure of the ionization produced in air by X or gamma radiation. The special unit of exposure is the roentgen, defined below. When the term "exposure" is used in connection with the inhalation of radon daughters, the special unit is the working-level month, defined below.
external gamma radiation	Gamma radiation emitted from a source(s) external to the body, as opposed to internal gamma radiation emitted from ingested or inhaled sources.
FBD	Ford, Bacon & Davis, Incorporated
gamma background	Natural gamma ray activity everywhere present, originating from two sources: (1) cosmic radiation, bombarding the earth's atmosphere continually, and (2) terrestrial radiation. The amount of natural gamma radiation absorbed by a person in the United States ranges from about 60 to about 125 millirems per year.
gamma ray	Electromagnetic radiation emitted from the nucleus of a radioactive atom, with specific energies for the atoms of different elements and having penetrating power similar to that of X-rays.
ground water	Subsurface water in the zone of full saturation.
health effect	Adverse physiological response from radiation exposure (in this report, one health effect is defined as one cancer death from exposure to radioactivity).
inert gas	One of the chemically unreactive gases: helium, neon, argon, krypton, xenon, and radon.
job slot	A labor position generated by the project.
lens	A geologic deposit thick in the middle and thin at the edges.
man-rem (person-rem)	A unit used in health physics to express amounts of radiation received by groups of people. It is obtained by summing individual amounts of radiation received by all people in the population.

mesic	Characterized by a moderate amount of moisture.
μR/hr	Microroentgen per hour (10^{-6} R/hr).
mR/hr	Milliroentgen per hour (10^{-3} R/hr).
minus-6-inch mine-run riprap	Angular rock material produced by blasting; can pass through a 6-inch sieve and has no more than 35 percent sand-sized fraction with the remaining material well-sorted gravel.
nuclide	A general term for an atomic species characterized by the constitution of its nucleus. Nuclides are distinguished by their numbers of protons and neutrons and by their energy state.
pCi/g	Picocurie per gram (10^{-12} Ci/g).
pCi/l	Picocurie per liter (10^{-12} Ci/l).
pCi/m^2-s	Picocurie per square meter per second (10^{-12} Ci/m^2-s).
rad	The basic unit of absorbed dose of ionizing radiation. A dose of 1 rad means the absorption of 100 ergs of radiation energy per gram of absorbing material.
radioactive decay chain	A succession of nuclides, each of which transforms by radioactive disintegration into the next until a stable nuclide results. The first member is called the parent, the intermediate members are called daughters, and the final stable member is called the end product.
radioactivity	The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation.
radium	A radioactive element, chemically similar to barium, formed as a daughter product of uranium (uranium-238). The most common isotope of radium, radium-226, has a half-life of 1620 years. Radium is present in all uranium-bearing material. Trace quantities of both uranium and radium are found in all areas, contributing to the background radiation.
radon	A radioactive, chemically inert gas. The nuclide radon-222 has a half-life of 3.8 days and is formed as a daughter product of radium (radium-226).
radon background	Low levels of radon gas found in air resulting from the decay of naturally occurring radium in the soil.

radon concentration	The amount of radon per unit volume of air. In this assessment, the average value for a 24-hour period, determined by collecting data for each 30-minute period of a 24-hour day and averaging these values.
radon daughter	One of several short-lived radioactive daughter products of radon (several of the daughters emit alpha particles).
radon-daughter concentration	The concentration in air of short-lived radon daughters, expressed in terms of working level (WL).
radon flux	The quantity of radon emitted from a surface in a unit time per unit area (typical units are pCi/m^2-s).
raptor	Bird of prey
recharge	The processes by which water moves into the zone of saturation of an aquifer, either directly into the formation or indirectly by way of another formation.
rem (roentgen equivalent man)	The unit of dose equivalent of any ionizing radiation which produces the same biological effect as a unit of absorbed dose of ordinary X-rays, numerically equal to the absorbed dose in rads multiplied by the appropriate quality factor for the type of radiation. The rem is the basic recorded unit of accumulated dose equivalent to personnel.
riprap	An irregular protective layer of coarse, broken rock.
roentgen (R)	A unit of exposure to ionizing radiation. It is that amount of gamma or X-rays required to produce ions carrying 1 electrostatic unit of electrical charge, either positive or negative, in 1 cubic centimeter of dry air under standard conditions, numerically equal to 2.58×10^{-4} coulombs per kilogram of air.
tailings	The remaining portion of a metal-bearing ore after most of the desired metal, such as uranium, has been extracted. Tailings also may contain other minerals or metals not extracted in the process (e.g., radium).
total suspended particulates (TSP)	Minute separate particles of matter.
UMTRA	Uranium Mill Tailings Remedial Action
vicinity properties	Properties to which contaminated material has been transported from the tailings site.

working level (WL)	A unit of radon-daughter exposure, equal to any combination of short-lived radon daughters in 1 liter of air that will result in the ultimate emission of 1.3×10^5 million electron volts of potential alpha energy. This level is equivalent to the energy produced in the decay of the daughter products that are present under equilibrium conditions in a liter of air containing 100 pCi of radon-222. It does not include decay of lead-210 (22-year half-life) and subsequent daughter products.
working-level month (WLM)	The exposure resulting from 170 WL-hours.

AGENCIES AND PERSONS CONSULTED

AGENCIES AND PERSONS CONSULTED

John S. Allan, Ph.D., Plant Ecologist, Orem, Utah, to assist in identifying plants from borrow sites and millsite vicinity.

Lois A. Arnow, Ph.D., Curator and Research Assistant Professor, Garrett Herbarium, University of Utah, Salt Lake City, Utah, to assist in identifying plants from borrow sites and millsite vicinity.

Levon Benally, Environmental Staff Assistant, The Navajo Nation Environmental Protection Commission (NEPC), Window Rock, Arizona, to ascertain whether specific permit requirements are needed by the NEPC before remedial-action operations.

Roy Dan, Advisor, Bureau of Indian Affairs, Tuba City, Arizona, to obtain information concerning special-permit needs on the site before remedial action is undertaken.

Kenneth Heil, Navajo Community College, Farmington, New Mexico, to obtain information on listed threatened or endangered plants.

Edward Olsen, Wildlife Biologist, U.S. Bureau of Indian Affairs, Window Rock, Arizona, to obtain information on Federally listed threatened or endangered wildlife.

Glen Rice, Director, Office of Cultural Resource Management, Arizona State University, Tempe, Arizona, to receive Class I archaeological survey data for proposed borrow sites.

Harold Tso, Navajo Environmental Protection Commission, Window Rock, Arizona, to obtain information concerning special permits and approvals for remedial-action activities on tribal lands.

Appendix A

U.S. ENVIRONMENTAL PROTECTION AGENCY STANDARDS FOR REMEDIAL ACTION AND U.S. NUCLEAR REGULATORY COMMISSION LICENSING CRITERIA FOR INACTIVE URANIUM PROCESSING SITES

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Appendix A

U.S. ENVIRONMENTAL PROTECTION AGENCY STANDARDS FOR REMEDIAL ACTION AND U.S. NUCLEAR REGULATORY COMMISSION LICENSING CRITERIA FOR INACTIVE URANIUM PROCESSING SITES

A.1 U.S. ENVIRONMENTAL PROTECTION AGENCY STANDARDS

As directed by Public Law 95-604, the U.S. Environmental Protection Agency (EPA) has issued health and environmental standards to govern the stabilization, control, and cleanup of residual radioactive materials at inactive uranium processing sites. The standards were published in the Federal Register (48 FR 590, January 5, 1983); they are in the Code of Federal Regulations, 40 CFR 192.

The standards are in two parts. The first part contains "Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites." Its purpose is "to provide for long-term stabilization and isolation in order to inhibit misuse and spreading of residual radioactive materials, control releases of radon to air, and protect water." It states numerical standards as follows:

Control shall be designed to:

(a) be effective for up to one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,

(b) provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:

(1) exceed an average release rate of 20 picocuries per square meter per second, <u>or</u>

(2) increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half picocurie per liter.

Footnotes to these standards explain that "monitoring after disposal is not required to demonstrate compliance" and that the average release rate applies "over the entire surface of the disposal site and over at least a one-year period."

In establishing guidance for implementing these standards, the EPA directs that the protection of water be considered on a "site-specific basis." The standards do not set numerical limits for the protection of ground water, but they state that "judgments on the possible need for remedial or protective actions for groundwater aquifers should be guided by relevant considerations described in EPA's hazardous waste management system (47 FR 32274, July 26, 1982) and by relevant State and Federal Water Quality Criteria for anticipated or existing uses of water over the term of the stabilization."

The second part of the standards deals with "Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites." It states numerical standards as follows:

> Remedial actions shall be conducted so as to provide reasonable assurance that, <u>as a result of residual radioactive materials from any designated processing site</u>:
>
> (a) the concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than--
>
> (1) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and
>
> (2) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.
>
> (b) in any occupied or habitable building--
>
> (1) the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL. In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL, and
>
> (2) the level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour.

Although the standards have been issued in final form, the EPA is still considering whether to set different standards for sites that the DOE has designated as having "low" or "medium" priority. In reviewing the standards, some Federal agencies suggested that less restrictive standards might be appropriate for such sites, most of which are in sparsely populated areas. The EPA has called for comments on this issue (48 FR 605, January 5, 1983). This environmental assessment assumes that the published standards for remedial action will continue to apply to all the sites, regardless of priority.

A.2 U.S. NUCLEAR REGULATORY COMMISSION CONCURRENCE AND LICENSING

The U.S. Nuclear Regulatory Commission (NRC) has not issued and does not intend to issue regulations that apply to the cleanup and disposal of residual radioactive materials at the Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I inactive uranium processing sites. In conformance with UMTRCA, NRC concurrence in proposed remedial actions and determinations as to the licensability of disposal sites for such materials will be to assure compliance with the final EPA standards discussed in Section A.1. On October 3, 1980, however, the NRC did issue regulations governing disposal of tailings from active uranium-milling operations. These regulations (45 FR 65533-65536) are not applicable to Uranium Mill Tailings Remedial Action Program remedial actions, but do contain technical criteria, primarily in the form of performance objectives, for disposal of uranium mill tailings. Although they will not be applied by the NRC to the inactive sites, the NRC technical criteria embody considerations that are relevant to the evaluation of remedial-action alternatives for an UMTRCA Title I inactive site.

Appendix B

APPLICABLE PERMITS, LICENSES, OR APPROVALS
FOR REMEDIAL ACTION
AT THE MONUMENT VALLEY SITE

Appendix B

APPLICABLE PERMITS, LICENSES, OR APPROVALS FOR REMEDIAL ACTION AT THE MONUMENT VALLEY SITE

Applicable permit, license, or approval	Granting or approving authority	Remarks
Cooperative agreement	Navajo Tribal Council, U.S. Department of Energy (DOE)	Prearrangement approvals and agreements between the DOE and the NEPC for all decontamination and remedial-action work on Uranium Mill Tailings Remedial Action Project sites on tribal lands.
Final license for disposal site	U.S. Nuclear Regulatory Commission (NRC)	Property and minerals to be maintained "in such a manner as will protect public health, safety, and the environment."
Activity-supervision approval	Navajo Environmental Protection Commission (NEPC), Window Rock, Arizona	An NEPC staff member must be present to oversee any remedial action activities on tribal lands.
Right-of-way permit	Bureau of Indian Affairs, Tuba City, Arizona	Placement of a service road on the site or installation of power lines require issuance of this permit.
Borrow site or tailings relocation site clearance approval	Arizona Historical Society, Bureau of Indian Affairs	Any proposed borrow sites or alternative tailings disposal sites must not impact any archaeological or other cultural resources in a project area.
Water well permit	Navajo Tribal Council	Culinary water use during project completion period; diversion rights from San Juan River or drill-site needs.

Appendix B (continued)

APPLICABLE PERMITS, LICENSES, OR APPROVALS
FOR REMEDIAL ACTION
AT THE MONUMENT VALLEY SITE

Applicable permit, license, or approval	Granting or approving authority	Remarks
Threatened and endangered species survey approval	U.S. Fish and Wildlife Service, U.S. Forest Service, Bureau of Land Management	Possible Section 7 consultation requirement in accordance with the 1978 amendments to the 1973 Endangered Species Act for borrow sites if threatened, endangered, or sensitive plant species are identified.

Appendix C

SUPPORT CALCULATIONS AND SCHEDULES

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SUPPORT CALCULATIONS AND SCHEDULES

C.1 VOLUMES OF CONTAMINATED MATERIALS

The information in this section has been derived from data taken from the Engineering Assessment of Inactive Uranium Mill Tailings, Monument Valley Site, Monument Valley, Arizona, prepared by FBDU (1981a) for the U.S. Department of Energy, Albuquerque, New Mexico. The volumes of contaminated subsurface and windblown areas are listed in Table C-1. Figure C-1 shows the location and configuration of the stabilized pile following remedial action.

Table C-1. Contaminated volumes

Area	Volume (cubic yards)
Old pile of tailings	123,000
New pile of tailings	698,000
Contaminated subsoil, old pile area	68,000
Contaminated subsoil, new pile area	105,000
Millsite area	12,000
Offsite contaminated windblown material	11,000
Onsite contaminated windblown material	37,000
Subtotal	1,054,000
Vicinity properties	1,200
Total	1,055,200

C.1.1 Vicinity properties

The following are generic assumptions for the 12 vicinity properties at Monument Valley:

1. There are 100 cubic yards of contaminated material and required fill at each property.

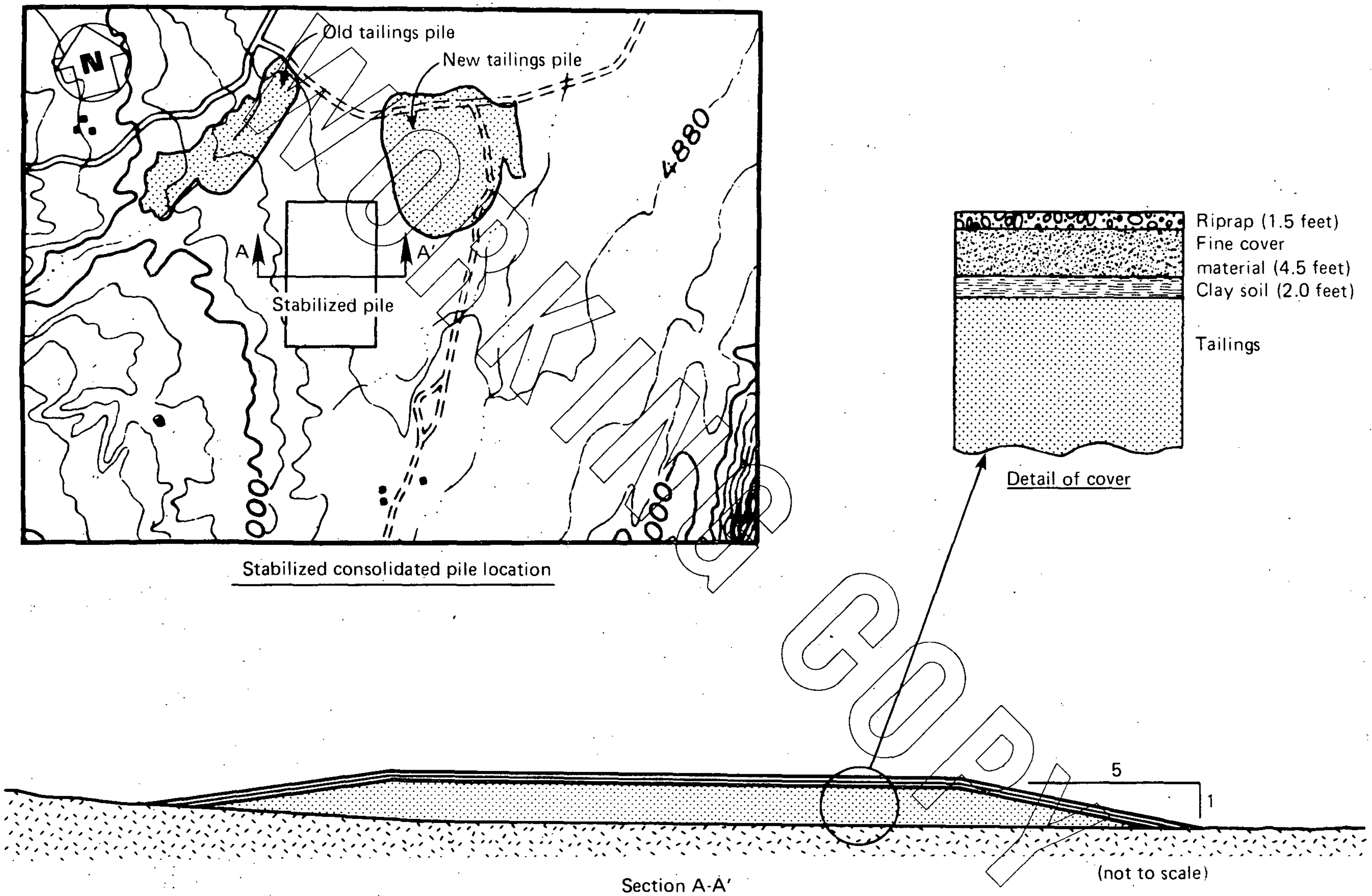

Figure C-1. Proposed action diagrams.

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2. Half the properties require a 5-mile haul and half require a 10-mile haul.

3. Fill is available at 5 miles from the properties.

4. Equipment is available within 5 miles of the property, and it is 5 miles from one property to another.

The assumed equipment for remedial action at the vicinity properties is shown below. This equipment is the same for both the 5-mile and 10-mile hauls.

1. Two "lowboy" trailers with trucks.

2. Ten dump trucks, 12 cubic yards each.

3. Three pick-up trucks.

4. Three front-end loaders.

5. Three bulldozers.

The relevant data per site, as calculated for the 5-mile haul situation, are as follows:

1. There would be about 400 gallons of fuel used. This number is from the number of running hours for the equipment times the hourly fuel use of the equipment.

2. The crew is estimated to be about 24 persons, working on the vicinity properties during site demolition and before material-handling work commences at the site. This is basically after the set-up and survey at the site.

3. It will take 3 work days to complete the remedial-action work at the six properties at 5 miles.

4. Adding the travel miles of the equipment items produces an estimate of about 330 vehicle-miles and 1000 yard-miles per property.

5. Based on $25 per hour for labor, and using the estimated hourly equipment involved, the cost per property is about $7920. Adding engineering fees and contingency gives a rounded total of $11,500.

The relevant data per site, as calculated for the 10-mile haul situation, are as follows:

1. There would be about 500 gallons of fuel used. This number is from the number of running hours for the equipment times the hourly fuel use of the equipment.

2. The crew is estimated to be about 24 persons, working on the vicinity properties during site demolition and before material-handling work commences at the site. This is basically after the set-up and survey time at the site.

3. It will take 3 work days to complete the remedial-action work at the six properties at 10 miles.

4. Adding the travel miles of the equipment items produces an estimate of about 480 vehicle-miles and 1500 yard-miles per property.

5. Based on $25 per hour for labor, and using the estimated hourly equipment charge for the equipment involved, the cost per property is about $9675. Adding engineering fees and a contingency gives a rounded total of $14,000.

The hours per day for each situation of 9 hours for two 5-mile properties and 11 hours for two 10-mile properties averages to the 10-hour day used throughout this document.

The total time for remedial action at the vicinity properties is the total for the 5-mile haul properties and the 10-mile haul properties as shown above, or about six work days, which is one six-day week.

C.1.2 Cover volumes for onsite stabilization

The contaminated materials would be relocated into a truncated pyramidal pile southwest of the existing conical pile. The total height of the pile including cover material will be 50 feet (see Figure C-1). The calculated overall dimensions at the base of the pile are 1367 by 912 feet.

The relocated tailings are assumed in the preliminary plan to be covered with 8 feet of cover material, consisting of 2 feet of clay soil, 4.5 feet of silty sand, and 1.5 feet of riprap. A total cover-material volume of 344,800 cubic yards is required. A breakdown of volumes by material type is included in Table C-2.

Table C-2. Cover-material volumes, onsite stabilization

Material type	Volume (cubic yards)
Clay-soil cover	81,200
Silty-sand cover	194,800
Riprap	68,800
Total	344,800

C.1.3 Duration, equipment fuel use, and vehicle-miles

The total volume to be moved is 1,055,000 cubic yards of contaminated tailings, dikes, and soils. To move this material will require 90,000 vehicle-miles and 255 days. The crew required for placing contaminated tailings, dikes, and soils will include the following:

Skill	Equipment	Number
Driver	truck	18
Foreman	--	5
Oiler	--	4
Surveyor	--	4
Health physics and radiological	--	5
Driver	water truck	2
Operator	front-end loader	4
Operator	dozer-scraper-grader	3
Operator	dozer-compactor	3
Security	--	2
General construction	--	2
	Total	52-person crew

There are 81,200 cubic yards of clay cover material required. This clay will be hauled from a borrow site 1 mile from the site. Clay-cover delivery requires 11 days and 14,000 vehicle-miles. The crew and equipment required for the placement of clay cover material will be the same as those required for moving the contaminated materials.

There are 194,800 cubic yards of silty-sand cover material required. This material will be hauled from a borrow site adjacent to the site, about a 1-mile haul (2-miles round trip). Silty-sand cover delivery requires 26 days and 33,000 vehicle-miles. The crew and equipment for the placement of the sandy cover material will be about the same as those listed for the placement of the contaminated materials.

A total of 68,800 cubic yards of riprap material will be required. This rock cover will be blasted from an area within 1 mile from the site. It is assumed that blasting will reduce all rock to a minus-6-inch size. Fourteen drill and blast crews can produce the required volume of rock in 46 days. Eighteen trucks with appropriate crews are required for haulage as the rock is blasted. A total of 18,200 vehicle-miles is required to blast and place the rock cover material. The crew and equipment for the placement of the blasted-rock cover will be the same as those listed for the placement of the contaminated materials. The crew and equipment required for blasting the rock cover material will include the following:

Skill	Number
Foreman	7
Driller	14
Equipment operator	14
Total	35-person crew

Table C-3 is a summary of the work force and duration of the project by tasks to be performed. The schedule of work by activity and months is graphically displayed in Figure C-2.

Table C-3. Project duration

Work force	Total days	Work description
20	10*	mobilize, set up, prepare site
24	8*	demolition and vicinity properties
52	255	place contaminated tailings, dikes, and soils
52	11	haul and place clay cover material
52	26	haul and place sandy cover material
35	46	drill and blast rock cover material
52	14	place rock cover material
12	10	fencing
24	15	access road
Total	387	project work days (use 390 project work days)

*Concurrent activities.

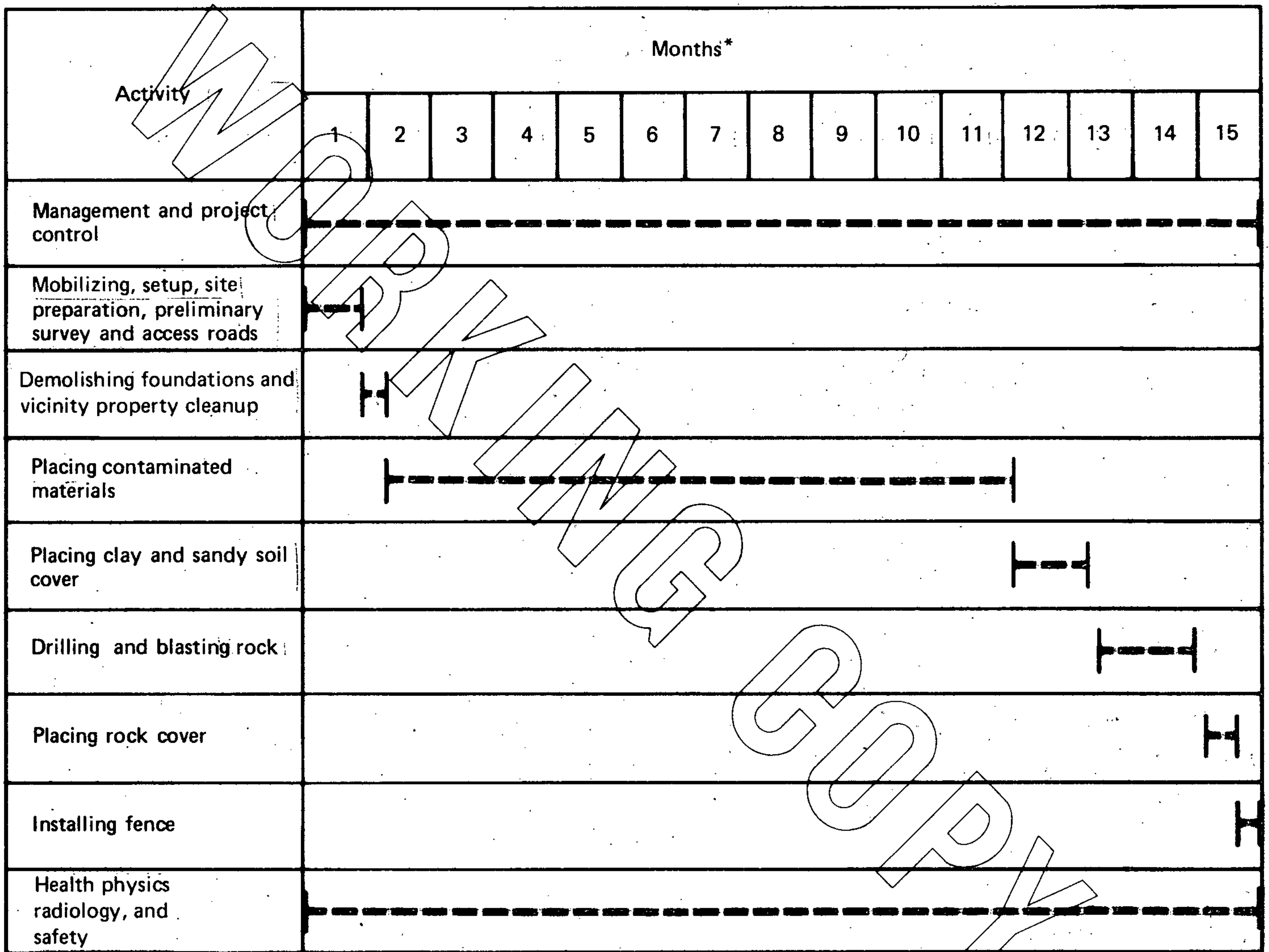
The average crew for the 15.1-month duration of the project is 49 men, with a peak of 52. Man-years are calculated for 49 men for 65 weeks, assuming that 2000 hours is the standard for a man-year. A total of about 96 man-years will be required.

Table C-4 provides the information used in the calculation of vehicle-miles. Table C-5 shows the equipment and projected fuel consumption. Table C-6 shows the work force and hours worked.

C.1.4 Air-pollution emissions and fugitive dust

The emissions for earthmoving equipment (such as dozer, shovel, scraper, truck, and loader with diesel or gasoline engines) used in off-highway situations are obtained from the Compilation of Air Pollutant Emission Factors (EPA, 1975). The particulate emissions produced by the proposed action are shown in Table C-7.

During the remedial-action work, large amounts of contaminated material and cover material will be handled. The activities include truck loading and dumping; hauling over dirt and paved roads; scraper, grader, shovel, and front-end loader operations; and other associated activities. These equipment activities can generally be categorized as heavy earthwork construction.



*One month = 4.3 weeks, one week = 6 work days, and one work day = 10 hours.

Figure C-2. Monument Valley work schedule.

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Table C-4. Vehicle-miles

Work description	Vehicle-miles
Vicinity properties	5,000
Place contamination	90,000
Haul and place clay cover material	14,000
Haul and place silty-sandy cover material	33,000
Drill, blast, and place riprap cover	18,200
Fencing and access roads	400
Site preparation, survey, water trucks, and contingency (5 percent)	8,400
Total	169,000

Table C-5. Equipment fuel use

Equipment type	Average number	Gallons per hour	Hours operated*	Total gallons
Dump truck, 12 cubic yards	18	5.0	3,060	275,000
Water truck	2	6.2	3,310	41,000
Front-end loader (Caterpillar 980C, 5 cubic yard)	3	8.5	3,060	78,000
Dozer-compactor	3	10.0	3,060	92,000
Dozer-scraper-grader	3	10.0	3,160	95,000
Pickup trucks	6	2.7	3,870	63,000
Vicinity properties	--	--	--	6,000
		Subtotal		650,000
		Contingency (5 percent)		32,500
		Total		682,500
		Rounded total		685,000

*"Hours operated" from days required by work type times 10 hours per day.

Table C-6. Work force by number, skill-trade, and hours worked*

Average number	Average hours	Skill-trade
2.5	3160	Grader operator
20	3085	Truck driver (dump and water)
4	3060	Dozer operator
4	3060	Front-end loader operator
3	3310	Oiler
7	460	Drill and blast crew foreman
14	460	Drill and blast driller
14	460	Drill and blast equipment operator (crawler, air compressor)
2	3870	Security personnel
2	3160	Roustabouts and helper
4	3870	Foreman
3	3260	Surveyor
4.5	3060	Health physicist and radiologist
3	3870	Project management
1	3870	Safety and health personnel

*The average crew size is approximately 49 persons. The total here exceeds 49; however, not all workers are on the site all of the time.

Table C-7. Air-pollution emissions for the proposed action

Pollutant	Emission factors			
	Pounds per 1000 gallons of fuel burned	Total gallons of fuel	Pounds of pollutant*	Pounds per month*
Carbon monoxide	92.2	685,000	63,160	4,180
Hydrocarbons	30	685,000	20,550	1,360
Oxides of nitrogen	524	685,000	358,940	23,770
Sulfur dioxide	31.2	685,000	21,370	1,420
Particulates	17.7	685,000	12,120	800

*Rounded to the nearest 10 pounds.

Fugitive-dust release for such activities can be estimated by application of the emission factor for heavy construction, 1.2 tons per acre of active construction per month, from Supplement 5 of the EPA Compilation of Air Pollutant Emission Factors (1975). This value is applicable only in arid western areas of the United States, which is true of the present project area. This emission factor is especially appropriate for estimating fugitive dust from borrow-site activities. Other models provided by the EPA are suitable for estimating fugitive dust from the haul roads and from the tailings pile itself during shaping and covering activities. The fugitive-dust emissions from all of the remedial-action activities at the Monument Valley site are shown in Table C-8.

Table C-8. Summary of fugitive-dust emissions[a,b]

	Uncontrolled emissions[c]		Maximally controlled emissions[d]	
	Project total (pounds)	Average per month (pounds per month)	Project total (pounds)	Average per month (pounds per month)
Haul roads (5.3 months)	44,700	8,400	13,800	2,600
Contaminated material (10.2 months)	3,206,900	314,700	320,800	31,400
Cover material (3.8 months)	102,100	26,900	10,200	2,700
Total	3,353,700	e	344,700	e
Average per month of remedial-action duration (project total divided by 15.1 months)	--	223,600	--	22,800

[a]Numbers are rounded summaries of extensive calculations.

[b]Sources: Methods for estimating fugitive dust are from EPA, 1975, Section 11.2, et seq. Data for project size (tons hauled, distance, times, etc.) are from FBD engineering estimates.

[c]Uncontrolled emissions are calculated for 40-mile-per-hour vehicle speeds; use of 10-wheel vehicles, which assumes 2.5 times actual vehicle-miles for "equivalent 4-wheel vehicle-miles;" no watering or chemical control of haul roads; and unpaved dirt roads with 30-percent silt content.

[d]Controlled emissions are based on the assumptions of covered trucks, 25-mile-per-hour vehicle speeds, watered roads, and watering of active tailings and borrow sites.

[e]Duration of each project is used for estimating emissions per month per activity rather than the total remedial-action duration; therefore, the entries in this column are not additive.

Fugitive dust will be one of the main air-quality concerns during an earthwork project as large as the proposed remedial action. The dust emissions will be intensive only during the remedial-action work, and no long-term impacts will occur. Fugitive-dust emissions can be controlled to a certain extent, and control measures will be important. These include watering of roads (50-percent reduction), application of stabilizing chemicals (50-percent reduction), and paving (about 85-percent control). In the estimates shown in Table C-8, the following control measures are assumed: speed control, covering of trucks, use of paved roads where possible, watering of dirt roads, and watering of traffic areas at the borrow sites and at the tailings piles during active construction.

The average controlled fugitive-dust releases per month in the vicinity of the Monument Valley remedial action will be approximately 23,000 pounds per month total. The activities contributing to this total are borrow sites (2600 pounds per month), haul roads (2600 pounds per month), and contaminated material (31,400 pounds per month). The fugitive-dust emissions expected at the Monument Valley site are comparable to those that would occur at a major construction site, such as a shopping mall of similar acreage, or when borrow material is taken from gravel pits to construct raised roadbeds in the interstate highway system.

C.1.5 Cost estimate

The cost estimate for the proposed action is shown in Table C-9. The items are rounded to the nearest $1000. The estimate does not include acquisition costs for property or borrow material.

C.1.6 Water use

It is estimated that 35 gallons of potable water are required per person per work day. For the average crew of 49 workers, about 670,000 gallons of potable water will be needed.

Water is also needed for dust control. A typical water truck holds 4000 gallons; with 2 trucks and an estimated average of 3 trips a day for 331 days, about 7,900,000 gallons will be required.

An increased use by up to 107 people (see Appendix G, Table G-13), each using 100 gallons per day for 65 weeks, will require a total of approximately 4,870,000 gallons.

The total increase in demand for water is as follows:

670,000 gallons	worker use
7,900,000 gallons	dust control
4,870,000 gallons	domestic use
13,440,000 gallons	total

Table C-9. Cost itemization for stabilization on the site

Item	Cost
Site preparation - setup, level, preliminary survey 2000 man-hours at $25.00 per hour plus equipment, pickups, etc., 100 hours at $200 per hour	$ 70,000
Access road - 35,500 square yards required at $2.90 per square yard	103,000
Demolition and vicinity properties - minor demolition, $16,800 plus vicinity properties: 6 at $7920 and 6 at $9675	122,000
Placing contaminated tailings, dikes, and soils - excavate, load, haul, place, and compact 1,055,500 cubic yards, average 0.5-mile haul at $4.00 per cubic yard	4,222,000
Clay cover material - excavate, load, haul, place, and compact on the site, average 1-mile haul, 81,200 cubic yards at $3.41 per cubic yard	277,000
Sandy cover material - excavate, load, haul, place, and compact on the site, average 1-mile haul, $3.41 per cubic yard over a broad area. 194,800 cubic yards required	664,000
Drilling and blasting rock cover material - 68,800 cubic yards required, $6.00 per cubic yard to drill and blast	413,000
Loading, hauling, and placing rock cover material - 1-mile haul, load, haul, place, and compact on the site, 68,800 cubic yards required, $3.10 per cubic yard	213,000
Management, health physics, and radiological monitoring personnel - average of 7.5 personnel over 390 days, $350 per day	1,024,000
Security fencing - 4750 linear feet at $12.60 per linear foot	60,000
Subtotal	$ 7,168,000
Engineering, 15%	1,075,000
Contingency, 30%	2,150,000
Total	$10,393,000

C.1.7 Accident risk

The truck accident and fatality rates used in Table C-10 were obtained from published National Safety Council statistics and the U.S. Department of Transportation 1980 Annual Report. The total of estimated vehicle-miles is taken from Table C-4.

Table C-10. Accident rates

Item	Rate	Vehicle-miles or man-years	Accidents
Truck accident rate	7.94 accidents / 1 million vehicle-miles	169,000 vehicle-miles	1.34
Fatality rate	3.78 deaths / 100 million vehicle-miles	169,000 vehicle-miles	0.006
Machinery accident rate	0.15 accident / 1 man-year	96 man-years	14.4

C.1.8 Noise levels

Noise levels during the different phases of remedial action are included in Table C-11. Table C-12 includes measurements of sound levels at various distances from different types of construction equipment.

Table C-11. Noise impacts during remedial action at Monument Valley[a]

	Range of possible sound levels on the A-weighted scale (dBA) during remedial-action work				
	at 50 feet	at 1/8 mile (660 feet)	at 1/4 mile (1320 feet)	at 1/2 mile (2640 feet)	at 1 mile (5280 feet)
1. Preliminary site preparation activities, including access road improvement (1 month duration)	89 - 104	67 - 81	61 - 75	55 - 69	49 - 63
2. Vicinity property cleanup (0.5 month duration)	88 - 100	66 - 78	60 - 72	54 - 66	48 - 60
3. Consolidation of contaminated material and covering with clay, soil, and rock. This category includes excavation at borrow sites. (12 months duration)	94 - 107	71 - 85	65 - 79	59 - 73	53 - 67
4. a. Drilling and loading rock	94 - 110	72 - 88	66 - 82	59 - 76	53 - 70
b. Blasting rock (1.5 months duration)	NA	*	*	*	*
5. Passing truck on haul roads	82 - 93	60 - 71	54 - 65	48 - 59	42 - 53

[a]Sources for basic data and calculation methods: EPA, 1972; Beranek, 1971; FBDU engineering estimates.

*Blasting, an intermittent, short-duration, impulse-type noise, cannot be estimated because of physical, chemical, and other variables, which will not be known until actual work begins.

NA: not applicable.

Table C-12. Sound levels from construction equipment

Equipment	feet / meters	Sound levels in decibels on the A-weighted scale (dBA) at indicated distances from source					
		25 / 7.6	50 / 15.2	100 / 30.5	200 / 60.9	500 / 152.9	1000 / 304.5
IMPACT EQUIPMENT							
Jackhammers, rock drills, and pneumatic chippers		87-104	81-98	75-92	69-86	61-78	55-72
INTERNAL COMBUSTION ENGINE-POWERED EQUIPMENT							
Earthmoving							
Tractors, bulldozers		82-102	76-96	70-90	64-84	56-76	50-70
Scrapers, graders		86-99	80-93	74-87	68-81	60-73	54-67
Trucks		88-99	82-93	76-87	70-81	62-73	56-67
Backhoes		78-99	72-93	66-87	60-81	52-73	46-67
Front-end loaders		79-92	73-86	67-80	61-74	53-66	47-60
Materials Handling							
Cranes (moveable)		82-93	76-87	70-81	64-75	56-67	50-61
Derrick cranes		92-94	86-88	80-82	74-76	66-68	60-62
Stationary Equipment							
Compressors		80-93	74-87	68-81	62-75	54-67	48-61
Generators		77-88	71-82	65-76	59-70	51-62	45-56
Pumps		75-77	69-71	63-65	57-59	49-51	43-45

Source: EPA, 1972.

C.2 ALTERNATIVE 2*: CONSOLIDATION ON THE SITE WITH TAILINGS MATERIALS FROM MEXICAN HAT

C.2.1 Assumptions used for combined disposal at Monument Valley

The following assumptions have been applied in calculating the costs of disposal of the Mexican Hat tailings in combination with Monument Valley tailings at a location adjacent to the Monument Valley site.

1. Cover material would consist of 6.5 feet of soil plus 1.5 feet of minus 6-inch riprap for a total of 8 feet of cover.

2. The final pile will be placed at the Monument Valley site so as not to cover any existing contaminated material or lie in any major drainage.

3. Road distance between the two sites is 18 miles.

4. Normal handling is assumed adequate for wet slimes at Mexican Hat.

C.2.2 Cover volumes

The alternative for offsite disposal at Monument Valley calls for combining the contaminated material from the Mexican Hat and Monument Valley sites. The volumes of contamination are 2,219,000 (FBDU, 1981b) and 820,600 cubic yards, respectively, and total 3,039,600 cubic yards. The final pile, a truncated pyramid, would be about 1206 by 2412 feet in overall dimension. The cover used is 6.5 feet of fine soil and then 1.5 feet of crushed rock. The fine-soil volume required is 663,000 cubic yards, and the crushed rock volume required is 161,100 cubic yards.

C.2.3 Cost estimate

The items in the cost estimate for combined disposal at Monument Valley, Table C-13, are rounded to the nearest $1000.

---

*Alternative 1 is no action.

Table C-13. Cost itemization for combined disposal at the Monument Valley site

Item	Cost
Site preparation - setup, level, preliminary survey (2 sites), 4000 man-hours at $25 per hour plus equipment, pickups, etc., 200 hours at $200 per hour	$ 140,000
Demolition of buildings and rubble, hauling of rubble - 10,000 man-hours at $25 per hour plus trucks, crane, and demolition equipment, 200 hours at $700 per hour	390,000
Vicinity properties - 8 at $7920 and 9 at $9675	150,000
Road improvement - 142,000 square yards at $2.15 per square yard	305,000
Hauling and stacking Mexican Hat contaminated materials - 2,199,000 cubic yards at $10.25 per cubic yard	22,540,000
Hauling and stacking Monument Valley contaminated materials - 820,600 cubic yards at $4.00 per cubic yard	3,282,000
Fine-soil cover material - excavate, load, haul, and compact on the site, 665,500 cubic yards at $3.10 per cubic yard	2,063,000
Drilling and blasting rock cover material - 161,800 cubic yards at $6.00 per cubic yard	971,000
Loading, hauling, and emplacing rock cover material - 161,800 cubic yards at $3.10 per cubic yard	502,000
Security fencing - 7500 lineal feet at $12.60 per lineal foot	94,000
Management, health physics, and radiological monitoring personnel - average of 9 persons over 1600 days, $350 per day	5,040,000
Subtotal	$ 35,477,000
Engineering, 15%	5,322,000
Contingency, 30%	10,643,000
Total	$ 51,442,000

C.3 ALTERNATIVE 3: BELOW-GRADE DISPOSAL IN THE MINE PIT

C.3.1 Assumptions used

It was assumed that the Monument No. 2 inactive open-pit mine would be of adequate size for the disposal of all contamination associated with the Monument Valley tailings site. Overburden from the mining was placed in the bottom of the open pit. Four feet of this material would be removed and stockpiled for final coarse cover.

The tailings would be moved approximately 1 mile to the pit for disposal. The haul roads would be upgraded. The material would be placed in the bottom of the pit. The same type of cover layers described for the proposed action would be used for this alternative.

C.3.2 Cover volumes

Required volumes of cover materials are as follows:

Clay soil	148,000 cubic yards
Silty-sand	333,000 cubic yards
Riprap	296,000 cubic yards

C.3.3 Cost estimate

The items in the cost estimate in Table C-14 are rounded to the nearest $1000. The estimates do not include acquisition costs for property or for borrow material.

Table C-14. Cost itemization for relocation and stabilization at the former mine pit

Item	Cost
Site preparation - setup, level, preliminary survey 2000 man-hours at $25.00 per hour plus equipment, pickups, etc., 100 hours at $200 per hour	$ 70,000
Access road - 53,250 square yards at $2.90 per square yard	154,000
Demolition and vicinity properties - minor demolition, $16,800 plus vicinity properties: 6 at $7920 and 6 at $9675	122,000
Placing contaminated tailings, and soils - excavate, load, haul, place, and compact 1,055,500 cubic yards, average 1-mile haul at $4.20 per cubic yard	4,433,000
Clay-soil cover material - excavate, load, haul, place, and compact on the site, average 2-mile haul, 148,000 cubic yards at $3.85 per cubic yard	570,000
Sandy-soil cover material - excavate, load, haul, place, and compact on the site, average 2-mile haul, $3.85 per cubic yard. 333,000 cubic yards of sandy soil required	1,282,000
Excavate, load, haul, and place rock cover material - load, haul, place, and compact on the site, 0.25 mile 2 times, 296,000 cubic yards required, $5.50 per cubic yard	1,628,000
Management, health physics, and radiological monitoring personnel - average of 7.5 personnel over 504 days, $350 per day	1,323,000
Security fencing - 8600 linear feet at $12.60 per linear foot	108,000
Subtotal	$ 9,690,000
Engineering, 15%	1,454,000
Contingency, 30%	2,907,000
Total	$14,051,000

C.4 ALTERNATIVE 4: BELOW-GRADE DISPOSAL ALONG THE BASE OF COMB RIDGE

C.4.1 Assumptions used

This alternative would move the contaminated material from the site to a below-grade disposal site 9.5 miles away at Comb Ridge; an estimated 6 miles of widened and improved road would be required. The disposal pit would be 30 feet deep with 1:1 sloped sides and would have two access trenches. The pit is assumed to be square in plan view. Clay-cover material, 6.5 feet thick (from pit excavation), and rock cover, 1.5 feet thick at the top, would cover the pit after filling. The total depth allowed for the disposal of tailings would be 22 feet. The final surface dimensions would be 1176 by 1176 feet.

C.4.2 Cover volumes

Required volumes of cover materials are as follows:

Clay cover	327,700 cubic yards
Riprap	76,700 cubic yards

C.4.3 Cost estimate

The items in the cost estimate in Table C-15 are rounded to the nearest $1000. The estimate does not include acquisition costs for property or for borrow material.

Table C-15. Cost itemization for offsite below-grade stabilization

Item	Cost
Site preparation - setup, level, preliminary survey, 2000 man-hours at $25 per hour plus equipment, pickups, etc., 100 hours at $200 per hour	$ 70,000
Access road - 106,500 square yards at $2.90 per square yard	309,000
Demolition and vicinity properties - minor demolition, $16,800 plus vicinity properties: 6 at $7920 and 6 at $9675	122,000
Excavating disposal pit - including fine-soil replacement, 1,801,000 cubic yards, 0.25-mile haul, load and haul at $2.75 per cubic yard	4,953,000
Placing contaminated tailings, and soils in disposal pit - includes excavation, load, haul, place, and compact, 1,054,000 cubic yards at $7.35 per cubic yard	7,747,000
Drilling and blasting rock cover material - 76,700 cubic yards required at $6.00 per cubic yard	460,000
Load, haul, and place cover rock - 3.5 mile haul, 76,700 cubic yards at $5.25 per cubic yard	403,000
Security fencing - 4900 linear feet at $12.60 per linear foot	62,000
Management, health physics, and radiological monitoring personnel - 7.5 each at $350 per man day for 990 days	2,599,000
Subtotal	$16,725,000
Engineering, 15%	2,509,000
Contingency, 30%	5,018,000
Total	$24,252,000

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FBDU (Ford, Bacon & Davis Utah Inc.), 1981a. Engineering Assessment of Inactive Uranium Mill Tailings, Monument Valley Site, Monument Valley, Arizona, DOE/UMT-0117 (FBDU-360-04), prepared for the U.S. Department of Energy, Albuquerque, New Mexico.

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U.S. Department of Energy, 1982. Criteria for Evaluating Disposal Sites for Wastes Transferred in Connection with the Uranium Mill Tailings Remedial Action Program (UMTRAP), UMTRA-DOE/ALO-7, Uranium Mill Tailing Remedial Actions Project Office, Albuquerque, New Mexico.

Appendix D

WEATHER AND AIR QUALITY

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Appendix D

WEATHER AND AIR QUALITY

Wind data at Blanding, Utah, are included in Table D-1. Air-quality data, obtained from three monitoring locations nearest to Monument Valley, are shown in Table D-2.

Federal standards for ambient-air quality are listed in Table D-3.

Table D-1. Wind speed at Blanding, Utah[a]

Direction	Average speed (miles per hour)	Frequency (percent)
N	8.5	5.9
NNE	8.7	7.4
NE	8.1	9.1
ENE	6.2	4.2
E	5.7	3.5
ESE	7.6	3.8
SE	8.0	5.7
SSE	5.8	5.1
S	9.4	9.6
SSW	11.9	7.9
SW	10.8	8.5
WSW	11.8	4.1
W	11.0	5.0
WNW	9.5	4.0
NW	10.9	9.4
NNW	9.6	7.1
All	9.2	100.3

[a]Data are for the 1-year period of March 1, 1977, to February 28, 1978, at Blanding, Utah (adapted from NRC, 1979).

Table D-2. Air quality at monitoring sites nearest to Monument Valley

	Bullfrog, Utah[a]	Blanding, Utah[b]	Page, Arizona[c]
Total suspended particulates (micrograms per cubic meters or $\mu g/m^3$)	11-21 (annual) 120-600 (max 24 hr)	26 (annual) 79 (max 24 hr)	37 (annual) 120 (max 24 hr)
Sulfur dioxide[d]	below detectable limits (annual) 0.03 ppm (max 1 hr) 0.03 ppm (max 3 hr) 0.01 ppm (max 24 hr)	less than 0.005 parts per million (ppm) annually	2 (annual) 147 (max 3 hr) 48 (max 24 hr)
Nitrogen dioxide ($\mu g/m^3$)	NA[e]	NA	24 (annual) 162 (max 1 hr) 41 (max 24 hr)
Carbon monoxide	NA	NA	NA
Hydrocarbons	NA	NA	NA

[a]Data from USDH, 1981. Only 5 years of particulate data are available from Bullfrog, from 1971 to 1972 and from 1975 to 1977. Sulfur dioxide was measured only in 1975 and 1976.

[b]Data from NRC, 1979. Only part of 1 year of data exists for this site.

[c]Data from ADHS, 1981. Reported values are from 1980 monitoring, the latest information available.

[d]Sulfur dioxide is reported in parts per million (ppm) in Utah and in micrograms per cubic meter ($\mu g/m^3$) in Arizona. The corresponding State standards are 0.03 ppm (80 $\mu g/m^3$) for the annual period, 0.5 ppm (1300 $\mu g/m^3$) for the 3-hour period, and 0.14 ppm (365 $\mu g/m^3$) for the 24-hour period.

[e]NA: not available.

Table D-3. Federal ambient-air standards

Pollutant	Averaging period	Standards[a] Primary	Secondary	Remarks
Sulfur dioxide	annual	0.03 parts per million (ppm) (80 micrograms per cubic meter or 80 μg/m^3)	none	Arithmetic mean
	24 hours	0.14 ppm (365 μg/m^3)	none	Not to be exceeded more than once per year
	3 hours	none	0.5 ppm (1300 μg/m^3)	Not to be exceeded more than once per year
Particulates	annual	75 μg/m^3	60 μg/m^3	Geometric mean
	24 hours	250 μg/m^3	150 μg/m^3	Not to be exceeded more than once per year
Carbon monoxide	8 hours	9 ppm (10,000 μg/m^3)	Same as Primary	Not to be exceeded more than once per year
	1 hour	35 ppm (40,000 μg/m^3)	Same as Primary	Not to be exceeded more than once per year
Ozone	1 hour	0.12 ppm (235 μg/m^3)	Same as Primary	Not to be exceeded more than once per year
Hydrocarbons	3 hours	0.24 ppm (160 μg/m^3)	Same as Primary	Corrected for methane. Not to be exceeded more than once per year
Nitrogen dioxide	annual	0.05 ppm (100 μg/m^3)	Same as Primary	Arithmetic mean
Lead	3 months	1.5 μg/m^3	Same as Primary	Arithmetic mean

[a]At standard temperature (25°C) and pressure (sea level: 760 millimeters of mercury) conditions.

Source: Title 40, Code of Federal Regulations, Part 50.

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Appendix E

HYDROLOGIC INVESTIGATIONS

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Appendix E

HYDROLOGIC INVESTIGATIONS

On June 8, 1982, Ford, Bacon & Davis, Incorporated, collected several samples for ground-water quality analyses from the vicinity of the Monument Valley site. The purpose of this field effort was to determine, on a reconnaissance level, the existing impact of the tailings on local ground-water quality. This appendix provides the results of the sample analyses and interpretation of the data. Also provided is an estimate of the impact on surrounding wells of withdrawing water for use during remedial action from an existing well located in the millsite area.

E.1 METHODS

Water-quality samples were collected from the nine locations shown in Figure E-1. Location names corresponding to the sample numbers are given in Table E-1. Samples were collected in plastic bottles and preserved in the field either with nitric acid (for metal and radiochemical analyses) or by cooling (for anion analyses). Preservation techniques were in accordance with guidelines established by the U.S. Geological Survey (1977).

Samples collected from the two wells located on the old millsite were obtained after pumping each well with a submersible pump for approximately 20 minutes at a rate of about 7.5 gallons per minute. Where present, hand pumps were operated for a period of 2 to 5 minutes before samples were collected. Grab samples were obtained from all other sources.

Field analyses of the unpreserved water samples were conducted immediately after collection. Laboratory analyses of the preserved samples were completed by Bendix Field Engineering Corporation, Grand Junction, Colorado. Standard laboratory techniques were used (U.S. Geological Survey, 1977).

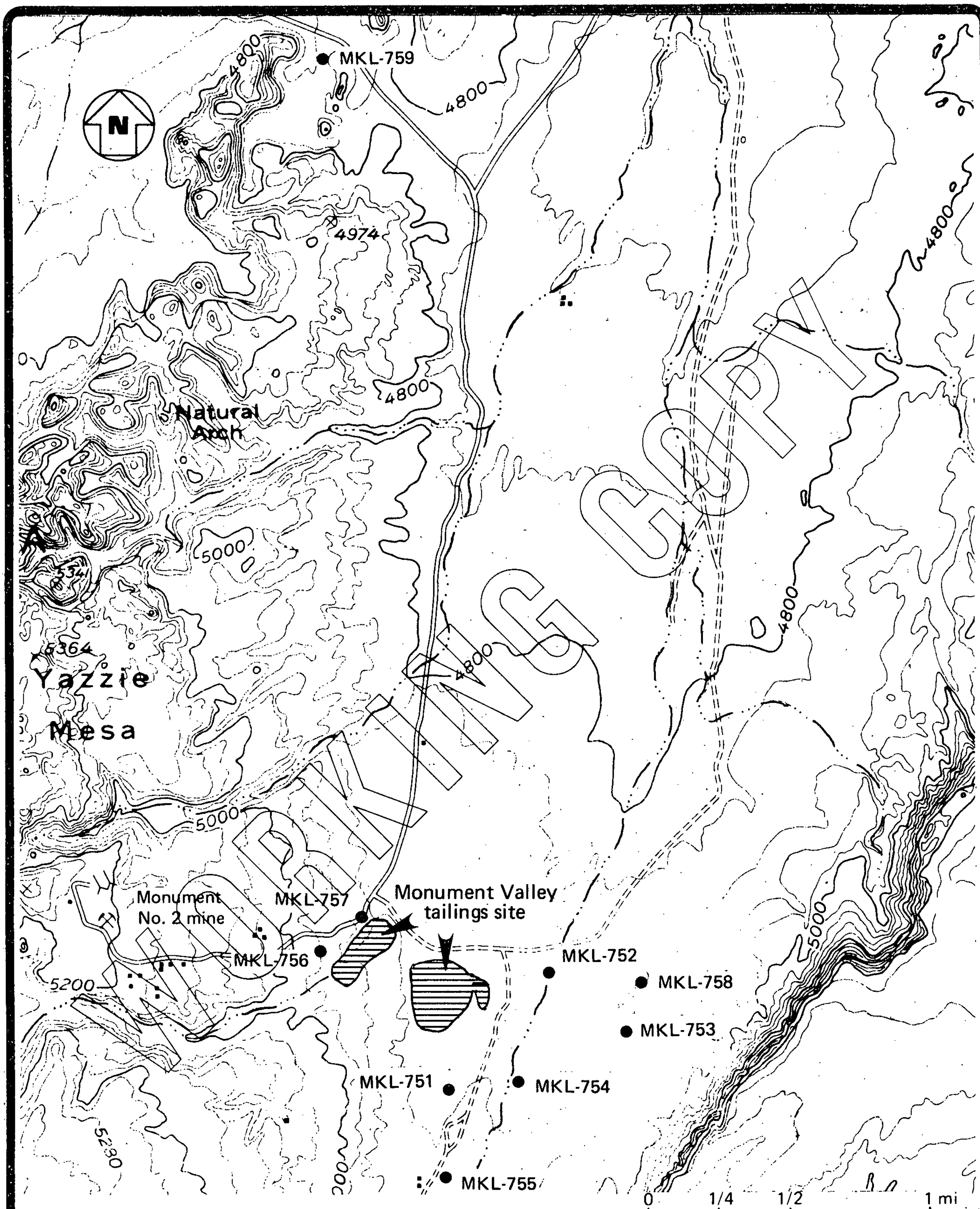

Figure E-1. Location of water-quality sampling stations.

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Table E-1. Monument Valley water-quality sample identification list

Sample number	Location	Remarks
MKL-751	Luke Yazzie well	With hand pump
MKL-752	Toni Yazzie well	Flowing (< 1 gal/min)
MKL-753	Trench 3400 feet east of new pile	From southern end
MKL-754	Lukai-Hi-Kaii well	With hand pump
MKL-755	Project No. 1 well	With hand pump
MKL-756	Millsite south well	4-inch diameter
MKL-757	Millsite north well	12-inch diameter
MKL-758	Sump 3500 feet northeast of new pile	Easternmost sump
MKL-759	Sloan well	With windmill

E.2 RESULTS

Results of field and laboratory analyses of the water-quality samples are listed in Table E-2. The general quality of the waters sampled, as represented by Stiff diagrams, is presented in Figure E-2.

E.3 DISCUSSION

E.3.1 Well-completion assumptions

No completion records are available for the wells near the Monument Valley site, making it difficult to determine the formations from which samples were collected; however, several reasonable assumptions can be made. Because each of the wells fitted with a hand pump appears to have been hand dug, these wells are assumed to tap only the unconsolidated dune and alluvial deposits covering the valley floor. Visual observation indicated that water found in the trench and sump east of Cane Valley Wash is also ground water contained in the unconsolidated dune and alluvial deposits.

The owner of the Sloan well (sample MKL-759 in Figure E-1) indicated that his well is approximately 260 feet deep. According to data presented by Witkind and Thaden (1963), this would place the well entirely within the De Chelly Sandstone Member of the Cutler Formation. The quality of the ground water obtained from the two millsite wells (MKL-756 and MKL-757) is similar to that obtained from the Sloan well, and the water level in the millsite wells appears to be near, but below, the top of the De Chelly Sandstone (based on stratigraphic information presented by Witkind and Thaden, 1963). Hence, the two millsite wells also appear to be completed in the De Chelly Sandstone.

Although topographic control in the valley bottom is not good, the water-level elevations in the millsite wells and in the flowing well located east of the site (MKL-752) appear to be similar. At the location of the flowing well, the depth to the top of the De Chelly Sandstone is approximately 250 feet, while its thickness is about 550 feet (Witkind and Thaden, 1963). It is doubtful that a domestic well in the area would be drilled to a depth exceeding 800 feet when good-quality water could be obtained from the De Chelly Sandstone at shallower depths. Given this and the similar water-level elevations, the flowing well located east of the designated site is assumed to be completed in the De Chelly Sandstone.

E.3.2 Water quality in the De Chelly Sandstone

The full thickness of the De Chelly Sandstone outcrops west of the site. No ground-water seepage is apparent along this outcrop, suggesting that ground water in the De Chelly Sandstone flows eastward and southeastward below Cane Valley, along the dip of the strata (Witkind and Thaden, 1963). Hence, samples MKL-756, MKL-757, and MKL-759 were collected upgradient from the tailings piles, while sample MKL-752 was collected hydraulically downgradient from the piles.

Table E-2. Results of Monument Valley area water-quality analyses, June 8, 1982

Parameter	MKL-751	MKL-752	MKL-753	MKL-754	MKL-755	MKL-756	MKL-757	MKL-758	MKL-759
	Sample number								
	Field measurements								
Temperature (°C)	19	16	19	18	18	20	20	20	22
pH (units)	6.90	8.52	7.17	6.97	7.72	8.36	7.05	6.91	8.05
Electrical conductivity (µmhos/cm @ 25°C)	560	510	560	1820	950	295	285	540	295
	Laboratory measurements								
Aluminum (mg/l)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.13	<0.05	<0.05
Arsenic (mg/l)	<0.010	<0.010	<0.010	0.010	0.010	<0.010	<0.010	0.014	<0.010
Bicarbonate (mg/l)	248	247	297	429	369	176	175	245	170
Calcium (mg/l)	32.5	3.4	43.4	81.2	18.4	37.0	35.7	36.9	27.7
Chloride (mg/l)	24	9	31	213	83	3	3	40	5
Fluoride (mg/l)	<1	<1	<1	1	1	<1	<1	<1	<1
Iron (mg/l)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.22
Magnesium (mg/l)	24	2	31	107	26	17	18	30	20
Molybdenum (mg/l)	<0.025	<0.025	<0.025	0.033	<0.025	<0.025	<0.025	<0.025	<0.025
Potassium (mg/l)	1.0	0.8	1.6	0.5	0.4	1.0	1.2	4.0	1.2
Radium-226 (pCi/l)	<2	2	<2	<2	<2	<2	<2	<2	<2
Selenium (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sodium (mg/l)	80.1	124	51.2	288	192	6.4	6.8	50.1	12.6
Solids, dissolved (calculated) (mg/l)	366	316	381	1520	675	165	164	362	195
Sulfate (mg/l)	80	53	74	615	171	13	12	78	44
Uranium, natural (mg/l)	0.004	<0.001	0.002	0.007	0.007	0.006	0.007	0.460	0.002
Vanadium (mg/l)	<0.025	<0.025	<0.025	<0.025	<0.025	0.028	0.080	0.108	<0.025

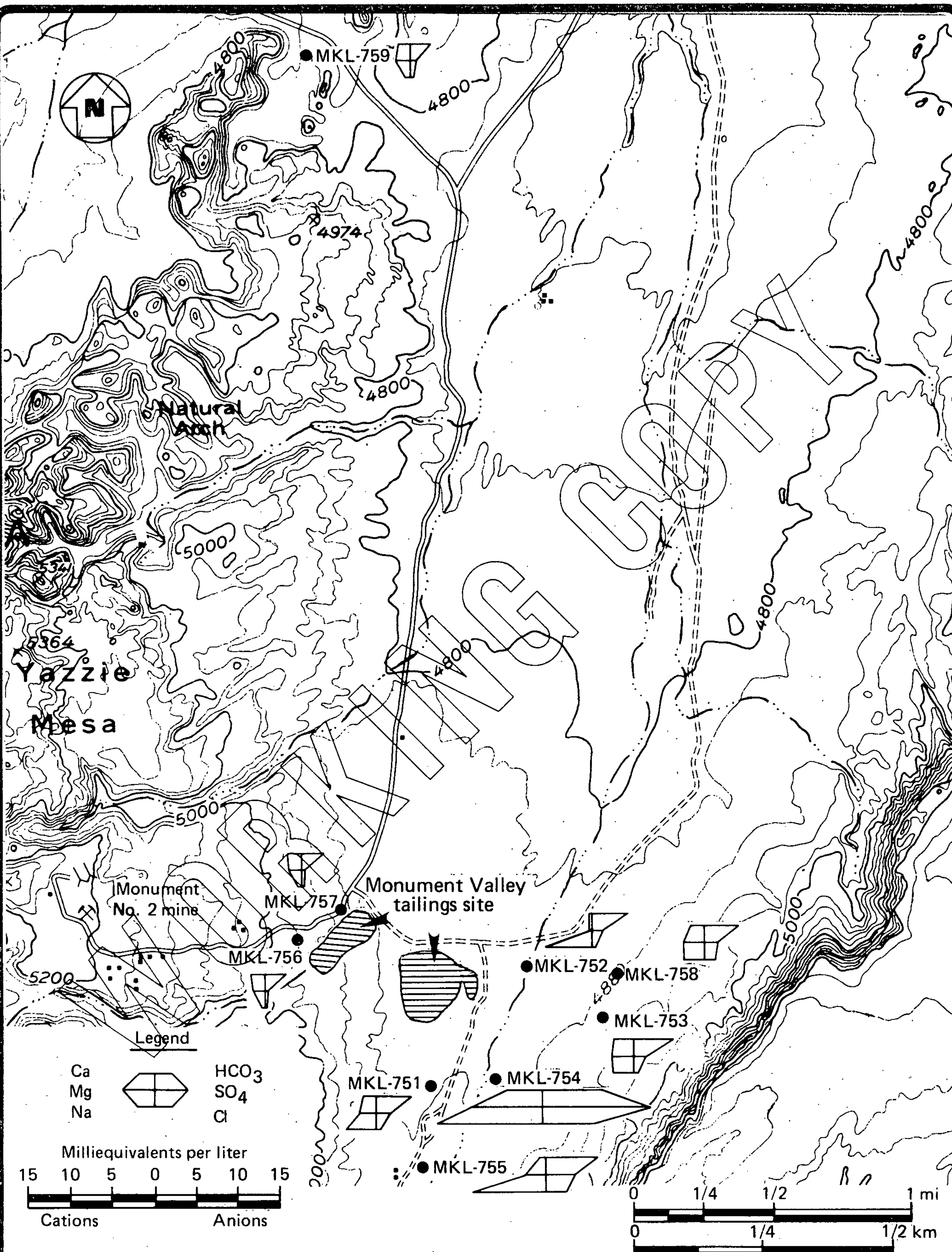

Figure E-2. General water quality represented by Stiff diagrams.

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There appears to be no major difference in the concentrations of trace metals and other minor constituents between the upgradient and downgradient wells. However, the total dissolved solids concentrations increase by a factor of 2 between the millsite wells and the flowing well in the valley bottom. The decrease in calcium and magnesium concentrations and increase in sodium concentration at the flowing well compared to the millsite wells suggest that changes in the gross constituents are caused by leaching and cation exchange within the De Chelly Sandstone rather than by the presence of the tailings piles. In addition, it is uncertain whether or not the flowing well is uncased below the interface between the unconsolidated material and the bedrock. The change in water quality at this well compared to upgradient wells may, therefore, be affected by interactions with the overlying Moenkopi Formation.

E.3.3 Water quality in unconsolidated deposits

Shallow ground water from the unconsolidated valley deposits tends to be more saline than that obtained from the De Chelly Sandstone. This is especially true of water from shallow wells adjacent to Cane Valley Wash, as seen in samples MKL-754 and MKL-755 (obtained adjacent to the wash) when compared with samples MKL-751, MKL-753, and MKL-758 (obtained from sources located 1000 to 1500 feet from the wash). The predominance of efflorescent salts in the bottom of Cane Valley Wash, along with the presumed downstream flow of shallow ground water, suggests that this salinity results from leaching of natural sediments rather than from the influence of the tailings piles.

Trace metal concentrations in shallow ground water do not vary significantly between locations; however, sample MKL-758, collected from a sump east of Cane Valley Wash, showed significantly higher natural uranium concentrations than all other sources sampled. This sample had a natural uranium concentration of 0.46 milligrams per liter (mg/l), amounting to an activity of about 150 picocuries per liter (pCi/l) (assuming that 10 pCi/l is equivalent to 0.03 mg/l). This compares with a maximum of 0.007 mg/l at all other locations. Vanadium concentrations were also elevated at this location, as shown in Table E-2.

Two factors suggest that the elevated concentrations found at this site have not been caused by the tailings piles. First, Dahlstrom (1982) identified a local outcropping of uranium ore at this location. In addition, the water level in the sump is higher than that in Cane Valley Wash, indicating the sump is upgradient from the wash, the supposed discharge point for any shallow ground water west of the wash. Hence, the uranium and vanadium concentration anomalies found in sample MKL-758 appear to have resulted from natural influences rather than contamination from the tailings piles.

E.4 IMPACT OF PUMPING DURING REMEDIAL ACTION

As noted in Section 3.5, the demand for water at the site during remedial-action operations will amount to approximately 8.6 million gallons. This water is presumed to be available from the 12-inch diameter millsite well that appears to be completed in the De Chelly Sandstone. Site-specific data concerning the hydraulics of the De Chelly Sandstone are unavailable, making a precise determination of the effects of pumping on local water levels difficult. However, regional data do allow an estimate of these impacts to be made.

An average laboratory permeability of 550 millidarcys was reported for the De Chelly Sandstone by Jobin (1962) for 5 sandstone samples collected 25 miles west of the site and for 12 sandstone samples collected 45 miles southeast of the site. For water at 20°C, this permeability converts to a hydraulic conductivity of 1.5 feet per day. This hydraulic-conductivity value compares reasonably well with the results of pumping tests conducted in the De Chelly Sandstone approximately 80 miles south of the site (Cooley et al., 1969). With a thickness of the De Chelly Sandstone at the site of 550 feet (Section 2.5), this hydraulic conductivity is representative of a transmissivity of 825 square feet per day.

Pumping from the well will probably occur sporadically as the demand requires. However, to determine the maximum expected impact to the aquifer, it was assumed that all pumping would be concentrated into a single 120-day period, requiring an average rate of 50 gallons per minute to meet the demand. Since the well exists under water-table conditions at the millsite (Section 2.6), a specific yield of the aquifer of 15 percent was assumed (based on an average porosity of 20 percent for the De Chelly Sandstone as reported by Cooley et al., 1969). Based on these assumptions and on the standard relationship between drawdown and distance from a pumping well (Freeze and Cherry, 1979), the distance at which no drawdown would be expected to occur is approximately 1400 feet. The nearest well completed in the De Chelly Sandstone that is in current use is the flowing well located east of the site near Cane Valley Wash (see Figure E-1). This well is located about 3700 feet from the 12-inch diameter millsite well and should, therefore, not be impacted.

The presence of confined-aquifer conditions east of the site may cause the effects of drawdown to spread slightly farther than indicated above. Although it is difficult to accurately assess this effect as the aquifer experiences a change from confined to unconfined conditions due to pumping, the added effect is expected to be minor.

E.5 CONCLUSIONS

Ground-water supplies in the Cane Valley area do not appear to have been contaminated as a result of the tailings piles. Downgradient changes in dissolved solids in the De Chelly Sandstone apparently result from leaching and cation exchange within the sandstone. The anomalous uranium and vanadium concentrations found in ground water contained in the shallow unconsolidated deposits appears to be associated with an ore outcrop. Pumping from the 12-inch diameter millsite well to provide water for remedial action should have no impact on a nearby flowing well.

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Appendix F

RESULTS OF BIOLOGICAL SURVEYS OF MONUMENT VALLEY SITE AND PROPOSED BORROW SITES

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Appendix F

RESULTS OF BIOLOGICAL SURVEYS OF MONUMENT VALLEY SITE AND PROPOSED BORROW SITES

This appendix is a summary of biological conditions at the Monument Valley site and the proposed borrow sites. The information is based on field reconnaissance and research conducted by Ford, Bacon & Davis, Incorporated (FBD) personnel and Dr. E. Linwood Smith of E. Linwood Smith & Associates, ecological consultants, Tucson, Arizona, in May and August 1981 and June 1982. It is also based on consultations with various Federal and State wildlife-management personnel.

F.1 TAILINGS PILE

F.1.1 Vegetation

The single, large tailings pile at the Monument Valley site is nearly devoid of vegetation. A few individual plants of downy chess (Bromus tectorum) and Indian ricegrass (Oryzopsis hymenoides) were found growing on the pile in May 1981; nothing was growing on the pile in August. A few salt cedars (Tamarix pentandra) were present along the northern edge of the tailings but, generally, the interface between the tailings material and intact native plant communities was dominated by Russian thistle (Salsola iberica), galleta (Hilaria jamesii), and a variety of shrubby species that are common elements of the local native communities (see Section F.2).

F.1.2 Wildlife

No evidence of any wildlife use of the tailings pile was observed on either visit to the site; no tracks, burrows, droppings, or other signs were present, even on the lower slopes of the tailings pile. Because the pile offers no vegetation or other usable habitat, it is very unlikely that any species of wildlife could survive.

F.2 BORROW AREAS

F.2.1 Vegetation

Several plant associations are present on the proposed Monument Valley borrow areas. The coarse-materials borrow area, immediately surrounding the tailings site and contiguous with the fine-materials borrow area, is characterized by sandstone outcroppings that support a plant community of blackbrush (Coleogyne ramosissima), shadscale (Atriplex confertifolia), rabbit brush (Chrysothamnus viscidiflorus), and Apache plume (Cowania mexicana). Occasional juniper trees (Juniperus sp.) are present in the rocky upland areas, as are individuals of single-leaf ash (Fraxinus anomala), plains yucca (Yucca angustissima), and bush knotweed (Polygonum ramosissima?). Douglas groundsel (Senecio douglasii) and brickellia (Brickellia scabra) are locally common.

On the less rocky, fine-soiled borrow area to the north, east, and south of the tailings site, other plant associations are found. In fine-soiled areas away from drainageways, snakeweed (Gutierrezia microcephala), haplopappus (Haplopappus drummondi), or rayless encelia (Encelia frutescens) are the more common species present. Other plants present in such areas include joint-fir (Ephedra viridis), Indian ricegrass, Douglas groundsel, galleta, rabbit brush, four-wing saltbush (Atriplex canescens), and yucca.

The major drainageway included in the fine-soils portion of the borrow area is very strongly dominated by greasewood (Sarcobatus vermiculatus) with sagebrush (Artemisia sp.), saltbush (Atriplex sp.), and seepweed (Suaeda torreyana). Also found in or adjacent to the drainageway are the plains prickly pear (Opuntia polycantha), rabbit brush (Chrysothamnus greenei), and occasional individals of Whipple sclerocactus (Sclerocactus whipplei). Table F-1 contains a partial listing of common plant species found in the proposed Monument Valley borrow areas adjacent to the tailings pile.

At a later date, an additional borrow site was identified about 8.5 miles north of the tailings site, and a vegetation survey was conducted by FBD personnel in June 1982. The site is in the Petrified Forest Member of the Chinle Formation, a heavily weathered area of purplish-gray mounds almost devoid of vegetation. The plant species found at this location are given in Table F-2. Thirty species were found, of which 27 are native to the area and 3 are introduced. Of the 30 species, 16 were annuals, 9 were perennials, and 5 were woody shrubs. The abundance of annual species, the preponderance of native species, the lack of tree species, the absence of certain prominent plants of the region (such as yucca, rosemary mint, and others), and the general scarcity of plant life are all indicative of a harsh, specialized habitat at this location. No threatened, endangered, or otherwise sensitive plant species were found despite a thorough search. The area is overgrazed, as indicated by the presence of Russian thistle, Patagonia Indian wheat, and cheatgrass, but it has little grazing value, in any case, because of the barren character and lack of vegetative cover.

Table F-1. Some common plant species found on the proposed Monument Valley borrow site

Scientific name[a]	Common name
EPHEDRACEAE	joint-fir family
Ephedra viridis	mountain joint-fir
GRAMINEAE	grass family
Bromus tectorum	black grama
Hilaria jamesii	galleta
Oryzopsis hymenoides	Indian ricegrass
Sitanion hystrix	squirrel tail
AGAVACEAE	agave family
Yucca angustissima	plains yucca
POLYGONACEAE	buckwheat family
Eriogonum sp.	wild buckwheat
*Polygonum ramosissima?	bush knotweed
CHENOPODIACEAE	goosefoot family
Atriplex canescens	four-wing saltbush
Atriplex confertifolia	shadscale
Salsola iberica	Russian thistle
Sarcobatus vermiculatus	greasewood
*Suaeda torreyana	desert seepweed
NYCTAGINACEAE	four-o'clock family
Abeonia elliptica	sand verbena
Allionia incarnata	trailing four o'clock
CRUCIFERAE	mustard family
*Lepidium montanum	pepper grass
Physaria sp.	twin pod
Sisymbrium cf. irio	London rocket
ROSACEAE	rose family
*Coleogyne ramosissima	blackbrush
Cowania mexicana	cliff rose
LEGUMINOSAE	pea family
Astragalus sp.	milk vetch
EUPHORBIACEAE	spurge family
*Euphorbia sp.	sand mat
RHAMNACEAE	buck-thorn family
Rhamnus serrata?	buck-thorn
MALVACEAE	mallow family
*Sphaeralcea digitata	juniper globe mallow

Table F-1. Some common plant species found on the proposed Monument Valley borrow site (continued)

Scientific name[a]	Common name
TAMARICACEAE	tamarix family
Tamarix pentandra	salt cedar
CACTACEAE	cactus family
Opuntia polycantha	plains prickly pear
Opuntia whipplei	Whipple cholla
†Sclerocactus whipplei	Whipple sclerocactus
ONAGRACEAE	evening primrose family
*Oenothera pallida	evening primrose
OLEACEAE	olive family
*Fraxinus anomala	single-family ash
*Menodora scabra	menodora
BORAGINACEAE	borage family
*Cryptantha flava	cryptantha
*Cryptantha micrantha	purple-rooted cryptantha
*Tiquilia latior	tiguilia
COMPOSITAE	sunflower family
Artemisia spinescens	bud sage
Brickellia scabra	brickellia
*Chrysothamnus greenei	rabbit brush
Chrysothamnus nauseosus	rabbit brush
*Chrysothamnus viscidiflorus	rabbit brush
Encelia frutescens	rayless encelia
Gutierrezia microcephala	three-leaf snakeweed
*Haplopappus drummondi	haplopappus
*Senecio douglasii	Douglas groundsel

[a]Scientific and common names generally follow those of Lehr (1978).
* Indicates that a voucher specimen was collected.
† Indicates that a photograph of the species was made.
? Indicates that identification is not positive.

Table F-2. Plants collected in June 1982, at an additional borrow site about 8.5 road miles north of the tailings site

Scientific name	Common name	Status*	Family
Amsonia eastwoodiana	Eastwood amsonia	NPF	Apocynaceae
Astragalus amphioxys	locoweed, milkvetch	NAPF	Fabaceae (Leguminosae)
Astragalus cymboides	locoweed, milkvetch	NPF	Fabaceae (Leguminosae)
Astragalus sp. (an annual herbaceous plant with narrow, elongated stems and leaves but lacking flowers or fruits; therefore, reliable identification is not possible)		AF	Fabaceae (Leguminosae)
Atriplex canescens	fourwing saltbush	NS	Chenopodiaceae
Atriplex patula	spearscale, spear orach	NAF	Chenopodiaceae
Bromus tectorum	cheatgrass	IAG	Poaceae (Graminae)
Chaenactis stevioides	dusty maiden	NAF	Asteraceae (Compositae)
Chrysothamnus greenei	rabbitbush	NS	Asteraceae (Compositae)
Cleome lutea	yellow beeplant	NAF	Capparidaceae
Cryptantha crassisepala	cryptantha	NAF	Boraginaceae
Descurainia pinnata	tansy mustard	NABF	Brassicaceae (Cruciferae)
Ephedra torreyana	joint-fir	NS	Ephedraceae (Gnetaceae)
Ephedra viridis	joint-fir	NS	Ephedraceae (Gnetaceae)
Eriogonum divaricatum	spreading eriogonum	NAF	Polygonaceae
Eriogonum salsuginosum	spreading eriogonum	NAF	Polygonaceae

Table F-2. Plants collected in June 1982, at an additional borrow site about 8.5 road miles north of the tailings site (continued)

Scientific name	Common name	Status*	Family
Eriogonum wetherillii	Wetherill eriogonum	NAF	Polygonaceae
Gilia leptomeria	slender gilia	NAF	Polemoniaceae
Hilaria jamesii	galleta grass	NPG	Poaceae (Graminae)
Lappula redowskii	desert stickseed	IAF	Boraginaceae
Mentzelia albicaulis	whitestem blazing star	NAF	Loasaceae
Monolepis nuttalliana	poverty weed	NAF	Chenopodiaceae
Oryzopsis hymenoides	Indian ricegrass	NPG	Poaceae (Graminae)
Phacelia corrugata	scorpionweed	NPF	Hydrophyllaceae
Plantago patagonica	Patagonia Indian wheat	NAF	Plantaginaceae
Salsola kali	Russian thistle, tumbleweed	IAF	Chenopodiaceae
Sitanion hystrix	squirreltail grass	NPG	Poaceae (Graminae)
Sphaeralcea coccinea	globe mallow	NBPFH	Malvaceae
Stephanomeria exigua	wirelettuce	NABF	Asteraceae (Compositae)
Townsendia incana	hoary townsendia	NPBAF	Asteraceae (Compositae)

Table F-2. Plants collected in June 1982, at an additional borrow site about 8.5 road miles north of the tailings site (continued)

	Status summary*				
	Species origin		Habit		
			Herbaceous		
	Introduced (I)	Native (N)	Annual (A)	Biennial and perennial (B,P)	Woody or partly woody (H,T,S)
Trees (T)	0	0	0	0	0
Shrubs (S)	0	4	0	0	4
Grasses (G)	1	3	1	3	0
Forbs (F)	2	20	15	6	1
Succulents ($)	0	0	0	0	0
Total	3	27	16	9	5
Grand total	30		30		

*Status code: N = native, I = introduced, A = annual, B = biennial, P = perennial, H = partly woody, G = grass and grasslike, F = herbaceous (forbs other than G), S = shrubs.

F.2.2 Wildlife

F.2.2.1 Mammals

The mammalian fauna of the proposed Monument Valley borrow areas is relatively diverse in a regional sense. This diversity is related to the variety of vegetation and substrate types present on the borrow areas. The distributions of mammals in Arizona (Cockrum, 1960) and southeastern Utah (Dalton et al., 1978) indicate that bats and small rodents are by far the most common kinds of mammals likely to be found on the site. Many species of bats likely to occur in Monument Valley would be transients during periods of spring or fall migration; the summer resident populations are probably only a handful of species; e.g., Yuma myotis (Myotis yumanensis), pallid bat (Atrozous pallidus), western big-eared bat (Plecotus townsendii), and western pipistrelle (Pipistrellus hesperus). Most rodent species likely to occur on the site are small nocturnal rats and mice; e.g., Ord kangaroo rat (Dipodomys ordi), Apache pocket mouse (Perognathus apache), deer mouse (Onychomys leucogaster), and white-throated wood rat (Neotoma albigula). The diurnal white-tailed antelope squirrel (Ammospermophilus leucurus) is a common species on the site; rock squirrels (Citellus variegatus) probably inhabit rocky outcrop areas and canyons; and, although no evidence was found on the site, pocket gophers (Thomomys sp.) are probably also part of the mammalian fauna.

Other mammals likely to occur on the site include desert cottontail (Sylvilagus audubonii), black-tailed jackrabbit (Lepus californicus), badger (Taxidea taxus), kit fox (Vulpes macrotus), coyote (Canis latrans), bobcat (Lynx rufus), and mule deer (Odocoileus hemionus).

Desert cottontail and white-tailed antelope squirrel were the only species of mammals observed during field visits to the Monument Valley site. Signs (burrows) of small mammals were common on the borrow site, and droppings of coyote and black-tailed jackrabbit were also found on the site.

F.2.2.2 Birds

The low, shrubby character of the plant communities present on the Monument Valley borrow sites greatly reduces the potential avifauna. Bird species that probably breed on the borrow areas include the mourning dove (Zenaida asiatica), poor-will (Phalaenoptilus nuttallii), ash-throated flycatcher (Myiarchus cinerascens), Say's phoebe (Sayornis saya), horned lark (Eremophila alpestris), rock wren (Salpinctes obsoletus), sage thrasher (Oreoscoptes montanus), loggerhead shrike (Lanius ludovicianus), sage sparrow (Amphispiza belli), and Brewer's sparrow (Spizella breweri).

During field visits, E. Linwood Smith observed species on or near the site such as the ash-throated flycatcher, common raven (Corvus corax), horned lark, Brewer's sparrow, loggerhead shrike, and western bluebird (Sialia mexicana).

A number of other species probably occur on the borrow area during spring and fall migration. Others probably nest elsewhere but may forage on the site (e.g., golden eagles, hawks, and owls). Dalton et al. (1978) and Monson and

Phillips (1980) list many species other than those listed above as likely nesting birds. These species probably occur, at least occasionally, on the study site.

F.2.2.3 Amphibians and reptiles

The only amphibians likely to occur on or near the Monument Valley borrow sites include the western spadefoot toad (Scaphiopus hammondi), red-spotted toad (Bufo punctatus), and possibly the Great Plains toad (Bufo cognatus). The absence of moist habitat in the area precludes the presence of other species of amphibians (Dalton et al., 1978; Stebbins, 1954; Lowe, 1964).

Several species of lizards are likely to be present. On fine soils, one is likely to encounter the lesser earless lizard (Sceloporus graciousus) and the western whiptail (Cnemidophorus tigris). On rockier sites, the collared lizard (Crotaphytus collaris), tree lizard (Urosaurus ornatus), and desert spiny lizard (Sceloporus magister) would be expected.

Snakes that might be present on the site include the striped whipsnake (Masticophis taeniatus), gopher snake (Pituophis melanoleucus), common king-snake (Lampropeltis getulis), long-nosed snake (Rhinocheilus lecontei), night snake (Hypsiglena torquata), and the western rattlesnake (Crotalus viridis).

During field visits to the site, the only species of reptiles encountered were the side-blotched lizard and western whiptail lizard.

F.2.2.4 Special status biota

None of the currently listed threatened or endangered plants of Arizona (U.S. Fish and Wildlife Service, 1980a) is known to occur in the vicinity of Yazzie Mesa or Monument Mine No. 2. Peebles Navajo cactus (Pediocactus peeblesianus var peeblesianus), an endangered species, is known to occur in central Navajo County, Arizona, and the Mesa Verde cactus (Sclerocactus mesa-verde), a threatened species, is known from San Juan County, New Mexico. These are the only two listed plant species known to occur anywhere near the Monument Valley tailings site or borrow sites. Neither of these species is likely to occur on the site (Kenneth Heil, San Juan College, personal communication, April 1982).

Plant species currently being reviewed for inclusion on the list of threatened or endangered biota of the United States (U.S. Fish and Wildlife Service, 1980b), include Cutler milkweed (Asclepias cutleri), which is found in sandy areas near Rock Point and east of Mexican Water; both localities are east of the Monument Valley tailings site and borrow sites (Dr. Arthur Phillips, personal communication, 1982). This species could occur in the Monument Valley borrow area, although no members of the genus Asclepias were found on the site during field visits in 1981. Errazurizia rotunda, at one time considered for listing (U.S. Fish and Wildlife Service, 1975), is a sand-dune plant that might occur in the Monument Valley area. The plant

has, however, been taken off the threatened or endangered plant list (U.S. Fish and Wildlife Service, 1980b) and is no longer thought to be in jeopardy (Drs. Arthur and Barbara Phillips, personal communication, 1982).

The cacti (Opuntia and Sclerocactus) and yucca (Yucca angustissima) that occur on the Monument Valley borrow site are protected by the Arizona Native Plant Law (Arizona Revised Statutes, 1978). Nothing in the law, however, prevents clearing of lands that support such species, provided that the plants are not offered for sale or transported from the land and that the Arizona Commission of Agriculture and Horticulture is given notice at least 30 days prior to land clearing. Moreover, it is unlikely that this law is applicable to lands belonging to the Navajo Nation.

No species of Federally listed wildlife (U.S. Fish and Wildlife Service, 1980a and 1980c) is known to occur in the vicinity of the Monument Valley site (Edward Olson, personal communication, 1982). Suitable habitat for the black-footed ferret (Mustela nigripes) and peregrine falcon (Falco peregrinus), two endangered species whose known geographic ranges include Monument Valley, does not occur on the study site. Peregrine falcons could occur along Comb Ridge south and east of the study site during periods of migration, but they do not nest along the ridge. Comb Ridge could be important as a nesting or roosting area for other unlisted species of raptors (Edward Olson, personal communication, 1982). Large colonies of prairie dogs (Cynomys sp.), which are necessary to sustain populations of black-footed ferrets, apparently do not occur on or near the Monument Valley site. No evidence of prairie dogs was found on the site, nor was any sign of prairie-dog activity noted in the area between Mexican Hat and the Monument Valley site.

Except for the peregrine falcon and the black-footed ferret, the only threatened or unique wildlife of Arizona (Arizona Game and Fish Department, 1978) likely to occur in the Monument Valley area are very rare transients (e.g., the spotted bat, Euderma maculata).

Conflict between the proposed actions at Monument Valley and major game populations should be minimal. Mule deer and mountain lion (Felis concolor), both big game species of Arizona (Arizona Game and Fish Department, 1981), may occasionally occur on the site. Such occurrences are most likely as animals move from one portion of their home range to another. Desert cottontail and mourning dove are probably the two most common small game species found on the site. Predators such as coyote and kit fox are probably fairly common in the Monument Valley area. The only furbearers likely to be present in the study area are the badger and bobcat. It is unlikely that there are large populations of either species on the proposed borrow site, and neither species uses the tailings site.

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AGENCIES AND PERSONS CONSULTED FOR APPENDIX F

John S. Allan, Ph.D., Plant Ecologist, Orem, Utah, to assist in identifying plants from borrow sites and millsite vicinity.

Lois A. Arnow, Ph.D., Curator and Research Assistant Professor, Garrett Herbarium, University of Utah, Salt Lake City, Utah, to assist in identifying plants from borrow sites and millsite vicinity.

Ted Cordery, Threatened and Endangered Species Specialist, U.S. Bureau of Land Management, Phoenix District Office, Phoenix, Arizona, to obtain information on threatened and endangered species of Arizona.

Kenneth Heil, regional expert on Pediocactus and Sclerocactus, San Juan College and Navajo Community College, Farmington, New Mexico, to obtain information on threatened and endangered cacti of the Monument Valley area.

Don Lingholm, Navajo Branch, U.S. Bureau of Indian Affairs, Tuba City, Arizona, to determine whether biological constraints exist that might interfere with proposed action.

Edward Olsen, Wildlife Biologist, U.S. Bureau of Indian Affairs, Navajo Area, Window Rock, Arizona, to determine whether biological constraints exist that might interfere with the proposed action.

Dr. Arthur Phillips, Botanical Curator and Threatened and Endangered Species Specialist, Museum of Northern Arizona, Flagstaff, Arizona, to obtain information on threatened and endangered plants of the Monument Valley area.

Dr. Barbara Phillips, Botanical Curator and Threatened and Endangered Species Specialist, Museum of Northern Arizona, Flagstaff, Arizona, to obtain information on threatened and endangered plants of the Monument Valley area.

John Shuler, Botanist, Navajo-Hopi Land Settlement Office, U.S. Bureau of Land Management, Flagstaff, Arizona, to assist in identifying plants of the Monument Valley area.

Appendix G

SOCIOECONOMIC CHARACTERISTICS OF THE AFFECTED REGION AND IMPACTS OF THE PROPOSED ACTION

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Appendix G

SOCIOECONOMIC CHARACTERISTICS OF THE AFFECTED REGION AND IMPACTS OF THE PROPOSED ACTION

This appendix addresses the socioeconomic characteristics of the area in terms of population, physical plant, and fiscal capacity. This supply-side characterization is then juxtaposed with the demands that the remedial-action program will place on area resources.

The socioeconomic aspects affected by the remedial-action program have been examined to determine whether a temporary influx of workers would strain the abilities of the county and nearby towns to provide services. Answers have been sought to the following questions:

1. Is the population large enough to provide workers for the remedial action in the next 2 to 4 years?

2. Is the current work force fully employed or would the remedial action create local employment?

3. Is housing available for in-migrant temporary workers?

4. Are the water and sewer systems capable of accommodating more people?

5. How well can area schools, health-care facilities, public-safety systems, and public works absorb growth?

6. Do the county and towns have a sufficient tax base to afford new growth (which may mean expanded services)?

The Monument Valley tailings are located on the Navajo Indian Reservation, Apache County, Arizona.

The closest residential settlement that could house the work force is in Halchita, approximately 17 miles north-northwest of the Monument Valley site. Halchita is located in San Juan County, Utah, and is the largest Navajo town on the Utah Strip of the Navajo Reservation. Since the socioeconomic impact will be tied to the community that houses the work force, Halchita will be examined in this report. By way of comparison, the other settlements that might compete with Halchita are the Goulding Trading Post with 19 motel units and another 20 units under construction in 1982. The Trading Post is 20 miles from the site and is accessible by Arizona Highway 163 and Navajo Road 6440. Kayenta, Arizona, is 40 miles to the south on Highway 163. Given these distances to a town, the assumption was made that the work force will be located in Halchita, where the Navajo Tribal Enterprise system has indicated the desire to accommodate the workers.

In the vicinity of the Monument Valley site is the Monument Valley Navajo Park. The park is a major tourist attraction in the area and was the

background for over 100 movies depicting the American West. The tailings pile is not visible from the park and if the workers are housed at Halchita, the increased road usage would not mingle with the tourist traffic, and, in fact, the worker traffic would not be visible from the park.

Some data used in this report were supplied by the Utah Navajo Development Council in Blanding, Utah. Where information directly relating to Mexican Hat or Halchita was not available, general San Juan County, Utah, data have been used. The Utah Strip is located in San Juan County.

G.1 POPULATION

San Juan County experienced a 27.6 percent increase from 1970 to 1980. No comparable data exist for the reservation; however, 1980 data are available for the Oljeto and Red Mesa divisions. The tailings site and Halchita are located on the boundary of the two divisions. Population data are given in Table G-1.

Table G-1. Population of San Juan County, Utah

	1980	1970	Percent change
Blanding Division	4,439	NA	
Blanding City	3,118	2,250	38.6
Monticello Division	3,027	NA	
Monticello City	1,929	1,431	34.8
Oljeto Division	1,680	NA	
Red Mesa Division	3,107	NA	
Total San Juan County	12,253	9,606	27.6

NA: not available
Source: U.S. Department of Commerce, 1981, p. 12.

Almost 60 percent of the county population resides outside of the incorporated cities of Blanding and Monticello, and this population relies on the county for the provision of services.

Population estimates for Halchita in 1980 list 500 in residence according to Jack McRedmond of the Utah Navajo Development Council, May 28, 1982.

Population projections for San Juan County are closely aligned with projections for energy development. The uranium industry, in particular, was forecast to be a major employer in the 1980s. Currently, the Rio Algom mine and the White Mesa uranium mill are the largest uranium employers in San Juan County with 107 and 179 employees, respectively (Utah Energy Office, 1981). San Juan County contains a total of 53 uranium and vanadium mines, which in 1979 produced 1.8 million pounds of uranium (U_3O_8) and 2.4 million pounds of vanadium (UGMS, 1981b). The population projections in Table G-2 are overly optimistic; when made in 1978, they were based on an expectation that uranium would remain at the late-1977 price of $43.00 per pound. This assumption produced a prediction of 25-percent population growth from 1980 to 1985. In current revisions of the population projections, the uranium industry is not assumed to recover until the end of the decade. This assumption predicts a 2.5-percent annual growth rate for the decade, which would result in a 1990 population of 15,718 (Utah Department of Employment Security, 1982).

Table G-2. Population projections for San Juan County, Utah

	1978	1980	1985	1990	1995	2000
San Juan County	13,850	15,150	18,950	20,600	21,350	21,350
Monticello	2,354	2,575	3,221	3,502	3,629	3,629
Blanding	3,462	3,787	4,737	5,150	5,337	5,337
Unincorporated	1,940	2,122	2,654	2,884	2,990	2,990
Navajo Reservation	6,094	6,666	8,338	9,064	9,394	9,394

Source: Burnett, 1981, p. 17.

Regardless of how uranium prices fluctuate, a stable population is needed for oil and gas exploration and production work in the Aneth and Lisbon fields. These two fields make San Juan County the state's leading producer of oil and gas. The Aneth field, in the extreme southeastern part of San Juan County, has produced more oil (300 million barrels) than any other field in Utah; in 1979, 7.4 million barrels were produced. The Lisbon field is the state's largest gas field; it produced 18.9 billion cubic feet of gas in 1979 (UGMS, 1981a). Thus, the production of oil and gas may serve to counteract some of the effects of population loss caused by setbacks in the uranium market.

G.2 HOUSING

The number of housing units increased at a faster pace than the population between 1970 and 1980. The available housing is detailed in Table G-3.

Table G-3. Housing supply in San Juan County, Utah

	1980	1970	Percent change
Blanding Division	1317	NA	
Blanding City	835	577	44.7
Monticello Division	1029	NA	
Monticello City	635	442	43.7
Oljeto Division	488	NA	
Red Mesa Division	912	NA	
Total San Juan County	3746	2417	55.0

NA: not available
Source: U.S. Department of Commerce, 1981, p. 12.

Mobile homes account for almost 26 percent of the total dwellings in San Juan County (Burnett, 1981, p. 26).

In 1979 the Utah Navajo Development Council (UNDC) conducted a housing survey on the Utah portion of the Navajo reservation, referred to as the "Utah Strip." The survey results, detailed in Table G-4, showed that 15.7 percent of the reservation housing stock was in good condition. Almost 56 percent of the units are either unavailable or in need of repair. Thus, existing housing on the reservation may prove inadequate for any increase in population.

In the immediate vicinity, transient housing consists of 22 motel units in Mexican Hat (Burnett, 1981, p. 101). A trailer park with 20 hookups is also available in Mexican Hat.

The UNDC owns and manages rental accommodations in Halchita. According to Jack McRedmond, UNDC property manager, an 18-room dormitory with an institutional kitchen is available for rent or lease. Single-dwelling rental houses in Halchita are also available at times; in April 1982 no houses were vacant. The potential exists for additional housing in a vacant trailer park adjacent to the tailings site, where 40 mobile homes could be placed. The park would require some electrical renovation; sewer and water hookups are available. The trailer park housed most of the workers when Texas-Zinc Minerals operated the uranium mill at Halchita.

Table G-4. Housing needs in 1979 on the Utah portion of the Navajo reservation

Chapters	Families without homes	Homes needing replacing	Homes needing major repair	Homes needing minor repair	Homes in good condition	Families not surveyed	Total
Aneth	30	49	95	76	66	15	331
Red Mesa	40	30	44	34	20	13	181
Oljeto	20	83	39	31	57	33	263
Navajo Mountain	16	33	19	7	3	17	95
Mexican Water	12	5	9	7	0	17	50
Tees Nos Pos	5	10	5	0	3	10 (est.)	33
Off-reservation[a]	5	3	4	4	7	20 (est.)	43
Total	128	213	215	159	156	125	996

[a]Includes Bluff and Mexican Hat only.
Source: Burnett, 1981, p. 32.

In summary, the available housing in Mexican Hat and Halchita consists of a variety of accommodations: dormitories, mobile homes, motel rooms, and single-family dwellings. Housing availability is currently strained, but trailer hook-ups are available for mobile homes that would have to be brought to the area.

G.3 EMPLOYMENT

San Juan County experienced an 8-percent unemployment rate in 1981. In the second quarter of 1982 the seasonally adjusted unemployment rate was 9.3 percent. Of the nonagricultural employment in the second quarter of 1982, mining accounted for almost 34 percent of the labor force, government for 27 percent, and trades and services for 25 percent. Table G-5 contains selected labor-market indicators for 1981 and the second quarter of 1982.

Table G-5. Employment in San Juan County, Utah

	Second quarter 1982	1981	Percent change
Civilian labor force	5237	5179	1.1
Employed	4780	4765	0.3
Unemployed	457	414	
Percent of labor force--seasonally adjusted	9.3	8.2	
Total nonagricultural jobs	3330	3334	-0.1
Mining	1122	1160	-3.3
Contract construction	85	90	-5.6
Manufacturing	164	165	-0.6
Transportation, communication, and public utilities	192	181	6.1
Trade	390	389	0.3
Finance, insurance, and real estate	31	30	3.3
Service	434	415	4.6
Government	912	904	0.9
Job market activities			
New applications	234	323	-27.6
Job openings	235[a]	428	-45.1
Job placements	226[a]	399	-43.4

[a]In 1982 a new program to place substitute teachers was instituted by the Job Service Offices in San Juan County; therefore, 1982 job openings and job placements are not strictly comparable to 1981 figures.

Source: Utah Department of Employment Security, 1982.

Current-year figures for the entire Navajo Nation show unemployment for males at 47.6 percent and females at 54.3 percent, for a combined unemployment rate of 50.8 percent (Rodgers, 1982, p. 22). Unemployment rates in the Utah Strip are approximately 50 percent (Burnett, 1980, p. 68). It should be noted that the unemployment rates for Utah and for the Navajo Nation are not strictly comparable. The unemployment rate used by the Utah Department of Economics refers to persons actively seeking employment. The Navajo rate refers to persons available for employment.

G.4 DEMOGRAPHICS

The population of San Juan County is composed of two dominant racial groups, whites and American Indians, as shown in Table G-6.

Table G-6. Racial configuration of San Juan County, Utah

	1980	1970
White	6425	4490
Black	11	16
American Indian, Eskimo, and Aleutian	5600	4740
Asian and Pacific Islander	40	10
Other	177	--
Spanish origin	433	350

Source: U.S. Department of Commerce, 1981.

The population is young; slightly over 47 percent are less than 18 years old. According to the 1980 census, almost 53 percent of the Navajo Indians are 17 years of age or younger, compared with 43 percent for whites. Table G-7 details the age and sex characteristics of San Juan County residents.

Table G-7. Population by age and sex in San Juan County, Utah

Age	Males	Females	Total
< 5 years	947	917	1,864
5 to 17	2,040	1,901	3,941
18 to 24	721	732	1,453
25 to 44	1,380	1,462	2,842
45 to 64	752	774	1,526
65 to 84	276	293	569
85 +	31	27	58
Total	6,147	6,106	12,253

Source: U.S. Department of Commerce, 1981.

G.5 EDUCATION

The educational resources of San Juan County consist of ten public schools and one private school. The name, location, current enrollment, and capacity enrollment for each school are shown in Table G-8.

Table G-8. Public educational services, San Juan County, 1981-1982

School name and location	Grades	Full-time teachers	Students	Student capacity
Blanding School, Blanding	3-6	20	399	400
Bluff School, Bluff	K-6	9	127	196
LaSal School, LaSal	1-4	4	68	65
Mexican Hat School, Halchita	K-8	11	178	201
Montezuma Creek School, Montezuma Creek	K-6	10	344	535
Monticello School, Monticello	K-6	20	427	563
A.R. Lyman School, Blanding	K-2	15	331	278
Monticello School, Monticello	7-12	25	347	431
San Juan High School, Blanding	7-12	45	656	679
Whitehorse High School, Montezuma Creek	7-12	34	370	560
Total		193	3247	3908

Source: Utah State Office of Education, 1981.

A new high school under construction in Goulding-Monument Valley will be ready for occupancy in the fall of 1983. In addition to the public schools, Seventh Day Adventists support an elementary school with a current enrollment of 38 students in Monument Valley.

In 1981, the UNDC identified 400 dropouts and placed 125 in alternative education or training programs on the Utah Strip. The UNDC maintains an active adult basic-education program with 122 adults enrolled in 1981. A Head Start program run by the UNDC provided educational experiences to 115 preschool children in 1981 (UNDC, 1981).

G.6 WATER AND SEWER

Mexican Hat residents receive their culinary water from wells north of the town. Halchita water is supplied from a water-treatment facility on the San Juan River. The water is stored in three tanks northeast of Halchita. The Halchita water system is 4 years old and can support additional population growth, according to Jack McRedmond of the UNDC, June 7, 1982.

A new sewer system with a capacity for 100 additional connections is slated for completion in Mexican Hat in 1984. The Halchita sewer system consists of two lagoons. Currently, only one lagoon is being used and at less than full capacity, so the sewer system is capable of accommodating growth.

G.7 TRANSPORTATION

San Juan County has eight municipal airports that serve small aircraft. The airports are located in Monticello, Bluff, Blanding, Oljeto, Montezuma Creek, Monument Valley, Bullfrog Basin, and Hall's Crossing.

There is no railroad service in San Juan County. Monticello has Continental Trailways bus service.

Ground transportation is the usual mode of travel. Federal and State Route 163 runs in a north-south direction through San Juan County, connecting Monticello, Blanding, Bluff, and Mexican Hat. The average daily traffic is detailed in Table G-9.

Table G-9. Average daily traffic

	1977	1978	1979	1980	1981
Monticello (SR 191)	2055	2200	2100	2150	2395
Blanding (SR 191)	2200	2255	2255	2295	2475
Bluff (SR 191)	810	830	850	850	920
Mexican Hat (SR 163)	700	720	735	785	795
Halchita intersection (SR 163)	675	690	705	755	765
Arizona state line (SR 163)	650	670	685	730	740

Source: Utah Department of Transportation, 1980, pp. 46 and 47 and 1981, pp. 57, 62-63.

Traffic flows are much heavier in the northern part of the county; 50 miles north of the site, in Monticello, Route 191 is used three times as much as the length of highway adjacent to Halchita. Near Mexican Hat, Route 163 could accommodate another 1000 daily trips. Navajo Route 6440 is a gravel road that could accommodate worker traffic, but heavy truck traffic would necessitate upgrading over drainages.

G.8 HEALTH CARE

Local health-care services are available at the Halchita Clinic, which is located within the designated site boundaries, and at the Monument Valley Hospital, 26 miles from Halchita.

The clinic at Halchita recorded approximately 4000 patient visits in 1981 (UNDC, 1981, p. 7). The clinic is staffed by a nurse practitioner and a licensed practical nurse; a physician attends 2 days per week. The Halchita Clinic can provide stabilization and triage for transportation to an acute-care facility via an ambulance kept in Mexican Hat. The clinic has difficulty maintaining a staff because of its location and a lack of community facilities.

Monument Valley Hospital has 14 full-time salaried employees with 2 active physicians, 3 consulting physicians, and 5 registered nurses. In 1980 the hospital experienced a 32-percent occupancy level, compared to the state average of almost 70 percent. The use of the 27-bed facility is described in Table G-10.

Table G-10. Monument Valley Hospital use rates

	1975	1976	1977	1978	1979	1980
Admissions	542	537	464	465	508	391
Patient days	4901	3621	3273	3396	3489	3161
Average length of stay (days)	9.04	6.74	7.05	7.3	6.87	8.08
Percent occupancy	49.7	36.6	33.2	34.5	35.4	32.0

Source: Utah State Health Department, 1975-1980.

Another hospital is located in Monticello, approximately 62 miles north of Halchita. The 36-bed hospital experienced a 29-percent occupancy in 1980 and is served by 17 fee-for-service physicians. The nearest tertiary-care facility is in Grand Junction, Colorado, and in Phoenix, Arizona. Since existing hospital services in San Juan County are underused, additional patients could be served.

G.9 RECREATION

Outdoor recreational opportunities abound in San Juan County. The San Juan River is used for river-running and the surrounding land formations lend themselves to hiking and camping. Fishing and boating are available on Lake Powell in the Glen Canyon Recreational Area.

Indoor recreation opportunities are limited to shooting pool and playing cards.

G.10 PUBLIC SAFETY

Police protection in the Mexican Hat area is provided by the San Juan County Sheriff's Office and the Utah Highway Patrol. The county sheriff has two deputies stationed at Bluff, 14 miles from Mexican Hat. Highway patrol officers who police Highway 163 are stationed at Blanding, 39 miles away.

The Navajo Police provide law enforcement to Halchita. Thirty-one officers stationed at Kayenta, Arizona, regularly patrol the Halchita area.

Fire protection in the area is provided by a volunteer fire department in Mexican Hat. Fire protection is limited, as the equipment is antiquated. The housing development in Halchita has new fire hydrants but no equipment.

G.11 FISCAL CAPACITY

The ability of Mexican Hat to respond to growth will depend on the provision of services to this unincorporated area by San Juan County. The opportunity for Halchita to grow depends on the Navajo Nation. Fiscal data for Halchita are not available.

A study of financial resources for San Juan County was made by the Four Corners Regional Commission. The results of that study are detailed in Table G-11. San Juan County has the fiscal capacity to provide municipal-type services for Mexican Hat. The county could establish Mexican Hat as a Special Services District with limited ability to tax to provide the specific service for which it was established. However, in 1978 the residents of Mexican Hat voted to disincorporate as a town, preferring the lower tax option of an unincorporated area. Thus, the fiscal ability of Mexican Hat to respond to growth may be limited to collection of user fees or hookup charges.

Table G-11. San Juan County fiscal resources

Item	1978	1979	1980	1981	1982	1983	1984
	Year						
Population	13,850	14,500	15,150	16,200	17,100	17,900	18,550
Assessed valuation	101,545,703	102,524,777	110,387,129	119,872,390	131,963,150	139,682,359	146,521,391
Local mill levy	16	17.89	16	17	18	18	18
Property tax revenue	1,624,731	1,834,168	1,766,192	2,037,824	2,375,334	2,514,276	2,637,378
Gross taxable sales	15,873,912	13,408,050	14,782,910	16,108,379	17,439,970	18,929,375	20,108,327
Local-option sales tax	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
Sales tax revenue	123,584	98,548	107,908	117,588	127,434	138,181	145,788
Bonded debt	-0-						
Government obligation bonds	-0-						
Revenue bonds	-0-						
Bonding capacity	10,154,570	10,252,477	11,038,713	11,987,239	13,196,315	13,968,236	14,652,139
Maximum mill levy	26 mills						

Source: Burnett, 1980, p. 157.

G.12 WORK FORCE AND SCHEDULE

Assuming that the UNDC succeeds in establishing a training facility for Navajo workers, most of the remedial-action work force for Monument Valley will be housed at Halchita for the 1.3-year project.

Local contractors are expected to perform the remedial action at Monument Valley. The crew required is described in Appendix C, Section C.2. The average crew size is 49 persons; the largest single crew on the site at any given time is 52 workers. For the purpose of this assessment, the largest single crew of 52 people is used to predict the worst-case impact.

The staffing level reflects a 10-hour-per-day, 6-day-per-week work schedule. The project would be completed in 65 weeks, or 15.1 months. The equipment needed for the project is listed in Appendix C, Table C-4.

G.13 LABOR-FORCE AVAILABILITY

In Table G-5, 461 people are listed as unemployed in San Juan County for the first quarter of 1982. However, the skills of the unemployed are not given. Since the Monument Valley site is located on the Navajo Reservation, hiring for the remedial-action work must conform with the Navajo preference-in-hiring law. The potential number of Navajos that may be available for work was calculated by extrapolation of the 1980 census. The census lists 2442 American Indians in San Juan County in the age category of 18 to 64 years of age. In that age group, 46.4 percent of the county population is male, yielding 1133 male Navajos in the 18 to 64 age bracket. Assuming that 50 percent of these males are unemployed, then 566 could be available for hire. (The Navajo culture views construction work as a male activity.)

To remedy the lack of a skilled local labor force, the UNDC proposes establishing a training center in the maintenance building on the Halchita UMTRAP site. The training center would operate under the auspices of the Navajo Engineering and Construction Authority. Should this plan reach fruition, a local labor force would be in place. Should the training center not materialize, workers might be drawn from the 32 construction firms currently involved in major Navajo Nation activities listed in the 1980 Overall Economic Development Program for the Navajo Nation. These firms employ 1006 Navajos and 877 non-Navajos, for a total construction labor force of 1883 people.

In short, labor-force requirements can be met either through the creation of a training program or through use of an existing program.

G.14 MIGRATION AND INDIGENOUS LABOR-FORCE REQUIREMENTS

The remedial-action contractor is expected to supply the personnel for 12 of the 52 direct job slots. Specifically, the supervisory engineers, health professionals, and project management will migrate to the area. A 15-percent turnover rate has been assumed for all 40 skilled and semi-skilled direct job slots. Thus, 46 total job slots will be filled by the local contractor. The project, with turnover, will create a demand for 58 direct job slots.

G.15 INDIRECT EMPLOYMENT OPPORTUNITIES

Calculation of the indirect job slots for a deconstruction project such as the Monument Valley remedial action is difficult for two reasons. First, the literature relative to indirect job opportunities assumes a large-scale project with both a construction and operation work force, and the latter work force will not be needed at Monument Valley. Second, the UNDC maintains that Navajo workers will travel to their homes whenever the work schedule allows; thus, workers may not obtain goods and services in the Halchita area.

Because the project will last for 1.3 years, inducements for indirect employment will exist. The literature for computing a multiplier suggests that a 1.6 multiplier be used. If the 1.6 multiplier were applied to the 58-person crew size, 35 indirect job slots would be created. While this multiplier is consistent with the Housing and Urban Development Rapid Growth from Energy Projects (1976) and the Environmental Protection Agency Action Handbook (1978), it is not reflective of Navajo tribal law and custom. For a business to open on the reservation, permission from tribal authorities must be obtained. Given the reservation regulations concerning business development, the indirect employment opportunities may be confined to Mexican Hat, which is off the reservation. In Mexican Hat, a business person would probably require some assurance that the business would last beyond the 1.3 years. Because of these hindrances to the opening of new businesses, for this assessment a 1.3 multiplier is used. That is, for the 58 direct job slots, there will be an additional 16 employment-opportunity (indirect job) slots created. The 1.3 multiplier is reasonable considering that the greatest number of workers on the site at any given time is only 52.

G.16 POPULATION IMPACTS

To calculate the population impacts generated by the 52 direct job slots and the 16 induced job slots, the demographic data available from the 1980 U.S. Census were used. To compute the percentages of married and single persons, the data base generated by the Construction Worker Profile (Mountain West Research, Inc., 1975) and the Bureau of Reclamation Construction Worker Survey (Chalmers, 1977) was used. Additional demographic information obtained from Fred Ochoa, Director of Training with the UNDC, (personal communication on May 28, 1982) shows that Navajos typically do not move their families for temporary work opportunities. The origin of the work force is important in calculating population impacts on Halchita. Table G-12 lists the work force by project duration.

Table G-12. Origin of work force

Job slot	Navajo Nation	In-migrant
Heavy equipment operator	10	
Truck driver (including water)	20	
Oiler/mechanic	4	
Surveyor	4	
General construction	2	
Security		2
Supervisory engineer foreman		5
Health physicist and radiologist		5
Subtotal direct slots	40	12
Turnover	6	0
	46	12
Induced	8	8
Total	54	20

While the project will generate a single highest peak of 54 direct and indirect job slots, no more than 52 workers will be on the site at any given time and no more than 16 induced workers will be in Halchita or Mexican Hat at any time.

The population impacts of the work force are listed in Table G-13.

Table G-13. Population impacts

	In-migrant direct employment	In-migrant indirect employment	Total
Total job slots	12	8	20
Single (24.6 percent)[a]	3	2	5
Married (75.4 percent)	9	6	15
Married but would not relocate family (26.5 percent)[a]	2	2	4
Family present	7	4	11
Family size of 3.04[b]	21	12	33
Total population impact[c]	33	20	53
Adults	19	12	31
Children	14	8	22

[a]Mountain West Research, Inc., 1975.
[b]Average family size of 4.04, 1980 U.S. Census, San Juan County, Utah.
[c]Cumulative of line items: single and married, not relocate, and family present and family size.

G.17 DEMOGRAPHICS OF INCREASED POPULATION

The principal purpose of computing the probable demographic profile of the in-migrant population is to determine the potential impact on the school system. To compute the age of the children who will in-migrate, the age-distribution data for San Juan County were used. The age data indicate that 15.2 percent of the children will be less than 5 years of age and 84.8 percent will be of school age. Table G-14 summarizes the impact on schools.

Table G-14. Impact of school-aged children

	Direct	Indirect	Total
Total children	14	8	22
Under school age, < 5 years (15.2%)	2	1	3
School age, 5 to 17 years (84.8%)	12	7	19

A summary of the project demands is listed in Table G-15.

Table G-15. Project demand summary

Resource	Demand
Schools	19 children
Housing (52 plus 16 induced)	68 units (maximum)
Water (100 gallons per person per day)	6800 gallons per day
Sewer (103 gallons per day)	7004 gallons per day

Table G-16 portrays the ability of the community to serve the influx of people caused by the proposed remedial action.

Table G-16. Project demand and community supply

	Project demand at any one time (people)	Current supply units
Housing units	68	80
Water	107[a] (10,700 gallons per day)	available
Sewer	107 (11,021 gallons per day)	available
Education	19	23
Skilled and semi-skilled workers	40	566

[a]The figure includes the increased population of 53 (Table G-13) and also allows for any workers from a rural area to have overnight accommodations at the Halchita dormitory. To liberally estimate the impact, overnight accommodations are assumed for all 54 workers.

G.18 FISCAL IMPACT

The remedial action would inject approximately $10.4 million into the economies of the Navajo Nation and Mexican Hat. Details of the budget for the proposed action are given in Table C-6, Appendix C.

Assuming that local contractors do the work, no taxes would accrue to the area, as there are no taxes on the reservation.

Some evidence exists that the almost $10.4 million fiscal impact is very conservative; in other words, it reflects the minimum fiscal benefit to the Navajo Nation and regional trade centers off the reservation. However, data are not available regarding how people on the reservation spend their money. It is not known if most of the personal income stays on the reservation or if purchases are made in regional trade centers such as Flagstaff, Gallup, and Farmington. Local governments would benefit from increased sales-tax revenue if goods and services are purchased off the reservation.

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AGENCIES AND PERSONS CONSULTED
FOR APPENDIX G

Jack McRedmond, Utah Navajo Development Council, Blanding, Utah, to obtain information on population, housing, and water in Halchita.

Fred Ochoa, Director of Training, Utah Navajo Development Council, Blanding, Utah, to acquire demographic information on the Navajo tribe.

Appendix H

ESTIMATES OF HEALTH EFFECTS OF RADIATION

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Appendix H

ESTIMATES OF HEALTH EFFECTS OF RADIATION

The contaminated material at the Monument Valley site exposes people who live and work nearby to low levels of radiation. The radiation doses received by these people could pose a potential threat to their health, principally excess cancer deaths. This appendix derives upper limits to the numbers of cancers that might be expected in people who live near the Monument Valley site and in the workers who carry out the remedial actions there.

H.1 BASIC FACTS ABOUT RADIATION AND ITS MEASUREMENT

Atoms that spontaneously transform into new atoms are said to be "radioactive." The original atom is called the "parent," and the atom produced by the transformation is called the "daughter product," or simply the "daughter." This transformation process is called "radioactive decay," or simply "decay." The rate at which atoms decay is the "activity," measured by the unit "curie." A more convenient unit for measuring the activity of the atoms in tailings piles is the picocurie, which is one-millionth of one-millionth of a curie.

When atoms undergo radioactive decay, they emit "radiation." Three types of radiation are discussed in this assessment; they are "alpha" and "beta" radiation, which are tiny particles, and "gamma" radiation, which is pure energy. Alpha and beta radiation do not penetrate far into matter; gamma radiation can penetrate deeper into matter in the same way as X-rays.

When radioactive parent atoms decay to radioactive daughter atoms, a "radioactive decay series," or simply a "decay series," is formed. Uranium-238 is such a radioactive parent atom. The uranium-238 decay series includes thorium-230, radium-226, radon-222, short-lived radon daughters, and other radioactive atoms; it ends with lead-206, an atom that is not radioactive. The only member of this series that is not a solid is radon-222; it is an inert gas. Radon does not react chemically with other elements; it can diffuse out of matter and into the atmosphere.

Trace amounts of uranium-238 and its daughters are found everywhere on the earth; therefore, radon-222, or simply radon, and its short-lived daughters contribute significantly to the background radiation exposure of the general population. In the uranium milling process, radium, the parent of radon, is left in the tailings, which then become a source from which radon emanates into the atmosphere.

When the daughter products in a radioactive decay chain have shorter half-lives than the parent, the daughter activities will increase until they equal the activity of the parent. When the activities of the parent and its daughters are equal, the daughters are said to be in "100-percent equilibrium" or simply in "equilibrium." If the daughters are diluted or carried away as they are formed, they will never reach 100-percent equilibrium.

Since radon is an inert gas, it contributes very little to a person's radiation exposure; it is inhaled and exhaled leaving no residual effect. The radon daughters, however, are solids; they can deposit in the bronchi and lungs as they are inhaled. Once deposited, radon daughters decay and expose the person to radiation.

The unit "working level" (WL) is used to measure radon-daughter concentration; it is defined as any concentration of radon daughters in 1 liter of air that will result in the ultimate emission of 1.3 x 10^5 million electron volts of alpha energy. A concentration of 100 picocuries per liter (pCi/l) of radon with the radon daughters at 100-percent equilibrium will result in a radon-daughter concentration of 1 WL. At equilibrium levels less than 100 percent, the number of working levels corresponding to a given radon concentration is reduced. The working-level month (WLM) is a unit of radon-daughter exposure; it is defined as the exposure resulting from the inhalation of air with a concentration of 1 WL of radon daughters for 170 working hours.

The intensity of gamma radiation in air is frequently expressed in roentgens. A microroentgen is one-millionth of a roentgen.

H.2 METHODS OF ANALYSIS

The estimations made in this appendix are based on data presented in BEIR-III, a major report issued by the National Research Council of the National Academy of Sciences (1980). Because the BEIR-III report itself does not always make firm recommendations about the best way to use the data, these estimates also make use of recommendations published in scientific journals.

H.2.1 Health effects of exposure to radon daughters

When radon gas escapes from tailings and from other materials, the radioactive daughters produced from its decay may become concentrated in the air. Persons who live or work nearby breathe this air and are therefore exposed to the radiation emitted by the radon daughters. The BEIR-III report gives a model for estimating the health effects of such exposures. The unit of concentration used in the BEIR-III report is the working level (WL); it is defined as any concentration of radon daughters in 1 liter of air that will result in the ultimate emission of 1.3 x 10^5 million electron volts of alpha energy. The unit of exposure used in the BEIR-III report is the working-level month (WLM); it is defined as the exposure resulting from the inhalation of air with a concentration of 1 WL of radon daughters for 170 working hours. The total exposure of one or more persons is the product of the number of persons and the average exposure they receive; the unit for the measurement of such a population exposure is the person-WLM.

Several studies of lung cancer in miners exposed to radon-daughter concentrations in air are used to formulate the model given in the BEIR-III report for predicting the risk of lung cancer. Because this model is age dependent

and arose from studies of workers, it must be interpreted before it can be used for estimating risks of lung cancer from low-level exposures to the general population. Cohen (1982b) has used the BEIR-III model to estimate the population risk of lung cancer as 520 x 10^{-6} deaths per person-WLM. He has also presented data (Cohen, 1982a) suggesting that this model overestimates radon-induced lung cancer among nonsmokers by a factor of 40. Evans et al. (1981) have reviewed the miner studies, lung-cancer risk estimates published by several authors, and epidemiological evidence. They conclude that the most defensible upper bound to the lifetime lung-cancer risk for the general population is 100 x 10^{-6} deaths per person-WLM.

Recent work has shown that an upper exposure of a given number of WLM is equally effective in inducing health effects during occupational exposure and during population exposure. Cohen (1982a) discusses several factors that affect the effectiveness of WLM exposures and cites two references that bracket his assumption of equality. Harley and Pasternack (1982) furnish further evidence for this equality. Equal effectiveness is assumed here, and the risk factor of 100 x 10^{-6} deaths per person-WLM is used to calculate an upper bound for lung-cancer deaths in the remedial-action workers and the population living near the Monument Valley tailings.

H.2.2 Health effects of exposure to gamma radiation

The tailings emit gamma rays that deliver radiation doses to nearby people; unlike the radiation from radon daughters, which principally affects the lungs, the gamma radiation produces an "external" exposure to the whole body. The rad is a unit for the measurement of dose received by a person; for gamma radiation the rad is essentially equal to the roentgen, the unit for measuring the intensity of gamma radiation in air.

The BEIR-III report contains several models for determining cancer risk resulting from exposure to gamma radiation. It is necessary to define the person at risk in order to know which risk model is applicable. This analysis assumes the work force is predominantly males who range in age from 20 to 49 years. The average age is assumed to be 35 years and the average age at death is assumed to be 70 years.

H.3 CALCULATIONS OF HEALTH EFFECTS

Calculated health effects at the Monument Valley site are presented in the body of this report. The methods of calculation are shown here.

H.3.1 General public

Only 28 people live close enough to the Monument Valley site to be affected by detectable concentrations of radon daughters from the tailings (Hans and Douglas, 1975). These people live in three Navajo hogans (Figure 1-1), about 1000, 1500, and 1700 feet from the site. This conservative analysis assumes that all of the people live there permanently. It assumes that the 28 persons spend 70 percent of their time at their hogans; 50 percent is spent indoors and 20 percent outside. Of the remaining 30 percent, 10 percent is spent at a distance of 0.5 mile from the tailings, and 20 percent is spent at a distance great enough for the radon-daughter concentration from the tailings to be negligible.

As explained in Section 2.8, the average radon concentration 0.11 mile downwind from the edge of the pile is 3.2 picocuries per liter (pCi/l), while the average background concentration in the Monument Valley area is 0.6 pCi/l. The difference, attributable to the tailings, is 2.6 pCi/l.

To estimate the concentration of radon daughters at distances other than 0.11 mile from the pile, it is necessary to know how their concentrations are diluted as they move through the air. Appendix A-3 of <u>Meteorology and Atomic Energy</u> (Slade, 1968) contains a log-log plot of normalized average axial concentrations versus travel distance for several conditions of atmospheric stability. Over the distances of interest in this report, the slopes of the curves for the stability conditions are approximately equal; therefore, the dilution of a contaminant between two points is affected very little by the stability of the atmosphere. The curve for Pasquill's condition F (minimum dilution) can be normalized to the measured radon concentration of 2.6 pCi/l above background at 0.11 mile from the site. The radon concentration at 1000 feet (0.19 mile) read from this normalized curve is 0.77 pCi/l; at 1500 feet (0.28 mile) it is 0.39 pCi/l; at 1700 feet (0.32 mile) it is 0.30 pCi/l; and at 0.5 mile it is 0.13 pCi/l.

The wind pattern at the Monument Valley site is assumed to be similar to that at Farmington, New Mexico, about 60 miles east of the site. To derive the number of working levels corresponding to these concentrations, the equilibrium value defined in Section 2.8 must be estimated. The average wind speed from the tailings toward Hogan No. 1 is 10.1 miles per hour, as noted above. This speed will carry radon daughters 0.28 mile in about 1.7 minutes, in which time they will reach about 2-percent equilibrium (Evans, 1980). The average wind speed in the direction from the tailings toward Hogan No. 2 is 11.7 miles per hour; radon daughters will be carried 0.32 mile in 1.6 minutes. Winds from the tailings area blowing toward Hogan No. 3 average 9.1 miles per hour. At this speed, radon daughters will be carried 0.19 mile in 1.2 minutes. It is assumed for this study that when people are at a distance of 0.5 mile

from the site, the wind would be continuously blowing at a speed of 10 miles per hour from the site to the population. This conservative assumption helps to set an upper bound to the lung-cancer risk. The radon-daughter equilibrium will be less than 10 percent at all locations; the value of 10 percent will be used for conservatism and convenience (Evans, 1980).

The radon-daughter concentration is assumed to be at 50-percent equilibrium indoors. Although some data show that this factor is appropriate for radon emanating from sources close to a structure (UNSCEAR, 1977), it is an overestimate for radon carried from more distant sources by wind.

With these factors, the radon-daughter concentrations in working levels are calculated as follows:

$$\frac{0.77\ \text{pCi/l}}{100\ \text{pCi/l-WL}} \times 0.1 = 7.7 \times 10^{-4}\ \text{WL at 0.19 mile;}$$

$$\frac{0.39\ \text{pCi/l}}{100\ \text{pCi/l-WL}} \times 0.1 = 3.9 \times 10^{-4}\ \text{WL at 0.28 mile;}$$

$$\frac{0.30\ \text{pCi/l}}{100\ \text{pCi/l-WL}} \times 0.1 = 3.0 \times 10^{-4}\ \text{WL at 0.32 mile;}$$

$$\frac{0.13\ \text{pCi/l}}{100\ \text{pCi/l-WL}} \times 0.1 = 1.3 \times 10^{-4}\ \text{WL at 0.5 mile.}$$

Under the assumptions discussed above, a 1-year exposure to persons living in each of the three hogans is

for Hogan No. 1, 0.28 mile east of the site:

$$(3.9 \times 10^{-4}\ \text{WL} \times 5 \times 0.5 + 3.9 \times 10^{-4}\ \text{WL} \times 0.2 + 1.3 \times 10^{-4}\ \text{WL} \times 0.1)$$
$$\times \frac{8760\ \text{hours/year}}{170\ \text{hours/working month}} \times 0.2$$
$$= 0.011\ \text{WLM per year}$$

for Hogan No. 2, 0.32 mile southeast of the site:

$$(3.0 \times 10^{-4}\ \text{WL} \times 5 \times 0.5 + 3.0 \times 10^{-4}\ \text{WL} \times 0.2 + 1.3 \times 10^{-4}\ \text{WL} \times 0.1)$$
$$\times \frac{8760\ \text{hours/year}}{170\ \text{hours/working month}} \times 0.08$$
$$= 0.0034\ \text{WLM per year}$$

and for Hogan No. 3, 0.19 mile south of the site:

$$(7.7 \times 10^{-4} \text{ WL} \times 5 \times 0.5 + 7.7 \times 10^{-4} \text{ WL} \times 0.2 + 1.3 \times 10^{-4} \text{ WL} \times 0.1)$$

$$\times \frac{8760 \text{ hours/year}}{170 \text{ hours/working month}} \times 0.17$$

$$= 0.018 \text{ WLM per year}$$

The number of lung-cancer deaths from the Monument Valley tailings among the 15 persons who live within 1 mile of the site would be less than

$$0.011 \text{ WLM/year} \times 100 \times 10^{-6} \text{ deaths/WLM-person} \times 10 \text{ persons}$$

$$+ 0.003 \text{ WLM/year} \times 100 \times 10^{-6} \text{ deaths/WLM-person} \times 10 \text{ persons}$$

$$+ 0.018 \text{ WLM/year} \times 100 \times 10^{-6} \text{ deaths/WLM-person} \times 8 \text{ persons}$$

$$= 2.8 \times 10^{-5}$$

$$= 0.000028 \text{ lung-cancer deaths per year of exposure.}$$

During the 10 months of remedial action, the radon concentration is assumed to be 100 percent higher because of disturbance of the tailings. The estimated excess number of lung-cancer deaths due to the remedial action would then be

$$2.8 \times 10^{-5}\text{/year} \times \frac{10 \text{ months}}{12 \text{ months/year}} \times 2.0$$

$$= 4.7 \times 10^{-5}$$

$$\simeq 0.00005 \text{ lung-cancer death.}$$

As shown in the main text of this assessment, the exposure from gamma radiation from the Monument Valley site in all populated areas is at or very near natural background. This condition is expected to continue throughout the remedial action. Therefore, no meaningful calculation of health effects among the general public from exposure to gamma radiation from the tailings can be made.

H.3.2 Remedial-action workers

As shown in Section 3.1.2.2, remedial-action workers working directly on the tailings will receive an exposure of 0.32 WLM. Using the risk estimator of 100×10^{-6} death per WLM-person to determine the upper limit for estimated excess lung-cancer mortality, one calculates

$$0.32 \text{ WLM} \times 100 \times 10^{-6}\text{/WLM-person} = 3.2 \times 10^{-5} \text{ per person.}$$

The upper bound for lung cancer among the 52 workers would be

3.2×10^{-5}/person x 52 persons = 1.7×10^{-3} = 0.0017 lung-cancer death.

For worker exposure to gamma radiation, the calculation is based on the risk factors described in Section H.2.2. The total gamma exposure due to the tailings is

$$D = 2640 \text{ hours} \times (63-9) \text{ microroentgens/hour}$$

$$= 143{,}000 \text{ microroentgens}$$

$$= 0.143 \text{ roentgen}$$

where the 9 microroentgens per hour due to background is explicitly subtracted.

To estimate the leukemia and bone-cancer mortality, one uses the coefficients given in Table V-16 of the BEIR-III report. The BEIR committee recognized that for doses of 1 rad per year or less the quadratic component--the term containing the square of the dose--in the calculation is so small that it can be safely ignored. Because the doses in this assessment are much less than 1 rad per year, the dose-squared term is not included in the calculations. For these two cancers, the text in the report recommends a short latent period (assumed here to be 0) and a risk period of 25 years. The age-dependent regression coefficients for males aged 20 to 34 and 35 to 49 are averaged to calculate the annual risk of leukemia from the following equation:

$$\frac{1.138 + 0.8511}{2} \times 10^{-6}\text{/person-rad-year} \times 0.143 \text{ roentgens} \times 1 \frac{\text{rad}}{\text{roentgen}}$$

$$= 1.4 \times 10^{-7} \text{ death per person per year of risk.}$$

The lifetime leukemia risk is

$$1.4 \times 10^{-7}\text{/person-year} \times 25 \text{ years} = 3.6 \times 10^{-6} \text{ per person.}$$

The bone-cancer risk is 2.2 percent of the leukemia risk or

$$3.6 \times 10^{-6}\text{/person} \times 0.022 = 7.8 \times 10^{-8} \text{ per person.}$$

To estimate the risk from fatal cancers other than leukemia and bone cancer, this analysis uses the model given in Table V-19 of the BEIR-III report. For these cancers the text of the report recommends a 10-year latent period followed by a lifetime risk. For the remedial-action workers, then, a 25-year risk period follows the 10-year latent period. The annual risk from cancers other than leukemia and bone cancer would be

$$\frac{1.774 + 2.278}{2} \times 10^{-6}\text{/person-rad-year} \times 0.143 \text{ roentgens} \times 1 \frac{\text{rad}}{\text{roentgen}}$$

$$= 2.9 \times 10^{-7} \text{ death per person per year of risk.}$$

The lifetime risk is

$$2.9 \times 10^{-7}\text{/person-year} \times 25 \text{ years} = 7.3 \times 10^{-6} \text{ per person.}$$

The lifetime risk from all forms of cancer due to exposure from gamma radiation is obtained by summing the risk of leukemia, bone cancer, and other cancers. This gives:

$$3.6 \times 10^{-6}\text{/person} + 7.8 \times 10^{-8}\text{/person} + 7.3 \times 10^{-6}\text{/person}$$

$$= 1.1 \times 10^{-5} \text{ per person.}$$

The lifetime risk for a crew of 52 persons would be

$$1.1 \times 10^{-5}\text{/person} \times 52 \text{ persons} = 5.7 \times 10^{-4}$$

$$= 0.0006 \text{ cancer death.}$$

H.4 ARIZONA CANCER DEATH RATES

The State of Arizona has reported total mortality from lung cancer and from all cancers during 1981 (Dutton, 1982). The U.S. Bureau of the Census has given the total Arizona population as of April 1, 1980 (USDC, 1981). From this information the individual risk of death from these causes may be estimated.

In Arizona, 1199 persons died of lung cancer during 1981, and the population as of April 1, 1980, was estimated at 2,719,000. It is estimated that the time of risk for lung-cancer death is 50 years. The individual 50-year risk then is

$$\frac{1199 \text{ deaths/year}}{2,719,000 \text{ persons}} \times 50 \text{ years} = 0.022 \text{ per person.}$$

For a population of 52 persons (the number in the Monument Valley work crew) the total estimated lifetime number of lung-cancer deaths is

$$0.022 \times 52 = 1.14.$$

In the same manner the risk of dying from other forms of cancer may be estimated.

The total number of other cancer deaths in 1981 was 3370. Deaths occurred at all ages, from less than 1 year to 85+. The period of risk is therefore a full lifetime, taken as 70 years. Then the individual lifetime risk is

$$\frac{3370 \text{ deaths/year}}{2{,}719{,}000 \text{ persons}} \times 70 \text{ years} = 0.087 \text{ per person.}$$

and the estimated number of deaths in a population of 52 is

$$0.087 \times 52 = 4.5.$$

The estimated number of deaths from all cancers in a population of 52 would be

$$1.1 + 4.5 = 5.6 \simeq 6.$$

H.5 CALCULATIONS OF RADON FLUX THROUGH SOIL COVERS

The calculation of radon flux emanating from covered tailings is complex, especially when the cover consists of more than one material. An equation has been delivered and is available in NUREG/CR-2340 (NRC, 1981). The equation is

$$J_n = J_o \left(\prod_{i=1}^{n} f_i \right) \exp \left(- \sum_{i=1}^{n} \sqrt{\frac{\lambda}{D_i}} \, d_i \right) \tag{1}$$

where

J_n = flux through the final layer

J_o = bare tailings flux

λ = radon decay constant

D_i = diffusion coefficient of ith layer

d_i = thickness of ith layer

$$f_i = \frac{2}{\left(1 + \frac{P_o}{P_i}\sqrt{\frac{D_o{}^i}{D_i}}\right) + \left(1 - \frac{P_o}{P_i}\sqrt{\frac{D_o{}^i}{D_i}}\right) e^{-2\sqrt{\frac{\lambda}{D_i}}\, d_i}} \tag{2}$$

where

$D_o{}^i$ = effective diffusion coeffcient for all lower layers

P_o = tailings porosity

P_i = porosity of ith layer

D_o = diffusion coefficient tailings

For simplification, the porosities of all soils, including tailings, are assumed to be approximately equal. The porosity, therefore, drops out of the calculations. Finally, the effective diffusion coefficient, D_o^n, is calculated from

$$D_o^n = \sum_{i-o}^{n-1} D_i \left[1-\exp\left(-\sqrt{\frac{\lambda}{D_i h_i}}\, d_i\right)\right] \exp\left(-\sum_{j=i+1}^{n-1} \sqrt{\frac{\lambda}{D_j h_j}}\, d_j\right) \qquad (3)$$

and

$$h_i = \left[1 - \frac{\ln f_i}{d_i \sqrt{\frac{\lambda}{D_i}}}\right]^{-2} \qquad (4)$$

As it turns out, f_i approaches unity for increasing cover thickness, so that $\ln f_i \Rightarrow 0$, and h_i also approaches unity. Therefore, h_i is neglected except for h_1.

Diffusion coefficients have been determined for various soils, to be used in the calculations. These are taken from information summarized in Table 3.1 of NUREG/CR-2340 (NRC, 1981). The coefficients are tabulated as follows:

Description	D (cm^2/s)
tailings	0.01
gravel	0.08
clay	0.01
sandy-silty soil	0.035

At Monument Valley the parameters needed to calculate the expected flux through the cover are the following:

$J_o = 50$ pCi/m^2-s $D_o = 0.001\ cm^2/s$

$d_1 = 2$ ft clay $D_1 = 0.01\ cm^2/s$

$d_2 = 4.5$ ft sand $D_2 = 0.035\ cm^2/s$

The flux through the cover (J_2) is calculated as follows:

$$J_1 = J_o f_1 e^{-d_1\sqrt{\frac{\lambda}{D_1}}}$$

$$f_1 = \frac{2}{\left(1+\sqrt{\frac{D_o}{D_i}}\right) + \left(1-\sqrt{\frac{D_o}{D_i}}\right) e^{-2d_1\sqrt{\frac{\lambda}{D_i}}}}$$

$$= \frac{2}{\left(1+\sqrt{\frac{0.01}{0.01}}\right) + \left(1-\sqrt{\frac{0.01}{0.01}}\right) e^{-2(60.96)\sqrt{\frac{\lambda}{0.01}}}} = \frac{2}{2} = 1$$

$$J_1 = 50\ e^{-60.96\sqrt{\frac{0.693}{3.8 \times 24 \times 3600 \times 0.01}}}$$

$$= 20.6\ \text{pCi/m}^2\text{-s}$$

$$J_2 = J_1\ f_2\ e^{-X_2\sqrt{\frac{\lambda}{D_2}}}$$

$$f_2 = \frac{2}{\left(1+\sqrt{\frac{D_o'}{D_2}}\right) + \left(1-\sqrt{\frac{D_o'}{D_2}}\right) e^{-2d_2\sqrt{\frac{\lambda}{D_2}}}}$$

$$D_o' = D_o\ e^{-d_1\sqrt{\frac{\lambda}{D_1h_1}}} + D_1\left[1-e^{-d_1\sqrt{\frac{\lambda}{D_1h_1}}}\right]$$

$$h_1 = \left[1 - \left(\frac{1}{d_1\sqrt{\frac{\lambda}{D_1}}}\right)\ln f_1\right]^{-2} = \left[1 - \left(\frac{1}{60.96\sqrt{\frac{\lambda}{0.01}}}\right)\ln 1\right]^{-2} = 1^{-2} = 1$$

$$D_o' = 0.01\ e^{-60.96\sqrt{\frac{0.693}{3.8x24x3600x0.01}}} + 0.01\left[1-e^{-60.96\sqrt{\frac{0.693}{3.8x24x3600x0.01}}}\right]$$

$$= 0.01$$

$$f_2 = \frac{2}{\left(1+\sqrt{\frac{0.01}{0.035}}\right) + \left(1-\sqrt{\frac{0.01}{0.035}}\right) e^{-2(4.5)(30.48)\sqrt{\frac{0.693}{3.8 \times 24 \times 3600 \times 0.035}}}}$$

$$f_2 = 1.26$$

$$J_2 = 20.6\ (1.26)\ e^{-4.5\ (30.48)} \sqrt{\frac{0.693}{3.8 \times 24 \times 3600 \times 0.035}}$$

$$= 8.95 \simeq 9.0\ \text{pCi/m}^2\text{-s.}$$

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