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United States Department of Energy

Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings Site at Shiprock, New Mexico

Appendix B of the Cooperative Agreement No. DE-FC04-83AL16258

June, 1985

Uranium Mill Tailings Remedial Action Project UMTRAP

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REMEDIAL ACTION PLAN FOR STABILIZATION

... THE

INACTIVE URANIUM MILL TAILINGS SITE

AT

SHIPROCK, NEW MEXICO

URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT OFFICE

ALBUQUERQUE OPERATIONS OFFICE

DEPARTMENT OF ENERGY

ALBUQUERQUE, NEW MEXICO 87108

U.S. Department of Energy
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Appendix B

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1.0 INTRODUCTION

1.1 PURPOSE

This Remedial Action Plan (RAP) has been developed to serve a twofold purpose. It presents the series of activities which are proposed by the Department of Energy (DOE) to effect long-term control of radioactive materials at the inactive uranium processing site located on the Navajo Reservation at Shiprock, New Mexico. It also serves to document the concurrence of both the Navajo Nation and the Nuclear Regulatory Commission (NRC) in the remedial action.

1.2 RESPONSIBILITIES

In 1978, Congress passed Public Law 95-604, the Uranium Mill Tailings Radiation Control Act (UMTRCA), expressly finding that uranium mill tailings located at inactive (and active) mill sites may pose a potential health hazard to the public. Title I to the UMTRCA identified sites to be designated for remedial action. On November 9, 1979, Shiprock was designated as one of 24 sites.

UMTRCA charged the Environmental Protection Agency (EPA) with the responsibility for promulgating remedial action standards for inactive mill sites. The purpose of these standards is to protect the public health and safety and the environment from radiological and non-radiological hazards associated with radioactive materials at the sites. The final standards were promulgated with an effective date of March 7, 1983.

The DOE will select and execute a plan of remedial action that will satisfy the EPA standards. Under UMTRCA, the DOE is authorized to enter into cooperative agreements with Indian tribal governments to perform remedial actions. The DOE will fund 100 percent of the remedial action cleanup costs on Indian land. A cooperative agreement covering the guidelines, responsibilities, and conditions for remedial actions was negotiated between the DOE and the Navajo Nation and signed on September 13, 1983. The cooperative agreement was concurred in by both the NRC and the U.S. Department of the Interior, Bureau of Indian Affairs.

All remedial actions must be selected and performed with the concurrence of the NRC. In conformance with the UMTRCA, the required NRC concurrence with the selection and performance of proposed remedial actions and the licensing of the long-term monitoring and maintenance of disposal sites will be for the purpose of ensuring compliance with the standards set by the EPA. Therefore, the RAP constitutes the initial document in the licensing process. A detailed listing of the responsibilities of the project participants is included in Section 7.0 of this report.

1.3 SCOPE AND CONTENT

This document has been structured to provide a comprehensive understanding of the remedial action proposed for the Shiprock site. Detailed supporting information can be found in appendices and referenced documents.

Section 2.0 presents the EPA standards, including a discussion of their objectives. Section 3.0 traces the history of operations at the Shiprock site with a description of the present site characteristics. Section 4.0 provides a definition of site-specific problems, a listing of remedial action alternatives which have been considered, and the action which is being proposed. Section 5.0 presents a summary of the conceptual design for the proposed action which includes objectives, design features, schedule, cost, and implementation methods. Section 6.0 summarizes the plan for ensuring health and safety protection for the surrounding community and the on-site workers. Section 7.0 presents a detailed listing of the responsibilities of the project participants. Section 8.0 describes the quality assurance process that will be used by the RAC during construction. Section 9.0 describes the features of the long-term maintenance and surveillance plan. Section 10.0 documents the on-going activities to keep the public informed and participating in the project.

Attached as part of the RAP are five appendices (A-E) which describe in more detail various aspects of the remedial action.

Appendix A, Regulatory Compliance, describes in detail the permits necessary for the remedial action activities.

Appendix B, Geomorphic Stability, describes the present geomorphic condition of the site and recommendations for mitigating measures.

Appendix C, Radiological Support Plan, describes the procedures used to characterize the present radiological condition of the site and the procedures to be used to control and verify the results of remedial action activities.

Appendix D, Environmental, Health, and Safety Plan, describes the procedures to be used to protect the health and safety of workers and the general public during remedial action activities.

Appendix E, Site Conceptual Design, describes in detail the proposed remedial action design. Attachment A to Appendix E provides a summary of the rationale and calculations that support the conceptual design. The reader is referred to this appendix in particular for an understanding of the proposed remedial action.

1.4 COLLATERAL DOCUMENTS

In addition to the RAP, the reader is referred to other documents which describe the existing conditions at the site and the results of the remedial action. These collateral documents are the Processing Site Characterization Report and the Environmental Assessment. They include details that are not reported in the RAP.

The Processing Site Characterization Report (PSCR, 1984), contains all of the data, including geotechnical, hydrological, radiological, meteorological, and physical, that describe the existing conditions at the site. It also contains data which characterize potential remedial action construction materials.

The Environmental Assessment (EA, 1984) describes the proposed remedial action and several alternatives and the environmental impacts of the proposed actions.

Copies of all of these documents as well as supporting data and calculations are on file in the UMTRA Project Office, Albuquerque, New Mexico.

2.0 EPA STANDARDS

2.1 GENERAL

Pursuant to the requirements of UMTRCA, EPA has promulgated health and environmental standards to govern cleanup, stabilization, and control of residual radioactive materials at inactive uranium mill tailings sites. The promulgated standards establish requirements for long-term stability and radiation protection and provide procedures for ensuring the protection of ground-water quality.

In developing the standards, EPA determined "that the primary objective for control of tailings should be isolation and stabilization to prevent their misuse by man and dispersal by natural forces such as wind, rain and flood waters" and that "a secondary objective should be to reduce radon emissions from tailings piles." A third objective should be "the elimination of significant exposure to gamma radiation from tailings piles." (Ref. preamble to Standards for Remedial Actions at Inactive Uranium Processing Sites, 40 CFR Part 192.) These conclusions were based on a determination that the most significant public health risks associated with inactive tailings were posed by exposure to people living and working in structures contaminated by relocated tailings. EPA further concluded that the potential for contamination of ground water and surface water should be evaluated on a site-specific basis.

The EPA standards are discussed in the following paragraphs and are summarized in Table 2.1.

2.2 LONG-TERM STABILITY

Isolation and stabilization of tailings in order to prevent misuse by man and dispersal by natural forces is the primary objective of the EPA standards. Accordingly, long-term stability was emphasized in the development and promulgation of the standards. This is consistent with the guidance provided by the legislative history of UMTRCA which stresses the importance of avoiding remedial actions which would be effective only for a short period of time and which would require future Congressional consideration.

The EPA standard-setting process distinguished "passive controls," such as thick earthen covers, below-ground disposal, rock covers, and massive earth and rock dikes, from "active controls" such as semi-permanent covers, fences, warning signs, and restrictions on land use. Active control covers could be expected to need frequent replacement or other major repairs requiring the appropriation and expenditure of public funds. In setting the standards, EPA called for designs which rely primarily on passive controls.

The Standard is framed as a longevity requirement which recognizes the difficulty in predicting very long-term performance with a very high degree of confidence. In establishing the longevity requirement, EPA concluded that existing knowledge permits the design of control systems

PART 192 - HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM MILL TAILINGS

SUBPART A - Standards for the Control of Residual Radioactive Materials from Inactive Processing Sites

192.02 Standards

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, or
(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.

SUBPART B - Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites

192.12 Standards

Remedial actions shall be conducted so as to provide reasonable assurance that, as a result of residual radioactive materials from any designated processing site:

(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.

SUBPART C - Implementation (condensed)

192.20 Guidance for Implementation

Remedial action will be performed with the "concurrence of the Nuclear Regulatory Commission and the full participation of any state that pays part of the cost" and in consultation as appropriate with other government agencies.

192.21 Criteria for Applying Supplemental Standards

The implementing agencies may apply standards in lieu of the standards of Subparts A or B if certain circumstances exist, as defined in 192.21.

192.22 Supplemental Standards

"Federal agencies implementing Subparts A and B may in lieu thereof proceed pursuant to this section with respect to generic or individual situations meeting the eligibility requirements of 192.21."

(a) ". . .the implementing agencies shall select and perform remedial actions that come as close to meeting the otherwise applicable standards as is reasonable under the circumstances."

(b) ". . .remedial actions shall, in addition to satisfying the standards of Subparts A and B, reduce other residual radioactivity to levels that are as low as is reasonably achievable."

(c) "The implementing agencies may make general determinations concerning remedial actions under this Section that will apply to all locations with specified characteristics, or they may make a determination for a specific location. When remedial actions are proposed under this Section for a specific location, the Department of Energy shall inform any private owners and occupants of the affected location and solicit their comments. The Department of Energy shall provide any such comments to the other implementing agencies [and] shall also periodically inform the Environmental Protection Agency of both general and individual determinations under the provisions of this section."

Ref: Federal Register, Volume 48, No. 3, January 5, 1983, 40 CFR Part 192.

TABLE 2.1 EPA STANDARDS

that have a good expectation of lasting at least 1000 years. Therefore, a design objective of 1000 years was established to be satisfied whenever reasonably achievable, but in any case with a minimum performance period of 200 years.

The Standard recognizes the need for institutional controls such as custodial maintenance, monitoring, and contingency response measures. In its preamble to the standards, EPA calls for such controls to be provided as an essential backup to the primary passive controls.

2.3 RADON EMISSIONS CONTROL

EPA identified a reduction of radon emissions from tailings piles as the second objective in its standards for the control of tailings. In developing the standards, it considered several alternative approaches and selected an emission limitation as the primary form of the standard. In addition, it established a concentration limit as an alternative form of the standard for use in cases where the DOE determined that the alternative was appropriate.

In establishing the emission limitation for tailings piles, EPA sought to reduce both the maximum risk to individuals living very near to the sites and the risk to the population as a whole. With regard to individuals very near to disposal sites, EPA estimates that exposure to radon emissions will be reduced by more than 96 percent. The radon standard of 20 $pCi/m^2 sec$ on the disposal site or 0.5 pCi/l outside the disposal site will limit the increase in radon concentration attributable to a pile to a small increase above the background radon level near the disposal site. Both standards are design standards with compliance to be determined on the basis of predicted rather than measured emission rates and concentrations. EPA states that "post-remediation monitoring will not be required to show compliance, but may serve a useful role in determining whether the anticipated performance of the control system is achieved."

In establishing the radon standard, EPA determined that the emission limitation could be achieved by well-designed thick earthen covers and that such control techniques would be compatible with the requirements of the EPA longevity standard.

2.4 WATER-QUALITY PROTECTION

EPA reviewed available water-quality data at inactive tailings sites and determined that there was little evidence of recent movement of contaminants into ground water. They also determined that any degradation of ground-water quality should be evaluated in the context of potential beneficial uses of the ground water as determined by background water quality and the available quantity of ground water.

Rather than establish specific numerical limitations for contaminant discharges or ground-water quality, EPA determined that the most appropriate course of action would be to require site-specific analyses of potential future contaminant discharge and a case-by-case evaluation of the significance of such a discharge. The implementation guidelines for the EPA standards call for adequate hydrological and geochemical surveys at each site as a basis for determining whether specific water-protection measures should be applied.

Specific site assessments must include monitoring programs sufficient to establish background ground-water quality through one or more upgradient wells and to identify the present movement and extent of contaminant plumes associated with the tailings piles. They further call for judgements of the need for restoration or prevention, or both, to be guided by EPA's hazardous waste management system and relevant state and Federal water-quality criteria. Decisions on specific actions to protect or restore water quality are to be guided by such factors as the technical feasibility of improving the aquifer, the cost of applicable restorative or protective programs, the present and future value of the aquifer as a water source, the availability of alternative water supplies, and the degree to which human exposure is likely to occur.

UMTRCA requires that the standards promulgated by EPA ". . .to the maximum extent practicable, be consistent with the requirements of the Solid Waste Disposal Act, as amended." In setting the standard, EPA determined that the statutory requirement for NRC to concur with the selection and performance of remedial actions and to issue licenses encompassing "monitoring, maintenance, or emergency measures necessary to protect public health and safety" was consistent with the EPA regulations implementing the Solid Waste Disposal Act (47 FR 32274, July 26, 1982). Accordingly, EPA established the implementation procedures requiring case-by-case evaluations of potential contamination at sites. Decisions regarding monitoring or remedial actions will be guided by relevant considerations in the hazardous waste management systems.

2.5 CLEANUP OF LANDS AND BUILDINGS

The EPA evaluated the risk associated with the dispersal of tailings off the site and concluded that the principal risk to man was the exposure to radon daughter products inside buildings. EPA therefore stated that the objective of the cleanup of tailings from around existing structures was to achieve an indoor radon daughter concentration (RDC) of less than 0.02 WL (working level). For open lands, the purpose of removing the contamination is to remove the potential for excessive indoor radon daughter concentrations that might arise from new construction on contaminated land. The 5 pCi/g and 15 pCi/g Ra-226 concentration limits for 15-cm surface and subsurface layers were considered adequate to limit indoor RDCs to below 0.02 WL. A secondary concern was to limit exposure to people from gamma radiation.

The Standard requires that residual radioactive materials be removed from buildings exceeding 0.03 WL. In cases where levels are between 0.02 and 0.03 WL, the Federal Government will have the flexibility to decide if any measures should be taken. Measures such as sealants, filtration devices, or ventilation devices may be used to provide reasonable assurance of reductions to below 0.02 WL.

3.0 SITE CHARACTERIZATION

Section 3.0, Site Characterization, describes the Shiprock site as it exists today. It includes a description of the site location, size, surface improvements, and quantity of contaminated materials. It also characterizes the geological, radiological, hydrological, and geohydrological conditions at the site. For a more detailed characterization of the site including boring logs, radiation surveys, and topographic surveys, the reader is referred to the Shiprock Processing Site Characterization Report (PSCR).

3.1 PHYSICAL DESCRIPTION

The Shiprock site is located on the Navajo Indian Reservation on the south side of the town of Shiprock, in northwestern New Mexico. It lies on the southwest bank of the San Juan River, 70 feet above the river. Farmington, New Mexico, is approximately 30 miles east of the Shiprock site (Figure 3.1). The designated site contains 143.6 acres, of which about 72 acres are covered with tailings in two adjacent piles. The upper (north) pile covers 26 acres and varies from 14 to 40 feet in height. The lower (south) pile covers 46 acres and is approximately 15 feet in height. Four of the original mill buildings remain on the site; they are the shower building, the engineering office building, the classroom, and the shop building. All are presently in use, but only the former engineering office and classroom are regularly occupied. The U.S. Public Health Service, Water and Sanitation Engineering Group, occupies the former engineering office.

There are also two new buildings on the site; one is the Navajo Engineering and Construction Authority (NECA) maintenance shop with a motor pool area and the other, a two-story concrete structure, houses the NECA engineering and administrative offices (Figure 3.2).

Approximately 80 NECA and Public Health Service employees regularly work on the site within 700 feet of the tailings piles. Approximately 900 people live within three-quarters of a mile of the site and 1300 people live within one mile of the site. The Shiprock High School is less than three-quarters of a mile to the north.

The average wind speed in the area is only 7.5 mph; however, there are numerous occasions when high winds and gusty conditions occur, thereby contributing to potential tailings pile erosion. These high winds are usually from the northwest. On an annual basis, the most frequent overall wind direction is from the east-southeast.

Approximately 160 days per year have low temperatures below freezing (USDC, 1968). The New Mexico State Highway Department uses three feet for a maximum frost depth in the Shiprock area.

The pile has been covered and stabilized, but the present condition of the pile does not meet the standards set by EPA. Additional radiological surveys have evaluated previous decontamination efforts and determined those areas which need additional contamination removal.

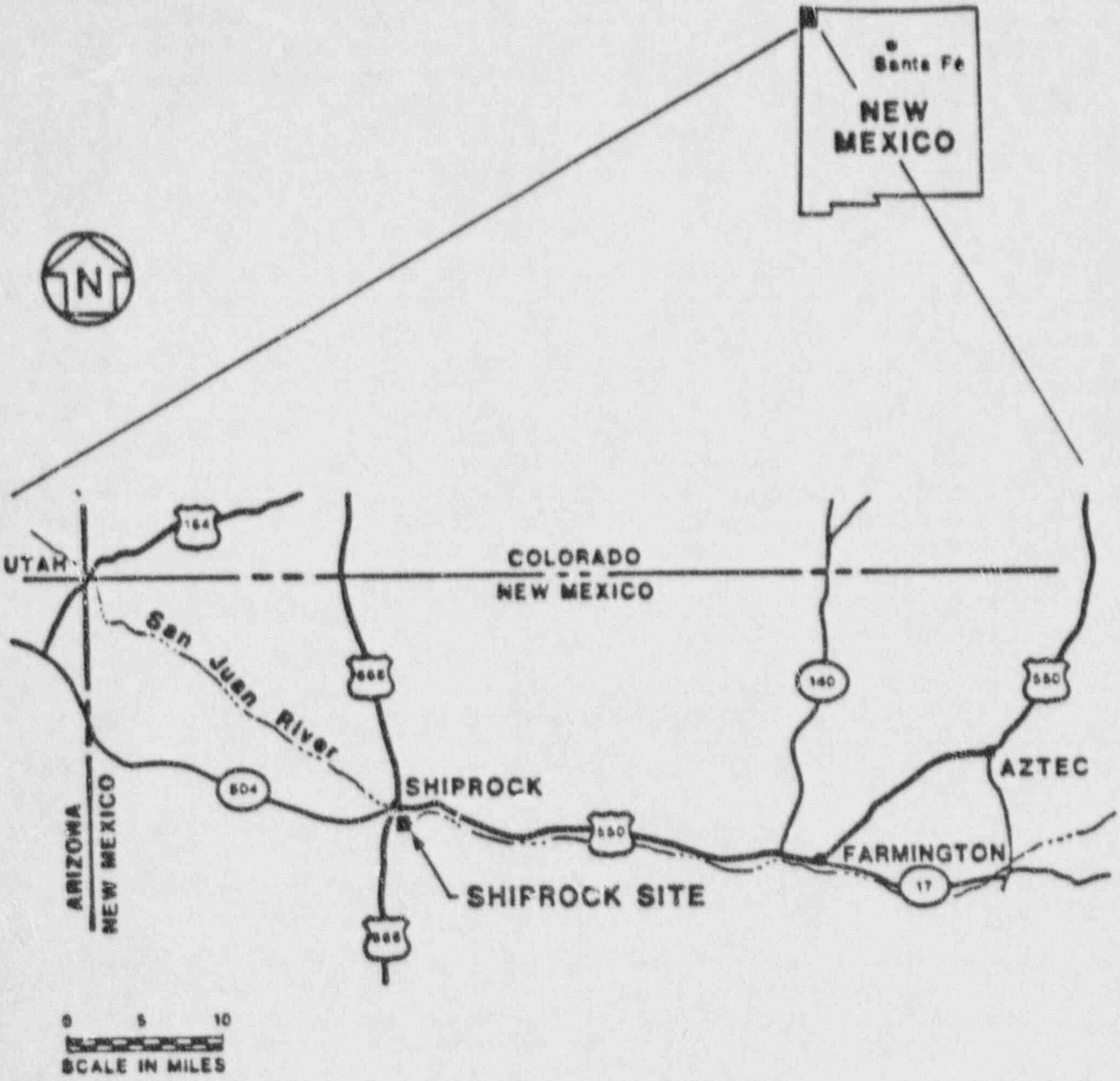

FIGURE 3.1 SHIPROCK SITE LOCATION MAP

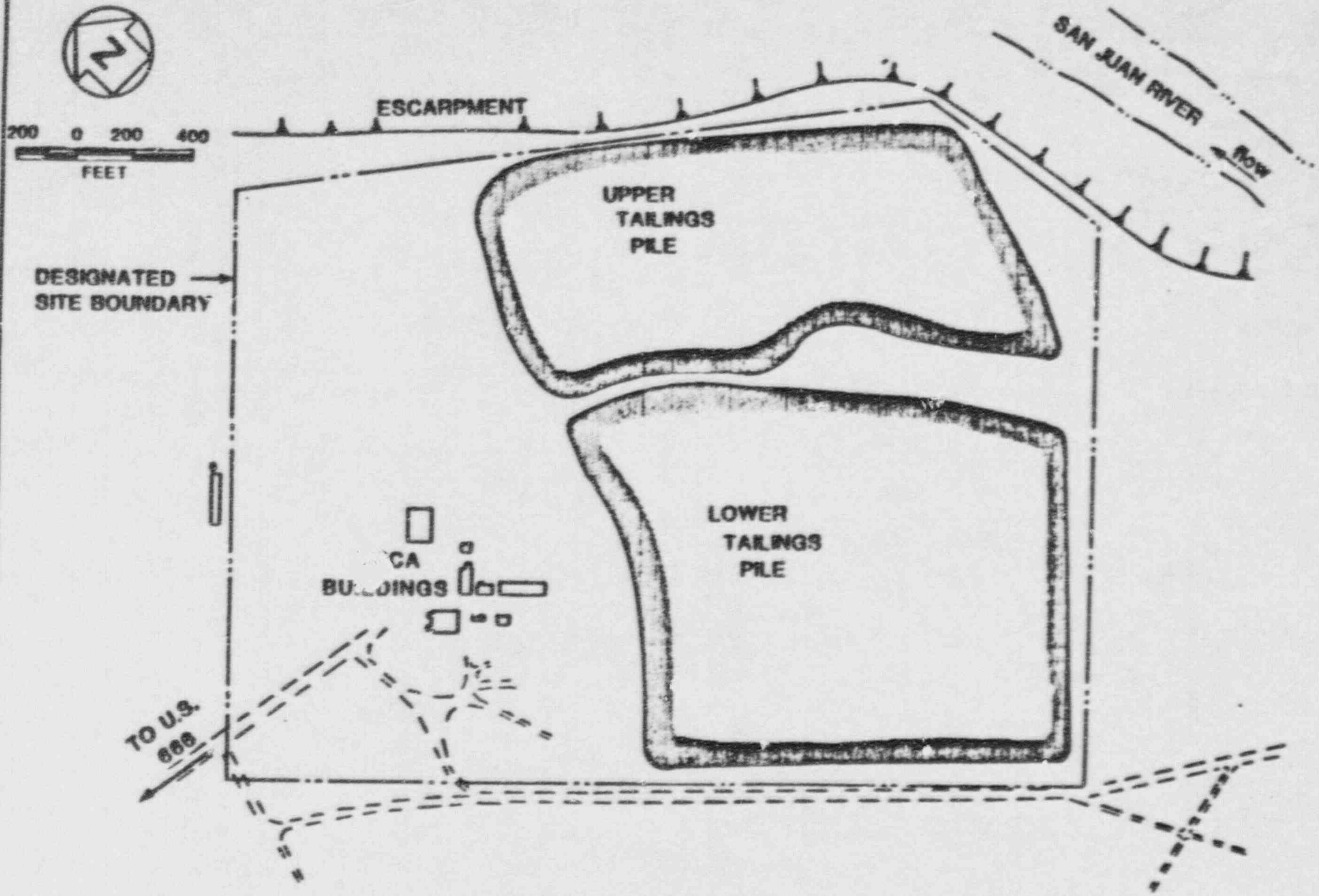

FIGURE 3.2 PRESENT CONFIGURATION OF THE SHIPROCK SITE

3.2 HISTORY

The former Navajo Mill at the Shiprock site was designed and built by Kerr-McGee Oil Industries, Inc., on a 230-acre tract leased from the Navajo Nation. Kerr-McGee operated the mill from 1954 until 1963, when it was purchased by the Vanadium Corporation of America (VCA). The VCA, which was later merged into Foote Mineral Company, continued operations until 1968. Upon expiration of the lease in 1973, ownership of the site reverted to the Navajo Nation. The mill processed a total of about 1.5 million short tons of ore along with smaller quantities of bulk precipitates from heap leach operations (from the Monument Valley area), and purchased vanadium liquor. A two-stage sulfuric acid leaching circuit, countercurrent washing circuit, and uranium and vanadium solvent extraction circuits were used. Tailings from the washing circuit and yellow cake filtrates were pumped to the tailings disposal areas, while raffinate from the solvent extraction circuits was allowed to evaporate in separate holding ponds.

After the site reverted to the Navajo Nation, a portion of the area was occupied by NECA. The NECA established a training school for heavy equipment operators and used the lower tailings pile as a practice ground. This resulted in enlargement of the pile and spread of the tailings over most of the former holding pond area. In April, 1974, a radiation survey was conducted at the site by the EPA. They noted that the training activities were adversely affecting radiological conditions and recommended that the training activities be redirected toward decontamination of the site and interim stabilization of the tailings. This recommendation was accepted and these actions were carried out from then until mid-1978 with guidance and support from the EPA. The EPA guideline for off-pile decontamination was to reduce the net above-ground exposure rate to less than 10 microR/hr above background.

Contamination, in some cases several feet deep, was unearthed from around and under the buildings. The main mill building was completely dismantled and those parts of it such as the roof that were too contaminated to be salvaged were buried in the pile area. Other buildings were cleaned using water sprays. Contamination over three feet in depth was common, and extended to depths of 10 feet or more in the mill drain and adjacent arroyo. All contaminated materials and soils were removed to the tailings piles. The soils were used as a cover to stabilize the lower pile. The upper pile has a stabilizing cover of about one foot of soil and gravel, except for a few places that have been thinned by erosion. Dikes were constructed around the tailings perimeter to prevent the spread of tailings resulting from runoff water erosion.

3.3 STABILITY

The Shiprock site is partially fenced; however, the fencing is inadequate to prevent access to the tailings piles by man or grazing animals.

Location of the tailings piles atop an escarpment 70 feet higher than the river floodplain positions them out of jeopardy from any river flood event.

Dikes presently around the tailings perimeter prevent the spread of tailings from runoff water erosion; the dikes and site surface grading direct other off-site and on-site surface runoff toward existing arroyos off the edge of the escarpment. Several of these arroyos close to the tailings are actively eroding the escarpment from above.

High winds that often occur in the Shiprock area, combined with steep sideslopes on the upper tailings pile, expose the thinly covered tailings to both rainfall and wind erosion with a potential for spread of contamination off the site.

3.4 RADIATION

In 1980, after the contaminated material had been placed on the pile and cover applied, radon flux measurements were made on the pile. These measurements ranged from 2 to 340 $pCi/m^2 sec$ with an estimated average of 110 $pCi/m^2 sec$. In addition, holes drilled off the pile revealed that some materials contaminated above the current EPA standard still exist in the old mill area and ore storage areas.

3.5 GEOTECHNICAL

The tailings are presently located on a terrace deposit of dense alluvium which is underlain by flat-lying beds of Mancos Shale. The site is immediately adjacent to an escarpment above the San Juan River. Foundation materials below the tailings are stable and not subject to long-term settlement. However, the foundation soil along the escarpment is subject to long-term degradation by mass wasting. The site is also susceptible to some amount of undercutting by long-term migration of the river.

There are erosional gullies both along the escarpment and near the tailings which do not pose a current problem; however, these gullies could migrate and result in release of tailings.

The site is located within the tectonically stable Colorado Plateau and there is little potential for seismically induced liquefaction of the foundation subsoil or tailings.

3.6 GROUND WATER

The Shiprock tailings occupy a river terrace adjacent to the San Juan River. Underlying the Shiprock site are about 20 feet of fine to coarse-grained alluvial and eolian soils which cover interbedded shales and sandy shales of the upper Mancos Shale. The Gallup Sandstone separates the upper Mancos Shale from the lower Mancos Shale. Below the lower Mancos are the Dakota Sandstone and Morrison Formation, respectively. The Mancos Shale is generally considered in the literature as a non-water-bearing formation, while the Gallup Sandstone, Dakota Sandstone, and Morrison Formation are all noted as water-bearing units (Callahan and Harshbarger, 1955).

The topmost weathered portion of the upper Mancos Shale, from 3 to 30 feet in thickness, and the coarse-grained alluvial deposits overlying the Mancos Shale are also known to be water-bearing beneath the site. To the north and northwest of the site is water-bearing floodplain alluvium of the perennial San Juan River. To the northwest and southeast of the site are small ephemeral washes which contain active water-bearing alluvium. The tailings are known to be unsaturated (CSU, 1982).

The hydraulic properties of the uppermost hydrogeologic units in the near vicinity of the site vary over a wide range. The active San Juan River alluvium can be expected to have high hydraulic conductivity and storativity, and will transmit large quantities of water. The upper eolian and alluvial deposits on the adjacent terrace are unsaturated but have been characterized as having low saturated permeabilities in the range of 2 to 3 x 10^{-5} cm/sec (PSCR, 1984). The coarser alluvial deposits directly overlying the Mancos Shale have moderate permeabilities which have been measured in the range of 1 x 10^{-5} to 1 x 10^{-3} cm/sec, and can be expected to have poor to moderately good storage properties. The permeabilities appear unusually low for the type of coarse alluvial materials found at the Shiprock site, but are judged to be a result of flow-through material which is known to be tight and partially cemented (Dames and Moore, 1982). The near-surface saturated Mancos Shale has measured permeabilities of 10^{-3} to 10^{-4} cm/sec for the upper weathered portions and 10^{-5} to 10^{-6} cm/sec for the lower less-weathered portions. These values are judged to represent bulk permeabilities which are influenced by fracturing and weathering. The Mancos Shale is known to have extremely poor to poor storage properties, based on the performance of monitoring wells subjected to pumping.

On the terrace occupied by the tailings, the shallow ground water is found in the lowermost 10 feet of the terrace alluvium deposits and in the uppermost 3 to 30 feet of fractured, weathered Mancos Shale. There are two separate shallow ground-water systems within the terrace. A laterally continuous system occupies the upper weathered Mancos Shale. To the south and southwest of the tailings, the overlying coarse terrace alluvium is saturated in its lower portion, and forms a single continuous system with the shale. Beneath the tailings there are local "pockets" of saturation within the terrace alluvium perched on top of the Mancos Shale. Based on observations in test pits and excavations, and water level measurements from paired wells completed at different depths, these perched "pockets" are not continuous with the zone of saturation in the underlying shale, where the potentiometric level is 3 to 5 feet below the top of the shale. These perched "pockets" may represent residual seepage resulting from active milling, or may be the results of irrigation done to establish vegetation on the tailings, or both.

The ground-water recharge zone for the terrace system appears to be along the perimeter of moderately dissected low hills to the south and west of the tailings. In this area ephemeral drainages become less distinct as they cross the gentle slope of the terrace, and the probably infrequent runoff can soak into the relatively low permeability upper terrace soils. From this area ground water flows slowly towards the tailings area. Local ground-water flow directions vary from west to northeast, probably influenced by fracture locations in the shale and varying permeability in the lower alluvial deposits. The net general flow direction is to the north. Ground water has been observed to discharge where the Mancos Shale crops out from the escarpment separating the terrace from the active floodplain alluvium.

The local shallow hydrogeologic system directly beneath the tailings can be characterized as relatively small, isolated, and slow-moving. The local system is probably bounded by relatively impermeable Mancos Shale which crops out just to the south of the apparent recharge area. The system is definitely bounded where discharge occurs along the northwest-southeast trending escarpment abutting the San Juan River floodplain. In the vicinity of the tailings, the distance between recharge area and discharge area varies from about 1,600 feet to about 4,700 feet. The local system is bounded to the northwest and southeast by small washes which incise the Mancos Shale and probably intercept local ground-water flow. The total area of the local system is in the range of 250 acres. As stated above, the permeability of the saturated shallow system is low, and the average rate of ground-water movement in the system has been estimated as 0.5 foot/year. Where discharge does reach the escarpment face as seeps, all of the discharge has been observed to evaporate at the face. This is probably due to the low discharge rate and the high ratio of potential evaporation to precipitation in the area. Thus it appears that the escarpment helps to isolate the local system.

The water quality of the shallow terrace system is variable and there appears to be little or no correlation between reported concentrations of uranium and concentrations of other dissolved constituents. Such correlations have been apparent at other uranium mill tailings sites, and the lack of a correlation combined with other observations about water quality tends to obviate a rational explanation of the geochemistry in the shallow system. All water samples from the shallow system have been characterized by high total dissolved solids (TDS) (12,000 to 35,000 mg/l) and high sulfate (4,000 to 25,000 mg/l) values. Beneath the tailings total uranium concentrations ranged from about 120 to 2,000 pCi/l (0.176 to 2.94 mg/l), while upgradient of the tailings uranium concentrations were 20 to 225 pCi/l (0.029 to 0.331 mg/l). The highest upgradient concentrations of uranium are found in monitoring wells to the southwest of the tailings, and are indicative of residual contamination from active milling. The raffinate ponds were located subjacent to the southwestern portion of the present tailings location, and it is possible that seepage and radial ground-water flow during milling contaminated shallow ground water southwest of the tailings.

Monitoring wells to the southeast of the tailings have low reported concentrations of dissolved uranium (20 to 30 pCi/l), and because of the location of the wells very near to the recharge area, it would be expected that ground-water quality at these locations would be indicative of background quality. However, high concentrations of nitrate (<10 to 4,300 mg/l) and ammonium (2,300 to 3,660 mg/l) at these wells may be indicative of contamination.

Among other radionuclides tested for in water samples, Ra-226 was detected in 16 of 18 samples in concentrations ranging from <1.0 pCi/l to 5.3 pCi/l. Neither Th-230 nor Pb-210 were detected as a dissolved constituent. For 13 of 17 samples, Po-210 was not detected at a level of 1.0 pCi/l; four samples showed detectable Po-210 at concentrations ranging from 2 pCi/l to 10 pCi/l.

Water use in the immediate vicinity of the tailings does not include utilization of the shallow terrace system. Scattered dwellings to the south and southwest of the tailings obtain water by hauling it in. The NECA buildings, adjacent industrial buildings to the southwest, and a residential area to the southwest are all linked to the Shiprock town water supply, which is pumped from the San Juan River near Hogback, New Mexico. Regionally along the San Juan River, it appears that terraces are extensively used for irrigated agriculture; however, the irrigation water is generally supplied by diversions from the San Juan River.

In the Shiprock area, the alluvium in the floodplain of the San Juan River is expected to be a reliable source of large quantities of good quality water, and there is historical record of pumping from the alluvium. The town of Shiprock and the U.S. Bureau of Mines both installed infiltration galleries in the alluvium starting about 3,000 feet downriver of the present tailings location. During milling, multiple seeps flowing at rates up to 20 gpm and containing up to 4,800 pCi/l of dissolved uranium discharged from the escarpment or from the mill drain in Bob Lee Wash to flow across the permeable alluvium. Ground water from the floodplain alluvium has been sampled to determine if the floodplain alluvium has been contaminated.

The successive deep bedrock aquifers directly beneath the tailings are not currently used, probably because of water quality with concentrations of total dissolved solids (TDS) in excess of 3,000 ppm or high concentrations of constituents such as sulfate. In the vicinity of Shiprock, water from the Gallup Sandstone is non-potable due to high concentrations of sulfate, more than 1,300 ppm, which increased markedly downdip in the sandstone (Callahan and Harshbarger, 1955). A well within the town of Shiprock encountered the Gallup Sandstone at 288 feet and reported that it produced salty water. The next underlying aquifer, the Dakota Sandstone, is also said to be locally unfit for human consumption. A well about 2,000 feet northwest of the tailings is completed in the Brushy Basin member of the Morrison Formation and has been abandoned due to excessive levels of TDS (greater than 3,000 ppm). Such levels of TDS do not preclude the use of the water for irrigation or for potable use after treatment; however, the availability of alternate supplies of better quality water (such as the San Juan River) would discourage the use of these aquifers.

The potential impact of the tailings on the successive bedrock aquifers appears to be little or none. Packer-permeability tests of the Mancos Shale underlying the tailings have shown that the hydraulic conductivity of the shale diminishes markedly with depth to values less than 1×10^{-6} to 1×10^{-7} cm/sec. There are probably between 175 to 250 feet of relatively impermeable Mancos Shale separating the tailings from the Gallup Sandstone. Between the Gallup Sandstone and the underlying better quality aquifers there are an additional 700 feet of relatively impermeable shale. The presence of thick layers of relatively impermeable shale have effectively isolated the tailings from potentially usable underlying aquifers.

3.7 DRAINAGE

Surface drainage across the site is from the south and west towards the San Juan River. The watershed area directly above the site is 98 acres. All cross drainage is presently diverted by the tailings dikes to adjacent arroyos that enter the San Juan River upstream and downstream of the tailings. The arroyos have developed steep-sided, deep cuts into the escarpment at several locations on the east side of the upper pile. These arroyos will continue to expand by erosion unless stabilized.

3.8 UTILITIES

All underground utilities were removed from the area of the tailings prior to stabilization efforts by NECA. The NECA and Public Health Service buildings are served by overhead power and telephone lines, an eight-inch sanitary sewer line, and a four-inch water line that border the access road and enter the site from the west. A six-inch high-pressure natural gas line (El Paso Natural Gas Company) runs along the south and west perimeter of the site and the service meter is in the NECA use area.

All known surface and underground utilities on or near the site are located and identified on Figure 3.3.

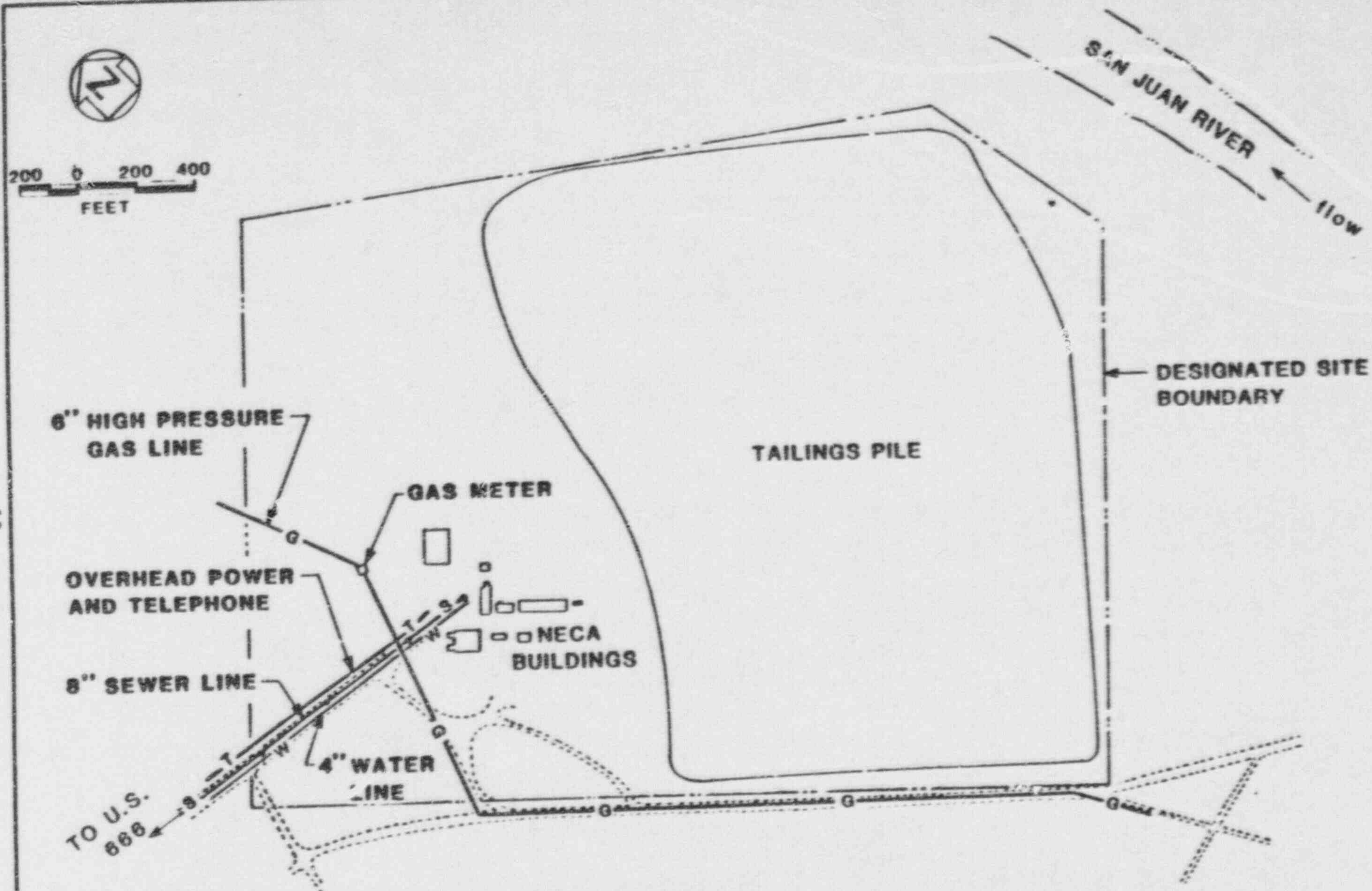

FIGURE 3.3
EXISTING UTILITIES FOR THE SHIPROCK SITE

4.0 PROBLEM DESCRIPTION AND REMEDIAL MEASURES

Section 4.0 presents a brief description of the problem. For more details the reader is referred to Appendix E, Site Conceptual Design.

4.1 GENERAL

Significant quantities of residual radioactive wastes and other contaminated materials which are at or near the ground surface, as well as in solution in the ground water, create a potential for human exposure to radionuclides. The direct exposure to ionizing radiation, the inhalation of radon daughter products, and the ingestion of radioactive materials produce a risk to human health. The long-term stabilization of such materials can effectively eliminate such risks.

4.2 LONG-TERM STABILITY

Under existing conditions the contaminated soils and tailings are not secure from physical removal off the site. Past removal of materials for construction purposes has resulted in an estimated sixteen sites in the community now requiring some form of decontamination. Little protection exists against inadvertent removal in the future. The contaminated material at or near the surface is susceptible to natural erosive forces and transport. Additionally, the materials at the edge of the escarpment could be released as a result of bank erosion and stream channel migration over a long period of time, and further erosion of the gullies to the east of the present embankment.

4.3 RADIATION

Radon emissions from the tailings estimated to be 110 pCi/m^2sec exceed the EPA standard of 20 pCi/m^2sec and measured average concentrations at the site boundary exceed the alternative EPA standard of 0.5 pCi/l. Individuals on the site may be receiving gamma radiation doses in excess of recommended limits, although doses to residents of adjacent areas probably are below recommended limits. All of the buildings on the site, along with previously cleaned-up windblown and pond areas, have been checked for contamination. With the exception of a small metal oil storage shed behind the former shop building, a cinder-block addition to the southeast end of the former shop building, and a doorsill within the former shop building (now used for storage by NECA), all buildings were found to be free of contamination or elevated radon levels. However, windblown (or spill water) contamination was located as indicated in Figure 4.1. A complete description of the location and depth of site and adjacent area contamination is included in Appendix E of this report and Appendix B to the Processing Site Characterization Report, dated April, 1984.

4.4 WATER QUALITY

Elevated concentrations of uranium found in the subsurface waters in weathered upper Mancos Shale and overlying unconsolidated materials appear

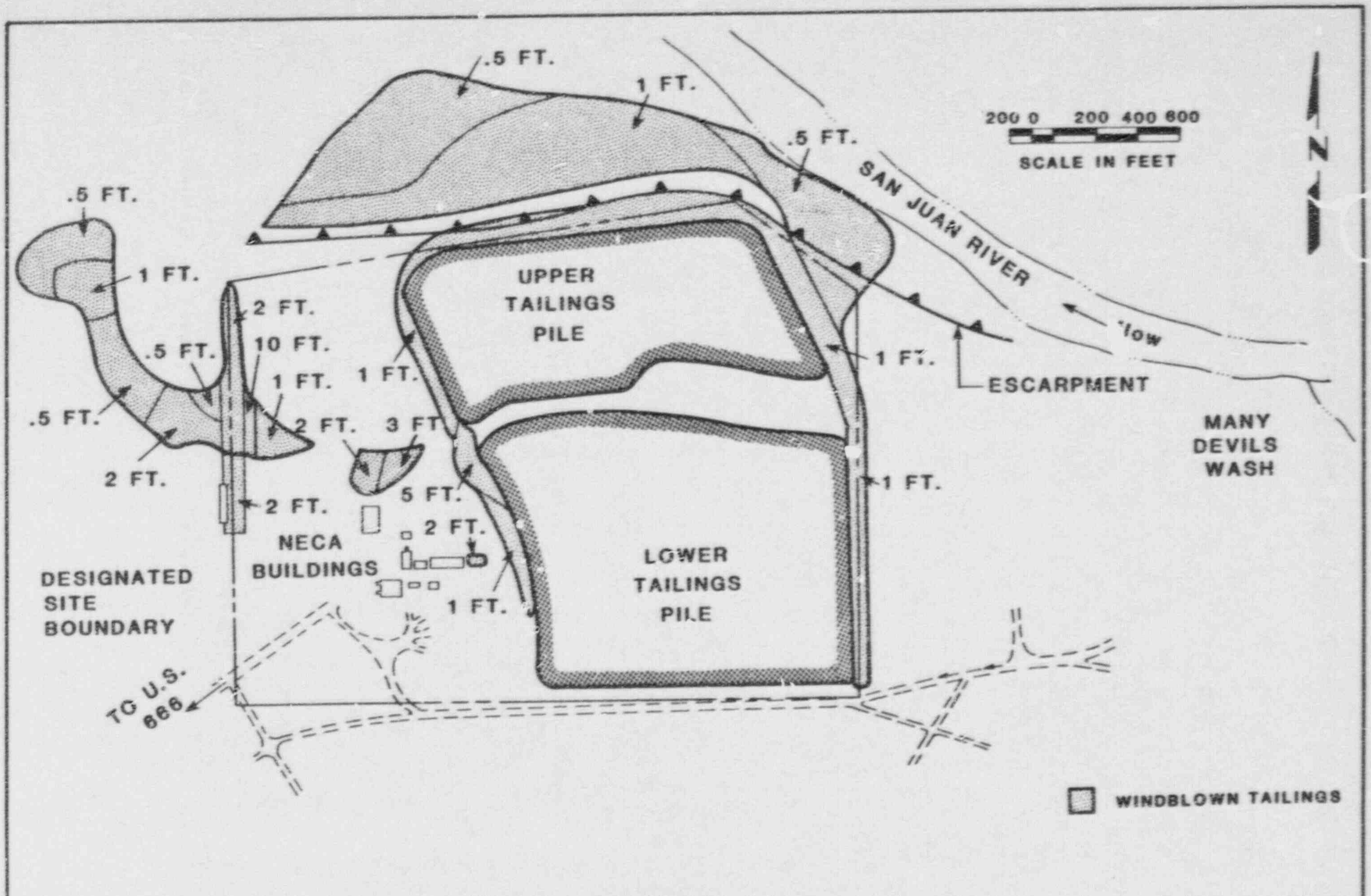

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FIGURE 4.1
WINDBLOWN CONTAMINATION ON AND ADJACENT TO THE SHIPROCK SITE

to be due to the presence of residual plant process (tailings) water. The present hydrologic regime indicates little or no net infiltration through the tailings. It can be assumed that, unless conditions are changed, this regime will continue into the future. Water-quality analyses indicate that the radionuclides in this system, primarily uranium, are migrating slowly across the site with the shallow ground water. This ground water is evaporating on the face of the escarpment. A seep discharging from the escarpment near the site showed only slightly elevated levels of uranium, while most other dissolved constituents were within background ranges.

Background water quality in the shallow system appears to be poor, but possibly anomalous levels of nitrate and ammonium in upgradient wells may be indicative of residual contamination. The water chemistry of the shallow system is very complex with no clear pattern to the areal distribution of dissolved constituents.

Because existing upgradient wells are very close (less than 1500 feet) to the recharge zone, wells further upgradient would have doubtful value in determining background water quality. This is because additional wells might still encounter contaminated water, and upgradient wells are not always indicative of background water quality in slow-moving hydrogeologic systems.

There is no known similar hydrogeologic system in the region from which water-quality data might be used to characterize the Shiprock system. A possible conclusion is that it may be impossible to define background water quality in the shallow system. Because of the small extent and isolation of the shallow system, the absence of present use, the low probability of future use, and the availability of alternative water supplies, the presence of contamination in the shallow ground water beneath the tailings is not considered to be a problem that requires remedial action. Given that the contaminated shallow ground water does not require remedial action, the difficulty of characterizing background quality of shallow ground water does not complicate the design of the remedial action.

Elevated concentrations of radionuclides have not been detected in the water-quality samples taken from the San Juan River recently, nor during actual mill operations. Downstream samples and samples taken adjacent to the site by Public Health Service, GECR, and EPA contained no contaminant concentrations or gross alpha activities greater than upstream water. Therefore, it has been concluded that presence of the tailings has not downgraded the water quality of the San Juan River. Further data summaries on river water quality are contained in the PSCR.

The water quality in the floodplain alluvium adjacent to the site is assumed to be very similar to the quality of the San Juan River. The present hydrologic regime does not indicate ongoing contamination of the floodplain alluvium because the floodplain alluvium is physically separated from the contaminated shallow system by an escarpment which is the discharge/evaporation boundary of the shallow system. During active milling there was discharge of contaminated water across the floodplain alluvium. The floodplain alluvium, both upgradient and downgradient of the tailings site, has been sampled to determine if there is any residual contamination.

4.5 ALTERNATIVES CONSIDERED

A comprehensive investigation of the site has been conducted and remedial action alternatives have been evaluated in the preparation of an Environmental Assessment (EA) for the project. Alternatives considered included both stabilization in place and relocation of the contaminated material and tailings, with the inclusion of appropriate measures to provide long-term stability, reduce radon emissions, protect ground water, and prevent misuse of tailings by man. Preliminary findings in the EA process have led to the conclusion that the EPA standards can be met by any of the alternatives. However, stabilizing the materials at the existing site has less environmental impacts and is more cost effective. The EA also indicates that the environmental impacts associated with stabilization in place are not significant.

An aspect of the project which was addressed in order to comply with PL95-604 is the economic and technical feasibility of reprocessing the tailings for the recovery of residual uranium and vanadium. Mountain States Research and Development (MSRD) was contracted in 1981 to perform an economic evaluation of reprocessing the Shiprock tailings. They conducted a drilling and sampling program to determine the amount of recoverable uranium, vanadium, and molybdenum. Laboratory leaching tests were conducted on the samples to estimate extractability and the process to be applied. The evaluation compared the recoverable value of the metals versus the capital and operating costs for processing, excavating, transporting, and final disposal. The results of the study indicated that reprocessing is not economical at present day or foreseeable future prices for the metals (MSRD, 1982).

5.0 SUMMARY OF REMEDIAL ACTION

Section 5.0 presents a brief summary description of the measures necessary to perform the remedial action at Shiprock. The conceptual design is described in detail in Appendix E, Site Conceptual Design.

5.1 PROPOSED REMEDIAL ACTION

The proposed remedial action calls for movement of radioactive tailings away from the edge of the escarpment; removal of contaminated materials from site yard areas, adjacent and floodplain areas, and vicinity properties; and consolidation of all contaminated materials in two large embankments in the same approximate location as the existing two tailings piles. The final configuration for the site is shown in Figure 5.1.

The gently contoured embankments will then be covered with a thick earthen layer and a rock layer to ensure the following: long-term stability while simultaneously reducing radon emissions, reduced infiltration of precipitation (thereby avoiding contaminated recharge to the shallow ground-water system), protection of surface-water quality, no animal intrusion, minimized plant root intrusion, no inadvertent human intrusion, and no materials dispersion. Relocating the tailings away from the escarpment will prevent the release of contaminated material due to undercutting and slope degradation. Site regrading combined with stabilization of the escarpment edge will retard long-term escarpment erosion and prevent surface-water runoff and river contamination. Fencing the perimeter of the consolidated pile and posting warning signs will discourage human intrusion.

5.2 DESIGN OBJECTIVES

The principal objective of this remedial action concept is to design control measures which meet EPA standards. These standards include specific limitations on the release of radon, along with limitations on the release of radiation from radium and radon daughter products. There is also the requirement for long-term stabilization, designed with controls effective for 1000 years. Applicable requirements of the Navajo Environmental Protection Administration and other agencies will be adhered to during construction. These requirements are included in Appendix A, Regulatory Compliance.

The purpose of remedial action and the formation of standards for this effort is the protection of the local environment. The public must be protected both during and after remedial action from unsafe levels of radiation. The quality of adjacent surface water and ground water must not be adversely affected by discharges from the site. The remedial action must provide assurance of long-term stabilization of the site through erosion control and flood protection. Inconveniences and increased hazards to the local public must be minimized by considering working schedules and construction vehicle routes. The site will be fenced during and after construction to prevent public access and will have custodial maintenance and surveillance to assure continued long-term compliance with EPA standards.

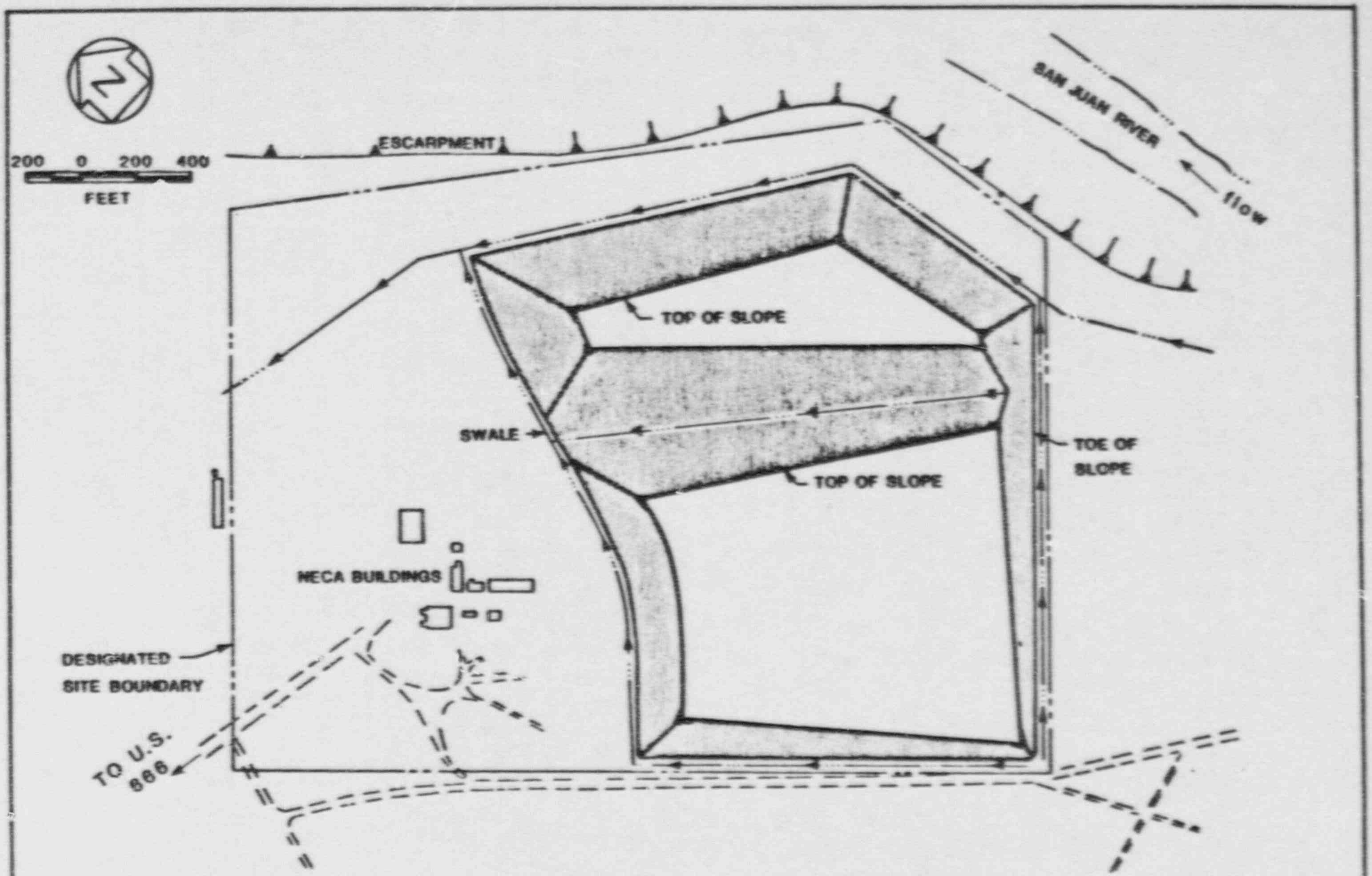

FIGURE 5.1
FINAL CONDITION - SHIPROCK SITE

5.3 DESIGN FEATURES

The remedial action will stabilize the uranium mill tailings and contaminated material at the site in a manner which complies with EPA standards. The conceptual design establishes the starting point for remedial action. Detailed plans and specifications will be subsequently prepared to provide the basis for final cost estimates and for the award and execution of construction contracts. The Site Conceptual Design is included as Appendix E.

The principal feature of the design concept is the movement of contaminated materials approximately 300 feet away from the edge of the escarpment and consolidation of the tailings and contaminated soils into gently contoured embankments in the same general location on the site as the existing two tailings piles. Moving the tailings away from the escarpment will prevent the release of tailings as a result of potential long-term undercutting by the San Juan River and the natural wasting of the escarpment. For more detail on geomorphology see Appendix B, Geomorphic Stability.

The design will require the following major construction activities:

- Preparation of the site, including erection of a security fence, and construction of a waste-water retention basin (evaporation pond) to protect against release of contaminants from the site during construction.
- Control over possible disturbance of nearby archaeological sites and protected plants.
- Construction of drainage control measures to direct all generated waste-water and storm-water runoff to the retention basin during construction activities.
- Construction of a fenced staging area.
- Excavation around subsurface utilities, utility relocation, or construction of utility crossing structures as required.
- Excavation and handling of contaminated materials during their consolidation and relocation, and placement in the final embankment area.
- Construction of the tailings embankment set back approximately 300 feet away from the edge of the escarpment.
- Decontamination of structures on the site as required.
- Relocation to the tailings embankment of windblown, waterborne, and human-transported contamination that has been carried from the site to the floodplain and vicinity properties.
- Modification of the top of the escarpment to drain surface-water runoff away from the edge and toward the embankment perimeter drain ditch.

- Fill and recompaction of erosion gullies in the escarpment area.
- Disposal of evaporation pond sediments in the embankment.
- Construction of a final cover system over the tailings embankment to inhibit water infiltration and radon exhalation.
- Emplacement of rock for erosion protection on the embankment and the remainder of the excavated site as necessary, with final grading to provide suitable drainage control.
- Installation of temporary and permanent fencing to discourage inadvertent intrusion of humans and livestock.

5.4 BASIS FOR EXCAVATION

The Radiological Support Plan (Appendix C) defines the monitoring surveys which will be required at the site during excavation of contaminated materials. A final survey will certify that applicable radiation standards are met following completion of construction.

5.4.1 Radiological survey plan

Radiological surveys are performed for three purposes: site characterization, excavation control, and final radiological verification. Site characterization surveys or pre-remedial action surveys have been performed to identify volumes of material which exceed the standard. The results have been used for planning and engineering design purposes. Excavation control monitoring is necessary as the work is being done to guide and control the amount of contaminated material to be removed. Finally, when the excavation control monitoring results indicate that the area meets the standards, a final radiological survey will be carefully performed to assure compliance with the cleanup criteria and the results documented.

5.4.2 Certification

During the remedial action operations, the DOE will make available to appropriate Navajo Nation agencies, Federal agencies, or DOE-designated contractors, data related to the cleanup. In addition, samples may be split for analysis by these agencies to allow comparison of analytical results. These data, along with any additional data collected at the discretion of the certifying agent, will be used in the final certification report.

After remedial action, the DOE will certify that remedial action has been completed according to the plan and final design, and the site meets applicable standards.

5.5 PROPOSED FINAL CONDITION

As shown in Figure 5.1, the completed site will be an embankment covering approximately 76 acres, situated on the southeast half of the present designated site. The completed site will be bounded on the northeast by the San Juan River escarpment, on the northwest by the NECA and Public Health Service facilities, and on the southeast by the NECA borrow area.

The top of the embankment will cover about 35 acres and will be a maximum of 50 feet above the surrounding terrain. Sideslopes of the embankment will have a maximum slope of 1 vertical to 5 horizontal. The top and sides will be covered with a layer of silty sand approximately 7 feet thick for radon attenuation and capped with a one- to 1.5-foot-thick layer of pit run rock for erosion protection.

An unpaved road will loop the bottom of the embankment and a security fence with warning signs will enclose the embankment and roadway. Drainage ditches adjacent to the embankment will divert surface drainage around and away from the embankment. Site access will be from New Mexico Highway 666. Where disturbed, the site, the borrow areas, and the decontaminated areas will be contoured for drainage or restored to original ground level and revegetated. Approximately 68 acres of the originally designated site will be released and available for continued unrestricted use by others.

5.6 SCHEDULE

Remedial action at the Shiprock site is scheduled to begin in October, 1984. Figure 5.2 is a graphical representation of the detailed Shiprock Remedial Action Schedule.

The Environmental Assessment, Finding of No Significant Impact, and Tribal and NRC concurrence are the remaining key items which affect this schedule and must occur as planned for the timely initiation of construction. It is estimated that construction activities will require approximately 18 months and will be completed in the spring of 1986. Maintenance and surveillance will continue after construction.

Funding constraints will dictate a staged construction program with the first stage to include mobilization, site preparation, drainage, tailings and contaminated soils excavation, embankment construction, and partial cover emplacement; the second stage will include completion of the embankment cover, escarpment stabilization, and site restoration.

The vicinity property remedial actions are scheduled to be completed in 1986; however, if there is a delay, space will be left in the embankment for the remaining contaminated material. As the remedial action construction nears completion, the site closure plan and vicinity property cleanup schedules can be coordinated.

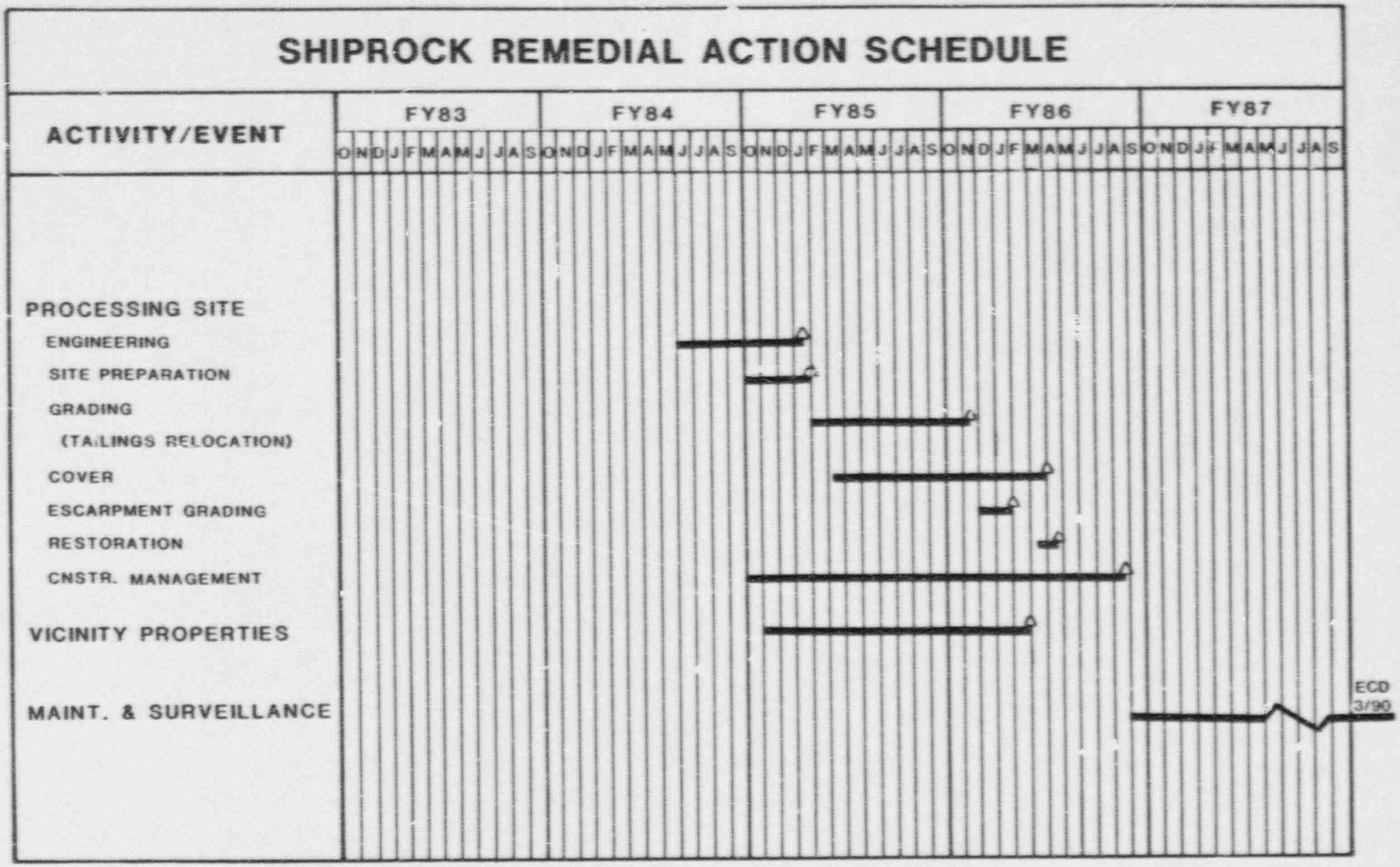

FIGURE 5.2 SCHEDULE FOR FINAL DESIGN AND REMEDIAL ACTION - SHIPROCK SITE

5.7 COST ESTIMATE

A preliminary cost estimate has been prepared, based upon the conceptual design described in this Remedial Action Plan. That cost estimate is $10,870,000 and is summarized on Table 5.1. Table 5.2 presents a time-phased distribution of the project costs, consistent with the staging schedule described above. In addition to these costs, costs will be incurred for remedial action at the vicinity properties.

Table 5.1 Site cost estimate summary (1983 - $000)

Item		Costs
Site Acquisition		
Mineral value	0	
Land value	50	
TOTAL SITE ACQUISITION		$ 50
Remedial Action (RA)		
Processing site		
Site preparation	400	
Tailings pile grading	2,060	
Pile cover	3,800	
Stabilize escarpment	760	
Decontamination	30	
Site restoration	170	
Security fencing	90	
Supervisory & field services	2,270	
TOTAL PROCESSING SITE REMEDIAL ACTION		9,580
Engineering/construction management		
Processing site		
Engineering (ENG)	400	
Construction management (CM)	670	
TOTAL ENGINEERING/CONSTRUCTION MANAGEMENT		1,070
MAINTENANCE AND SURVEILLANCE		170
		======
TOTAL PROCESSING SITE COST ESTIMATE		$ 10,870

Table 5.2 Expenditure schedule ($000)
Shiprock stabilization in place (SIP)

Item/Year		Cost
FY-1984		
Site acquisition		$ 50
Engineering		400
	TOTAL:	450
FY-1985		
Stage I construction		5,210
Engineering & construction management		370
	TOTAL:	5,580
FY-1986		
Stage II construction		4,370
Construction management		300
Maintenance and surveillance		30
	TOTAL:	4,700
FY-1987		
Maintenance and surveillance		40
FY-1988		
Maintenance and surveillance		40
FY-1989		
Maintenance and surveillance		40
FY-1990		
Maintenance and surveillance		20
	TOTAL:	$ 10,870

6.0 ENVIRONMENTAL, HEALTH, AND SAFETY

6.1 UMTRA PROJECT HEALTH AND SAFETY POLICY

The DOE and its contractors will take all reasonable precautions in the performance of the remedial action work to protect the health and ensure the safety of employees and the public. The DOE will comply with all applicable Federal and Tribal health and safety regulations and requirements including but not limited to those established pursuant to the Occupational Safety and Health Act (OSHA).

6.2 ENVIRONMENTAL, HEALTH, AND SAFETY PLAN

The Environmental, Health, and Safety Plan, Appendix D, specifies the basic Federal safety and health standards and special Tribal and DOE requirements applicable to the remedial action at Shiprock. This section provides an overview of the plan and summarizes its key features. Responsibilities in carrying out this plan are delineated. Where not otherwise specified, the Remedial Action Contractor (RAC) will have the principal responsibility for implementing this plan. Guidance on program requirements and radiation control and monitoring is also included.

6.3 RESPONSIBILITIES

The responsibilities of the DOE, the Navajo Nation, and the RAC are described below:

6.3.1 <u>The DOE/UMTRA Project Office and appropriate divisions of the Albuquerque Operations Office</u>

- o Conduct periodic surveys, with assistance from the Technical Assistance Contractor (TAC), of contractor programs and site activities and prepare Health and Safety Survey Reports.
- o Act on employee inquiries and complaints in accordance with procedures outlined in this plan.
- o Ensure compliance with the health and safety standards by reviews of UMTRA Project contractor performance, and reviews of violations of the prescribed plan and the timing and manner of correction.

6.3.2 <u>The Navajo Nation</u>

- o Participate in the planning for the remedial action by identifying and interpreting applicable Tribal regulations.
- o Advise the DOE/UMTRA Project Office of changes to regulations which apply to this project.

- Identify and assist in obtaining necessary reviews and approvals to comply with environmental regulations.

6.3.3 The Remedial Action Contractor

- Develop implementation procedures for the requirements set forth in this plan.
- Execute programs and policies in a manner that shall ensure compliance with the requirements set forth in this plan.
- Assure that the required information specified in subsequent sections of this plan is recorded and reported.
- Submit requests for variance from the standards of this plan to the DOE Contracting Officer or Contracting Officer's Representative.
- Include the requirement for compliance with the plan in all applicable subcontracts.

6.4 KEY FEATURES OF THE HEALTH AND SAFETY PLAN

The following elements are included in the Environmental, Health, and Safety Plan (Appendix D):

6.4.1 General

The RAC will maintain on-site professional radiation health staffing whenever contaminated materials are exposed. These personnel will develop and implement procedures for all activities involving potential safety or radiological health risks.

6.4.2 Community protection

During construction an environmental monitoring program will be conducted to document the effects on the environment and exposure of the general population to environmental hazards resulting from the remedial action activity. Air particulate samples, Rn-222 samples, ground-water samples, and surface-water samples will be collected and analyzed for radiological parameters. Monitors will be located in areas mutually acceptable to the Navajo Nation and the DOE. Monitoring locations will include the upwind and downwind site boundary, and a background location.

In addition, an array of environmental radon monitors will be placed around the site to provide a measurement of the average radon concentration. In order to provide immediate information, two or more real-time, continuous radon monitors will also be located near the site and in the community to provide hourly readout of radon concentrations.

Operating response plans will be prepared by the RAC to formulate response to severe weather events, construction accidents, or medical emergencies. Operational alert levels will be developed to control any elevated radon emissions detected by monitoring programs during construction activities. Typical responses to elevated radon levels will include additional wetting of exposed contaminated material, reduction of the uncovered area, or suspension of operations. Administrative controls will be utilized to limit increases in off-site radon levels to 3 pCi/l averaged during a 52-week period, and 6 pCi/l averaged during any 26-week period.

6.4.3 Worker protection

Training sessions applicable to the degree of radiation hazard present at the site will be conducted for all employees prior to the start of work. These sessions will include discussion of site conditions, potential radiological hazards, effects of radiation, and emergency procedures. Records will be maintained which document successful completion of training by employees.

Controlled areas will be designated and conspicuously marked. Access control points will be established for controlled areas, and all personnel and equipment will be monitored. Access control records will be maintained. Those records will include a log of personnel and equipment entering and leaving the controlled area and a log of dosimeters issued.

Protective clothing will be distributed to employees at the access control point when conditions warrant. Change and cleanup facilities will be provided.

Thermoluminescent dosimeters (TLDs) or film badges will be supplied to permanent employees working in controlled areas. Dosimeters will be changed quarterly or more frequently if necessary. Urinalysis will be used to monitor employee internal exposures, and additional dosimetry may be required if positive results are noted. A system of employee health records will be maintained which documents individual radiation exposures and the results of personnel dosimetry and bioassays.

Air particulate samples will be collected in work areas and at site boundaries. Samples will be analyzed for gross alpha levels, and will be stored for later isotopic analyses, if necessary. Additional samples will be collected in work areas where ventilation is limited, and analyzed for radon daughter concentrations.

A respiratory protection program, with procedures for training employees and checking for adequate fit of respirators, will be developed by the RAC. Respirators will be used in work areas where the airborne particulates cannot be controlled by dust suppression measures. An administrative limit shall be established to restrict exposure to airborne particulate concentrations at 25 percent of the regulatory limit for radionuclides. Industrial hazards will be controlled in accordance with OSHA regulations.

7.0 RESPONSIBILITIES OF PROJECT PARTICIPANTS

7.1 INTRODUCTION

The following defines the various responsibilities of the Department of Energy (DOE) UMTRA Project Office, the Nuclear Regulatory Commission (NRC), the Department of Interior/Bureau of Indian Affairs, and the Navajo Nation during Title II design, remedial action, and through the initiation of custodial maintenance and surveillance. Responsibilities are divided into major categories to be performed by the parties. The DOE will be assisted by its Technical Assistance Contractor (TAC) and Remedial Action Contractor (RAC), but all assigned responsibilities will remain the ultimate responsibility of the DOE. In general, the TAC will assist the DOE in the preparation of concept designs and remedial action plans and will provide quality assurance, audits, and recommendations for final certification. The RAC will prepare detailed designs and manage field construction activities.

The Navajo Nation's responsibilities will be administered and coordinated by the Navajo Environmental Protection Administration.

The Department of Interior/Bureau of Indian Affairs responsibilities will be performed by the Navajo Area Office.

Major areas of responsibility for future actions by the DOE, the Navajo Nation, the Department of Interior/Bureau of Indian Affairs (DOI/BIA), and the NRC are summarized as follows:

1. <u>DOE (including TAC, RAC)</u>:

   Manage and coordinate projects.
   Obtain permits and approvals.
   Prepare detailed designs and specifications.
   Prepare quality assurance plan.
   Prepare and implement public participation and information plan.
   Provide funds.
   Conduct remedial action.
   Audit remedial action.
   Prepare licensing plan and submit license application.
   Prepare maintenance and surveillance plan.
   Certify remedial action.
   Obtain license.
   Conduct maintenance and surveillance.

2. <u>Navajo Nation</u>:

   Review and concur in the RAP.
   Assist DOE in acquiring or extinguishing the interests of allottees or others with property interests at the mill site.
   Assist in obtaining Tribal Chapter approvals.
   Issue Tribal permits or approvals.
   Assist in public participation and information.
   Convey to the Federal Government title to residual radioactive materials stabilized at the site.

3. Department of Interior/Bureau of Indian Affairs:

Provide consultation services.
Issue permits.

4. NRC:

Review and concur in RAP.
Review and concur in maintenance and surveillance plan.
Review and concur in final certification report.
Issue license for long-term monitoring and maintenance of the disposal site.

7.2 DETAILED RESPONSIBILITIES

Detailed responsibilities of project participants in the areas of permitting, licensing, land acquisition, detailed design, construction, health and safety, public information, radiological support, quality assurance, and custodial maintenance and surveillance are defined in the following text.

7.2.1 Regulatory compliance

Requirements for regulatory compliance, previously identified by Federal and Tribal agencies (Agencies), will be incorporated into the final design specifications, as needed, by the DOE. Revisions to the design and specifications resulting from internal DOE reviews will be incorporated prior to the Agencies' review for permits.

The RAC will submit permit applications, and supporting details to the Agencies for permit issuance.

During the remedial action, the DOE will audit construction activities for compliance with provisions in the permits and approvals. (Permitting Agencies may independently audit relevant activities consistent with normal practice.) Summary audit reports will be prepared by the DOE and submitted to appropriate Agencies as required. Depending upon Agency comments, revisions to construction compliance activities will be made.

Upon completion of the permitted action, the DOE will conduct a final review and will prepare a close-out report for submittal to the Agencies. Permits will then be terminated.

7.2.2 Licensing

As part of the licensing task and prior to completion of the remedial action, the DOE will prepare a draft license application including a site maintenance and surveillance plan. The draft application will be submitted to the NRC and Navajo Nation for review and concurrence. Revisions resulting from this review will be incorporated into the final application which will be submitted after DOE has certified that remedial action is complete.

Any final revisions required will be added and the license will be issued by the NRC to the DOE (or responsible designated Federal agency).

7.2.3 Land acquisition

DOE is granted permanent right-of-entry to the disposal site through Article 5, Acquisition, Disposition and Use of Property of the cooperative agreement. The Navajo Nation will assist DOE in acquiring or extinguishing the interests of allottees, permittees, lessees, and sublessees of, or other individuals with property interests in the disposal site. Ownership and control of the site and residual radioactive material will be in accordance with a Land Withdrawal Agreement for Stabilization of Residual Radioactive Material to be executed between the DOE and the Navajo Nation.

7.2.4 Detailed design

The Remedial Action Contractor (RAC) will prepare preliminary engineering drawings for review by the DOE. Based upon this review, the RAC will prepare final design drawings, specifications, and bid packages. Once finalized and approved by the DOE, the bid packages will be issued to prospective bidders pursuant to Federal regulations and a construction subcontractor will be selected.

Final design and specifications will be available to the NRC and the Navajo Nation, upon request.

7.2.5 Construction

The DOE will prepare guideline documents to comply with health and safety, security, quality assurance, public information, and other regulatory requirements.

The RAC will acquire the necessary permits and approvals from the appropriate agencies.

Site mobilization and initiation of construction activities will occur in accordance with the DOE-approved construction schedule.

Construction activity audits will be performed by the TAC on behalf of the DOE. These audits will be provided to the NRC, the Navajo Nation, and other regulatory agencies upon request to DOE. Revisions to the remedial action resulting from site audits will be incorporated into the as-built design and the remedial action plan by the DOE as necessary.

Audit reports will be available to the NRC and the Navajo Nation.

Upon completion of the remedial action, the site will be certified by the DOE. The NRC will review and concur in the final site certification report.

7.2.6 Health and safety

The DOE will prepare an Environmental, Health, and Safety Plan (Appendix D) in conformance with the UMTRA Project Health and Safety Plan. Based upon this guidance, site-specific implementation procedures will be developed by the DOE. As part of the implementation procedures, the DOE will institute radiation control and environmental monitoring, and will develop response procedures for severe weather and medical emergencies.

Construction contractors will comply with approved procedures and file reports with the DOE that record the results of monitoring, and report accidents and illnesses. Records will be maintained by the DOE following remedial action construction.

Employee and public complaints will be investigated by the DOE.

7.2.7 Public information

The DOE will establish a local site manager who will provide information to the public and local media.

Prior to and during construction, the DOE, with assistance from Navajo Nation officials and local citizens, will conduct public information meetings to inform the interested public of key aspects and current progress of the remedial action.

Concurrent with the public meetings, the DOE will provide status and progress reports for the Navajo Nation and other agencies (e.g., NRC, EPA, DOI/BIA).

7.2.8 Radiological support

The DOE will prepare and implement a Radiological Support Plan (Appendix C), and will take measures to independently assure the quality of the analyses and compliance with the procedures.

After remedial action, the DOE will prepare a completion report, conduct a final certification survey, and provide a recommendation for site certification. The NRC will concur in the final site certification report.

7.2.9 Quality assurance

On behalf of the DOE, the RAC will prepare a Quality Assurance (QA) Plan in conformance with guidelines established in the UMTRA Project QA Plan (DOE/AL-185). The DOE will audit the construction activities and will submit audit reports as appropriate. Details on quality assurance are included in Section 8.0.

7.2.10 Maintenance and surveillance

The DOE will prepare and submit to NRC and the Navajo Tribe the Site Maintenance and Surveillance Plan for review and concurrence. The DOE (or responsible Federal agency designated) will assure that the plan is implemented. The general objectives and elements of the maintenance and surveillance activities are discussed in Section 9.0.

8.0 QUALITY ASSURANCE

8.1 GENERAL

The RAC shall provide and maintain an effective quality assurance (QA) program and procedural system which will assure that all work, materials, supplies, and services required under the contract conform to contract requirements, whether constructed or processed by the RAC or its subcontractors, or procured by subcontractors or vendors. The RAC shall perform or have performed adequate inspections and tests as will ensure and substantiate that all work, materials, supplies, and services conform to contract requirements.

The RAC shall furnish a QA test and inspection plan outline for the site with the preliminary design which defines the health, safety, and environmental activities to be incorporated into the design and/or performed during construction to ensure contract compliance and site certification. Test and inspection requirements shall be subject to approval by the DOE prior to the start of any physical job site construction work under this contract. For procurement in advance of construction, those portions of the QA plan dealing with procurement shall be submitted to the DOE for review and approval prior to placement of any purchase requisition. If the RAC revises the plan, the RAC shall furnish a copy of the revision to the DOE for approval prior to implementing the revision on work under the contract.

8.2 QUALITY ASSURANCE PLAN

Before construction operations are started, the RAC shall meet with the authorized QA representative of the DOE to review and discuss the RAC's proposed project QA plan. The meeting shall develop mutual understanding relative to details of the individual site plan requirements including the formats to be used for recording and reporting tests and inspections, administration of the plan, personnel assignments, and the interrelationship between the RAC and the DOE QA representative. The RAC shall furnish a list of the procedures required to implement the project plan within ten working days after receipt of written notice of acceptance of the QA plan. This list shall include, at a minimum, procedures for data collection, analyzing samples, inspection and testing, and formats of reports to be used.

8.3 DAILY INSPECTION REPORT

The RAC shall prepare a daily report for every day worked and a weekly summary report covering the RAC and/or subcontractor's operations in an appropriate format. These reports shall be maintained at the site until completion of work. These logs shall provide complete and factual evidence that continuous, effective quality control construction inspections and tests have been performed, including but not limited to: 1) the type and number of inspections and tests involved, 2) results of inspections and tests, 3) nature of deficiencies requiring corrections, and 4) corrective actions taken or to be taken. A weekly summary inspection report shall be submitted to the DOE. These aforementioned reports for construction quality control, which form part of these records, shall cover both conforming and defective contract work and shall include a statement that all samples, materials, and equipment used and work performed are in compliance with the contract plans and specifications, except as noted in the reports.

The RAC shall maintain current records of all inspections and shall furnish two legible copies of all inspection reports to the DOE. The reports of inspection shall cover all work placement subsequent to the previous report, and they shall be verified by the RAC's designated QA representative.

8.4 MEASURING AND TEST EQUIPMENT CALIBRATION AND CONTROL

The RAC shall provide measuring and test equipment having the precision and accuracy needed to establish conformance with specified quality requirements. Calibrations shall be in accordance with nationally recognized standards. The RAC shall identify procedural systems for test equipment calibration and recall.

8.5 NONCONFORMANCES

A nonconformance and change procedural system shall be developed by the RAC and approved by the DOE prior to the start of any site construction activities.

8.6 RECORDS CONTROL

The RAC shall be responsible for generation, retention, and retrieval of legible records providing objective evidence of conformance to the specified quality requirements. These records shall be considered valid only if they are completed and signed or otherwise authenticated and dated by authorized personnel. These records should include, but are not limited to:

- Radionuclides in soil data.
- Air monitoring data.
- Design review files.
- Water contaminant analysis.
- Personnel radiation exposure data.
- As-built drawings.
- Test and inspection reports.
- Engineering specifications.
- Material certifications.
- Certificates of compliance.
- Reports and corrective action requests.
- Operating procedures.

All records shall be available to the DOE for review upon request. All personnel radiation exposure records shall be turned over to DOE upon completion of the site remedial action.

8.7 CODES AND STANDARDS

The RAC shall have on the job site, no later than three weeks after site mobilization, the applicable quality assurance codes and standards available for ready reference by all personnel. The RAC shall maintain at the job site copies of all "approved for construction" drawings, specifications, and other documents which describe the remedial action.

8.8 AS-BUILT DRAWINGS

The RAC shall develop QA procedural systems to assure the use of authorized "approved for construction" drawings and specifications and the maintenance of current as-built drawings. Two full-size sets of contract drawings shall be used by the RAC for this purpose. All variations from the contract drawings shall be depicted in red on two sets of the latest applicable contract drawings. Generally, the drawings shall reflect only such changes and/or corrections to data and dimensions shown on contract drawings. Where the contract specifications or drawings permit optional use of more than one type of material or equipment, the type of material or equipment installed shall be shown on the drawings. The drawings shall be maintained in a current condition at all times and shall be made available for review by the DOE at all times. Variations from the contract drawings shall be shown in the contract working drawings and shall be incorporated onto the as-built drawings. Upon physical completion of the contract work, two copies of the as-built drawings shall be furnished to the DOE.

8.9 MATERIAL CERTIFICATION

The technical specifications may require that certain materials be certified. Two types of certifications may be specified:

- Certificates of compliance.
- Material test reports (MTR). (When an MTR is requested from the RAC or its subcontractors, it shall be accompanied by a certificate of compliance certifying that the tested material is actually that material incorporated in the work.)

8.10 QUALITY ASSURANCE PROGRAM VERIFICATION

Verification of the QA Program implementation by the DOE may be accomplished by:

- Review of daily or weekly summary reports.

- On-site inspections and surveillance.
- Periodic audits.
- Acceptance of DOE QA recommendations based on DOE QA audits of RAC activities.
- Any combination of the above.

9.0 MAINTENANCE AND SURVEILLANCE

9.1 INTRODUCTION

The objectives of the custodial maintenance and surveillance program are to assure that, upon completion of remedial action, the stabilized embankment remains undisturbed and that the tailings continue to be nonhazardous to the public.

The custodial maintenance and surveillance program will be defined jointly by the DOE and the NRC during the license application and approval process. Following are the basic elements that may be included in this program.

9.2 SURVEILLANCE

9.2.1 Site inspections

Site inspections constitute a visual and definitive verification that the disposal site continues to function as designed and assures continued compliance with the EPA standards. Inspections will consist of two phases: Phase I, a systematic walk-over designed to qualitatively evaluate the condition of the disposal site; and Phase II, investigation to quantitatively assess changes in the disposal site that could lead to functional failure of the design in the absence of custodial maintenance.

The Phase I inspection will be conducted on a specific schedule, such as annually, by a team of qualified professionals. The inspection team will review as-built drawings, engineering details, aerial photographs, and supporting documentation. A site walk-over will then be performed to evaluate any changes at the site with regard to factors such as erosion, flood effects, seepage along the San Juan River escarpment, slope/cover stability, settlement, displacement, plant or animal intrusion, and access control. Monitoring wells around the periphery of the site will be maintained for water level measurement or sampling as desired. DOE will either retain wells used for site characterization or install new wells upon completion of the remedial action. Well locations will be coordinated with the Navajo Nation.

Based upon the evaluation and recommendations of the inspection team, Phase II evaluation may be conducted to quantitatively determine the magnitude and rate of effect of changes in the above factors. From these studies, the need for a corrective action (i.e., custodial maintenance) would be ascertained.

9.2.2 Aerial photography

Aerial photography may be used to supplement site inspections. The objectives will be to identify changes in site conditions (e.g., patterns of developing erosion that may affect the function of the design), provide visual documentation of long-term variation in site conditions, and to identify activities (e.g., road conditions, storm drainage construction) adjacent to the site that may affect its function.

Aerial photography may also be conducted on a periodic schedule. Photographs will be taken at both low (i.e., high resolution) and high (i.e., for adjacent activities) altitudes, and at oblique and vertical angles. The type of film, ground control, camera specifications, amount of aerial overlap, interpretative keys, and other requirements will be established prior to completion of remedial action.

9.2.3 Reporting

Summary surveillance and monitoring reports that evaluate the results of these activities and recommend needed custodial maintenance (i.e., corrective actions), along with future surveillance and monitoring, will be prepared. Reports and supporting documentation will be placed on file with DOE, NRC, and the Navajo Nation.

9.3 CUSTODIAL MAINTENANCE

The need for custodial maintenance (i.e., corrective action) can only be determined following site inspection and monitoring. However, it is anticipated that custodial maintenance will consist primarily of the following:

- Limited soil/rock replacement due to unanticipated erosion, human or animal intrusion, or cover disturbance -- these activities are expected to be required infrequently.
- Control of deep-rooted plants by infrequent application of herbicides or physical removal as required.
- Mechanical repairs to security fence, gates and locks, and warning signs, when necessary.

9.4 CONTINGENCY PLANS

Procedures will be developed to inspect and perform custodial maintenance of the disposal site upon the occurrence of severe meteorological events (e.g., extreme rainfall, or seismic events) or unusual human intrusion

10.0 PUBLIC PARTICIPATION AND PUBLIC INFORMATION

10.1 INTRODUCTION

Section III of UMTRCA states,

> "In carrying out the provisions of this title, including the designation of processing sites, establishing priorities for such sites, the selection of remedial actions and the execution of cooperative agreements, the Secretary (of Energy), the Administrator (of the Environmental Protection Agency), and the (Nuclear Regulatory) Commission shall encourage public participation and, where appropriate, the Secretary shall hold public hearings relative to such matters in the state where processing sites and disposal sites are located."

It is the intent of the public participation and public information program to fully inform the interested public in the decision-making processes and remedial action activities relative to the UMTRCA-designated site on the Navajo Reservation near Shiprock, New Mexico. The following sections describe the actions the DOE will take to encourage the participation of an informed public in this project.

10.2 PUBLIC PARTICIPATION

The National Environmental Policy Act (NEPA) of 1969 requires an evaluation of the environmental impacts of major Federal actions that may significantly affect the environment. Before remedial action construction can begin, an EA will be completed for the Shiprock site. Public participation is an important part of the preparation of the EA and the participation requirements are detailed in the Council on Environmental Quality (CEQ) Regulations (effective July, 1979) for implementing the provisions of NEPA, and in the DOE guidelines of 1980 for NEPA compliance.

In preparing the EA, DOE has conducted and will continue to conduct individual meetings with community officials and private citizens to discuss the purpose of the proposed remedial actions and ascertain the extent of public interest in this project. At these meetings, the public is given the opportunity to express their concerns and identify what they believe to be significant issues.

The identified issues are documented in the EA. The DOE accepts written comments for a 30-day period after publication of both the EA and the draft Finding of No Significant Impact (FONSI) or need for Environmental Impact Statement (EIS) determination.

In addition to meetings on the EA, the DOE will hold public information meetings in Shiprock to describe the remedial action plan for the Shiprock site.

A Shiprock Task Force, formed to serve as a major communication link in the decision-making process, will meet with the DOE to convey community response on project activities. The Task Force will continue to meet periodically throughout the duration of remedial action construction.

Frequent meetings and briefings are held by DOE and its contractors to provide information and project status updates and solicit public participation in the project activities. Tribal and local officials and interested citizens are involved in frequent discussions with project personnel regarding remedial action construction schedules, radiation monitoring reports, ground-water protection plans, and other project activities.

10.3 PUBLIC INFORMATION

In order for public participation to be effective, the public must be informed concerning the remedial action project in Shiprock. Several methods of information dissemination are being used by the DOE. Press releases and press packets are prepared for project status updates, including report summaries, texts of presentations, and graphics.

The names and addresses of some 180 individuals, media representatives, and Federal, Navajo Nation, and local officials have been computerized for information dissemination purposes. Information is provided to interested persons in the Federal Government, Navajo Nation administration, and Shiprock Chapter offices, and private citizens in Farmington, Shiprock, and smaller communities on the Navajo Reservation on a regular basis.

A Navajo translator/cultural advisor has been retained by DOE to assist in all information dissemination activities.

A public pre-construction meeting will be conducted by the DOE. Principal topics of discussion will include the remedial action plan and construction methods and schedules.

An on-site representative will be designated to respond to public inquiries during remedial action construction. This representative will work closely with the DOE to provide information, and will meet frequently with the public throughout the construction period.

A variety of printed materials have been prepared concerning the UMTRA Project and the Shiprock site. These include project fact sheets, a site fact sheet, an EA summary fact sheet, and the EA document. As they are printed, these materials and other fact sheets and documents are sent to interested individuals and are available in the Navajo Community College, Shiprock Branch Library, the BIA Shiprock Area Office, and the Navajo Environmental Protection Administration Office in Window Rock, Arizona.

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GLOSSARY

absorbed dose, radiological	Radiation energy absorbed per unit mass, usually given in units of rads.
alluvium	Sediment deposited by flowing water.
alpha particle	A positively charged particle emitted from certain radionuclides. It is composed of two protons and two neutrons, and is identical to the helium nucleus.
aquifer	A subsurface formation containing sufficiently saturated permeable material to yield usable quantities of water.
aquitard	A water-bearing zone that allows transmission of water at a very slow rate.
areal	Horizontal area of extent.
atom	A unit of matter; the smallest unit of an element consisting of a dense, central, positively charged nucleus surrounded by a system of electrons, equal in number to the number of nuclear protons and characteristically remaining undivided in chemical reactions except for a limited removal, transfer, or exchange of certain electrons.
background radiation	Levels of radiation, or concentration of radionuclides which are typical of an undisturbed area, or area not affected by residual radioactive material.
beta particle	Charged particle emitted from the nucleus of an atom, with mass and charge equal to those of an electron.
bioassay	A method for quantitatively determining the concentration of radionuclides in a body by measuring the quantities of those radionuclides that are eliminated from the body, usually in the urine or the fec .
CDM	Climatological dispersion model.
CEQ	Council on Environmental Quality.
COE	U.S. Army Corps of Engineers.
confined aquifer	An aquifer bounded above and below by relatively impermeable beds.
contamination	In this report, the presence of radioactive material in undesirable concentrations and in undesirable locations.
contiguous	Adjoining.
dpm	Disintegrations per minute.

daughter product(s)	A nuclide resulting from radioactive disintegration of a radionuclide, formed either directly or as a result of successive transformations in a radioactive series; it may be either radioactive or stable.
decay, radioactive	Disintegration of the nucleus of an unstable nuclide by spontaneous emission of charged particles, photons, or both.
decontamination	The reduction of radioactive contamination from an area to a predetermined level set by a standards-setting body such as the EPA, by removing the contaminated material.
disintegrations per minute or second	The number of radioactive decay events occurring per minute or second.
disposal	The planned, safe, permanent placement of radioactive waste.
DOE	U.S. Department of Energy.
DOI/BIA	U.S. Department of Interior, Bureau of Indian Affairs.
dose	A general term denoting the quantity of radiation or energy absorbed, usually by a person; for special purposes, it must be qualified; if unqualified, it refers to absorbed dose.
dose, absorbed	The amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material at the point of interest; given in units of rads.
dose commitment	The cumulative dose equivalent that results and will result from exposure to radioactive materials over a discrete time period; given in units of rems.
dose equivalent	The quantity that expresses all kinds of radiation on a common scale for calculating the effective absorbed dose; defined as the product of the absorbed dose in rads and modifying factors, especially the qualifying factor; given in terms of rems. Often abbreviated "dose."
EA	Environmental Assessment.
EID	Environmental Improvement Division (New Mexico Health and Environment).
EIS	Environmental Impact Statement.
electron volt	A unit of energy equal to the energy acquired by an electron falling through a potential difference of one volt, approximately 1.602×10^{-19} joules.
eolian	Deposited by the wind.
EPA	U.S. Environmental Protection Agency.
escarpment	A steep face terminating high lands abruptly.

evaporite	One of the sediments which are deposited from a solution as a result of extensive or total evaporation of the solvent.
exposure	A measure of gamma radiation that may deposit energy in an individual; given in units of roentgens.
external dose	The absorbed dose that is due to a radioactive source external to the individual as opposed to radiation emitted by inhaled or ingested sources.
flux, radon	The emission of radon gas from the earth or other material, usually measured in units of picocuries per square meter per second.
FONSI	Finding of No Significant Impact.
F&WS	U.S. Fish and Wildlife Service.
G-M probe	Geiger-Muller probe - an instrument used to detect, measure, and record nuclear emanation, cosmic rays, and artificially-produced subatomic particles.
gamma dose	Radiation dose caused by gamma radiation.
gamma logging (or logs)	A technique for determining gamma radiation levels at various depths in a borehole.
gamma ray	High-energy electromagnetic radiation emitted from some radiation radionuclides. The energy levels are specified for different radionuclides.
gamma spectral analysis (gamma spectroscopy)	An analytical technique for identifying radionuclides based on their different gamma energy levels.
grazing allotment	An entitlement given by a tribe to a person or persons to use a specified parcel of tribal lands for the grazing of livestock.
ground water	Water in saturated permeable material below the land surface.
hydraulic conductivity	Ratio of flow velocity to driving force (for viscous flow under saturated conditions of a specified liquid in a porous medium).
hydraulic gradient	Rate of change of static head per unit of distance of flow in a given direction.
half-life	The time it takes for 50 percent of the quantity of a radionuclide to decay into its daughters.
IAS	Interagency Archaeological Service.
in-situ	In the natural or original position.
internal dose	The absorbed dose or dose commitment resulting from inhaled or ingested radioactivity.

ISC	Industrial Source Complex.
ISCST	Industrial Source Complex Dispersion Model for Short-Term Applications.
isotopes	Nuclides having the same number of protons in their nuclei, but differing in the number of neutrons; the chemical properties of isotopes of a particular element are almost identical.
KeV	One kilo (thousand) electron volts.
laterally discontinuous	Not continuous in a sideways direction.
licensing	In this report, the process by which the NRC will, after the remedial actions are completed, approve the final disposition and controls over a disposal site.
m^2sec	meter squared per second.
maintenance, custodial (passive)	The repair of fencing, repair or replacement of monitoring equipment, revegetation, minor additions to soil cover, and general disposal site upkeep such as mowing grass.
man-rem	Unit of population exposure obtained by summing individual dose-equivalent values for all people in the population. Thus, the number of man-rems attributed to 1 person exposed to 100 rems is equal to that attributed to 100 people each exposed to 1 rem.
mass wasting	The slow downslope movement of rock or soil debris due to gravity.
MeV	One mega (million) electron volts.
micro	A prefix meaning one millionth (x 1/1,000,000 or 10^{-6}).
milli	A prefix meaning one thousandth (x 1/1000 or 10^{-3}).
Modified Mercalli (scale)	A standard scale for the evaluation of the local intensity of earthquakes based on observed phenomena such as the resulting level of damage. Not to be confused with magnitude, such as measured by the Richter scale, which is a measure of the comparative strengths of earthquakes at their sources.
monitor	To observe and make measurements resulting in data for evaluation of the performance and characteristics of the disposal site.
MPC	Maximum permissible concentration.
MSRD	Mountain States Research and Development.
MTR	Material test report.
NECA	Navajo Engineering and Construction Authority.

NEPA	National Environmental Policy Act.
NRC	U.S. Nuclear Regulatory Commission.
OSHA	Occupational Safety and Health Act.
passive institutional controls	Those controls which require action by a governmental agency to preclude human contact with the waste or require a continuing social order. Examples include Federal ownership of a disposal site, monuments on the site, records with agencies, and physical barriers (e.g., riprap covers, vegetation, waste burial).
PAL	Point area line.
perched ground water	Ground water separated from an underlying body of ground water by unsaturated material.
permeability	The capacity of a rock or soil mass to transmit a fluid.
permissible dose	That dose of ionizing radiation that is considered acceptable by standards-setting bodies such as the EPA. Also, the dose of radiation that may be received by an individual within a specified period with the expectation of no substantially harmful result.
person-rem	Same as man-rem.
pico	A prefix meaning one trillionth (1 x 1/1,000,000,000,000 or 10^{-12}).
picocurie (pCi)	A unit of radioactivity defined as 0.037 disintegrations per second.
potentiometric surface	A surface representing the static head along a particular surface or stratum in an aquifer. The water table is a particular potentiometric surface.
PMF	Probable Maximum Flood.
PMP	Probable Maximum Precipitation.
promulgate	To make known by open declaration; proclaim.
proton	An electrically positive elementary particle found in the nucleus of an atom. Also, the nucleus of a hydrogen atom.
PSCR	Processing Site Characterization Report.
QA	Quality assurance.
RAC	Remedial Action Contractor.
rad	A unit of measure for the absorbed dose of radiation. It is equivalent to 100 ergs per gram of material.

radioactivity (radioactive decay)	The property of some nuclides of spontaneously emitting particles of gamma radiation or of spontaneous fission.
radioisotope	A radioactive isotope of an element with which it shares almost identical chemical properties.
radionuclide	A radioactive nuclide.
radium-226, Ra-226	A radioactive daughter product of uranium-238. Radium is present in all uranium-bearing ores; it has a half-life of 1620 years.
radon-222, Rn-222	The gaseous radioactive daughter product of radium-226; it has a half-life of 3.8 days.
radon-daughter product	One of several short-lived radioactive daughter products of radon-222. All are solids.
RAP	Remedial Action Plan.
RDC	Radon daughter concentration.
recharge	Resupply, replenish.
rem	A unit of dose equivalent equal to the absorbed dose in rads times quality factor times any other necessary modifying factor. It represents the quantity of radiation that is equivalent in biological damage to 1 rad of x-rays.
ROD	Record of Decision.
roentgen	A unit of measure of ionizing radiation in air; 1 roentgen in air is approximately equal to 1 rad and 1 rem in tissue.
SCD	Site Conceptual Design.
short ton	A unit of weight equal to 2000 pounds or 0.907 metric tons.
SHP	Shiprock.
SDC	Site Design Criteria.
SIP	Stabilization in place.
soil infiltration rate	The rate at which water enters the soil surface and moves vertically downward.
soil percolation rate	The rate at which water moves through soil in all directions.
stabilization	The reduction of radioactive contamination in an area to a predetermined level by a standards-setting board such as the EPA, by encapsulating or covering the contaminated material.
standard Proctor	A test procedure to measure moisture-density relationships (ASTM D698).

static head	Height to which a column of water can be supported by the pressure exerted by the water.
surveillance	The observation of the disposal site for purposes of visual detection of need for custodial care, evidence of intrusion, and compliance with other license and regulatory requirements.
TAC	Technical Assistance Contractor.
T&E	Threatened or endangered.
tailings, uranium-mill	The wastes remaining after most of the uranium has been extracted from uranium ore.
TDS	Total dissolved solids.
thorium-230, Th-230	A radioactive-daughter product of uranium-238; it has a half-life of 80,000 years and is the parent of radium-226.
TLD	Thermoluminescent dosimeter.
transmissivity, hydraulic	A measure of the ability of an aquifer to transmit water equal to the product of the permeability and the thickness of the aquifer, expressed in gallons per day per foot of drawdown.
tribe	Any tribe, band, clan, group, pueblo, or community of Indians recognized as eligible for services provided by the Secretary of the Interior to Indians.
TSP	Total suspended particulates.
UMTRA	Uranium Mill Tailings Remedial Action.
UMTRCA	Uranium Mill Tailings Radiation Control Act.
unconfined aquifer	An aquifer that is not confined by impermeable beds. The upper water surface is called the water table.
uranium-238, U-238	A naturally-occurring radioisotope with a half-life of 4.5 billion years; it is the parent of uranium-234, thorium-230, radium-226, radon-222, and others.
USGS	U.S. Geological Survey.
vadose	Saturated.
VCA	Vanadium Corporation of America.
vicinity property	A property in the vicinity of the Shiprock site that is determined by the DOE, in consultation with the NRC, to be contaminated with residual radioactive material derived from the Shiprock site, and which is determined by the DOE to require remedial action.

water table — The upper surface of a zone of saturation in an unconfined aquifer, along which the pressure is atmospheric.

working level (WL) — A measure of radon-daughter-product concentrations. Technically, it is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of alpha particles with a total energy of 130,000 MeV.

working-level month (WLM) — Exposure to a worker resulting from inhalation of air with a concentration of 1 WL of radon daughters for 170 working hours. Continuous exposure of a member of the general public to 1 WL for one year results in approximately 53 WLM.

APPENDIX A

REGULATORY COMPLIANCE

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LIST OF FIGURES

REGULATORY COMPLIANCE

INTRODUCTION

Obtaining permits and other regulatory approvals for the remedial action is essential for the smooth completion of the project. This Regulatory Compliance Appendix is intended to identify and describe the permits, licenses, and approvals that are likely to be required for the proposed action based upon the concept design (Appendix E). Other permits and approvals may be required for activities beyond the scope of the Remedial Action Plan or due to modifications in the concept design.

Each permit/approval identified includes the following information:

- Legal citation.
- Agency contact (individual, address, phone number).
- Application procedure and required detail.
- Special considerations (e.g., multiple agency review).
- Schedule.

A tentative schedule of regulatory compliance activities (Figure A.1.1) is included for initial project planning purposes. The Remedial Action Contractor (RAC) should sequence the preparation and filing of permit applications so that approvals will be received in a timely manner without causing delay to construction activities. TAC Environmental Services personnel will provide additional assistance to the RAC as needed. Figure A.1.2 is a matrix indicating the lead agencies and cooperating agencies involved with each permit.

The RAC should consider this Regulatory Compliance Appendix to be an introduction to the permitting process, while details must be obtained from the regulatory agencies by RAC personnel.

FIGURE A.1.1 REGULATORY COMPLIANCE SCHEDULE SHIPROCK SITE

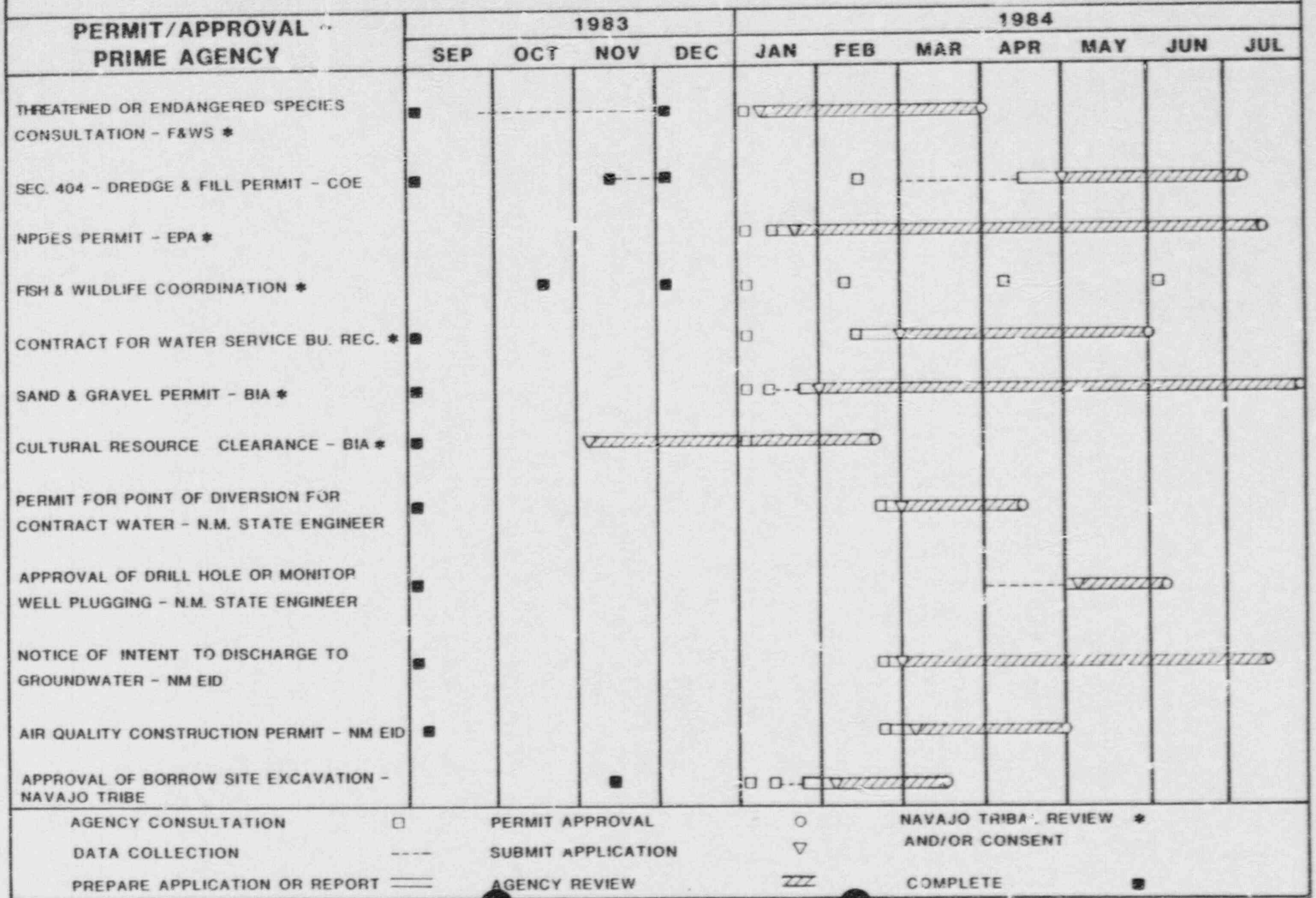

FIGURE A.1.2

SHIPROCK TAILINGS REGULATORY COMPLIANCE

PERMIT OR APPROVAL	NAVAJO TRIBE	BIA	COE	US EPA	US FWS	BU REC	NM STATE ENGINEER	NMEID	NM HISTORIC PRES
SAND AND GRAVEL PERMIT	C	L							
APPROVAL OF BORROW SITE EXCAVATIONS	L	C							
SECTION 404 - PERMITS FOR DISCHARGE OF DREDGED OR FILL MATERIAL			L	C	C				
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT (NPDES)	C			L				C	
THREATENED OR ENDANGERED SPECIES CONSULTATION PROCESS	C	C			L				
CULTURAL RESOURCE CLEARANCE	C	L							C
CONTRACT FOR WATER SERVICE	C					L	C		
PERMIT FOR POINT OF DIVERSION FOR CONTRACT WATER							L		
APPROVAL OF DRILL HOLE OR MONITOR WELL PLUGGING							L		
NOTICE OF INTENT TO DISCHARGE TO GROUNDWATER								L	
AIR QUALITY CONSTRUCTION PERMIT								L	
WATER USE PERMIT	L								

L - LEAD AGENCY

C - COOPERATING OR CERTIFYING AGENCY

ACTIVITY: SECTION 404 PERMIT FOR DISCHARGE OF DREDGED OR FILL MATERIAL

LEGAL CITATION: Clean Water Act of 1977, 33 USC 1344; 33 CFR 323.1 (1982), 33 CFR 230, and 40 CFR 230

AGENCY/CONTACT: U.S. Army Corps of Engineers (COE)
Albuquerque District Office
SWACO-OR
P.O. Box 1580
Albuquerque, NM 87103
ATTN: Richard D. Blum, P.E.
Chief, Construction-Operations Division
Andrew J. Rosenau
Supervisor, Regulatory Section (505) 766-2724

PROCEDURE: Placement of fill in the San Juan River floodplain will be subject to a COE permit if the fill is placed in a wetlands (as determined by the COE). COE approv of fill placement is likely to be granted by issuance of an individual Section 404 permit.

A permit application consists of a completed "ENG Form 4345" which includes the following information:

(1) Complete description of the proposed activity including vicinity maps, plan view drawings, and section drawings, sufficient for public notice.

(2) The location and purpose of the proposed activity.

(3) Schedule of the activity.

(4) Names and addresses of adjoining property owners.

(5) Location and dimensions of adjacent structures.

(6) A list of authorizations required by other Federal, interstate, state, or local agencies for the work, including all approvals received or denials already made.

Within 15 days of receipt of the application by the COE, the application is reviewed for completeness and the applicant is notified of the need for additional information prior to further processing. A public notice of the application is issued by the COE, also within 15 days of receipt of the application. Comments from the public and from other government agencies (e.g., EPA, F&WS) are considered by COE in processing the application. The COE prepares an environmental assessment of the impacts of the project and, in some cases, an EIS. A public hearing may be scheduled in some circumstances. The COE determines whether or not a permit should be issued and prepares a statement of findings (SOF) or, in the case of an EIS, a record of decision (ROD).

SPECIAL CONSIDERATIONS: The COE has determined that several sloughs on the San Juan River floodplain where excavation of contaminated materials will take place are considered to be wetlands under the 404 permit program. A Section 404 permit will be required if fill will be placed in these low-lying areas as a result of contamination removal or related land contouring.

Consultation with the regional EPA Office, as required by Section 404C of the Clean Water Act, may result in delay in the permitting process.

SCHEDULE: Section 404 permits normally require 90 days for processing, although simple applications may involve as little as 60 days.

ACTIVITY: SAND AND GRAVEL PERMIT

LEGAL CITATION: Surface Exploration, Mining and Reclamation of Lands, Bureau of Indian Affairs Regulations 25 CFR 216.

AGENCY/CONTACT: Branch of Real Property Management
Bureau of Indian Affairs (BIA)
Shiprock Agency
P. O. Box 966
Shiprock, NM 87420
ATTN: T. J. Namingha (505) 368-5109
Branch Chief
Gennie Denetsone (Window Rock) (602) 871-5151

PROCEDURE: Issuance of a sand and gravel permit is based upon review of a completed Application Form 5-154j (original and four copies) and accompanying information. The following information is required:

(1) Name of applicant.

(2) Land ownership (either Navajo Tribe of Indians or allottee's name).

(3) Location of proposed operation.

(4) Proposed expiration date of permit.

(5) Exact acreage of land to be covered by the permit.

(6) Metes and bounds description of the property boundary.

(7) Royalty rate or royalty waiver explanation.

(8) Description of the type of material to be mined.

(9) Performance bond to assure reclamation of the site.

(10) Signatures of the majority of Tribal Council delegates for tribal lands or written consent of current owners of allotted lands.

Exhibit A of the application should include:

(1) Description of the project.

(2) Description of project purpose and need.

(3) Summary of existing environmental conditions, including:

- o Land use.
- o Vegetation.
- o Water.
- o Air.
- o Biology.
- o Existing facilities.

(4) Statement of influence on the environment.

(5) Summary of environmental impacts.

(6) Mining and Reclamation Plan, including:

- o Type of equipment to be used.
- o Topsoil to be stockpiled for later reclamation use.
- o Revegetation procedures based on recommendations of the BIA Branch of Land Operations.

SPECIAL CONSIDERATIONS: Concurrence must be obtained by the BIA from the local Tribal Chapter leadership and from the Tribal Council prior to issuance of the permit. Waiver of the royalty requirement also requires Tribal Council approval. A technical review of the mining and reclamation plan is completed by the Bureau of Land Management at the request of the BIA.

A Temporary Use Permit with similar requirements may be required for the remedial action staging area. Alternatively, the borrow site and staging area could be included in one applicable package for land withdrawal of the final disposal site.

SCHEDULE: The time required for BIA application review and processing is typically six months, although special handling of the application may considerably reduce the review period.

ACTIVITY: NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT

LEGAL CITATION: Sections 25-8-501 through 508 CRS 1978 in conformity with the Federal Water Pollution Contract Act Amendments of 1972, the Clean Water Act of 1977, and regulations promulgated thereunder.

AGENCY/CONTACT: U.S. Environmental Protection Agency (EPA)
Region VI
6WPI
Interfirst One Building
1201 Elm Street
Dallas, TX 75270
ATTN: Jayne Watson, Chief
Permits Issuance Section (214) 767-9823
Fred Humke (Technical Specialist)
Jeanie Slaven (Administrative Specialist)

PROCEDURE: The permit applies to all operations discharging to waters of the state from a point source. Application is made by filing completed EPA Forms 1 and 2C under the EPA Consolidated Permits Program. Information required on Form 1 includes:

(1) Name, mailing address, and location of the facility.

(2) Facility contact.

(3) Standard industrial classification code for the facility.

(4) Existing Federal, state, or local permits.

(5) A map covering an area extending at least one mile beyond the facility property boundaries. The map should be based on a 7 1/2-minute USGS quadrangle map.

(6) A description of the nature of the business.

Form 2C requires the following information:

(1) Location, by latitude and longitude, and number designation of each effluent outfall.

(2) Name of receiving water for each outfall.

(3) A schematic flow diagram indicating sources of water, operations contributing waste water for the effluent water balance, and treatment processes for each waste stream.

(4) A list of each operation, average flow, and treatment related to each outfall.

(5) Description of the variation and frequency of water flow.

(6) Explanation of any Federal, state, or local implementation schedule for construction or improvement of waste-water treatment or other environmental programs.

(7) Influent and effluent characteristics:

- pollutants present.
- source of pollutants.
- concentration of pollutants.
- temperature of effluent.
- flow of effluent.
- pH of effluent.

SPECIAL CONSIDERATIONS: Form C may be used as an alternative to Form 2C in the application. The concept design specifies that a zero discharge evaporation pond will be used to receive contaminated water. For this type of facility, the main purpose in obtaining an NPDES permit is to limit the liability of the operator for discharges that may result from a very large precipitation event or other unanticipated situations. EPA officials encourage operators to obtain a permit for a no-discharge facility. Prohibitions of discharge permit include, but are not limited to, the following:

(1) No discharge is allowed that will violate state, regional, or local land use plans unless all requirements and conditions of applicable Federal and state statutes and regulations are met or will be met according to a schedule of compliance. Similarly, no discharge is permitted that by itself or in combination with other pollutants will result in pollution of the receiving waters in excess of standards, unless the permit contains effluent limitations and a schedule of compliance with water-quality requirements.

(2) No discharge of any radiological, chemical, or biological warfare agent or high level radioactive waste is permitted. Limits of radiological wastes that may be discharged are determined by state water-quality standards.

(3) No discharge from a point source that is in conflict with an established water-quality management plan promulgated under Sections 201, 208, 209, and 303(e) of the Federal Water Pollution Control Act of

1972 and the Clean Water Act of 1977 is permitted unless the waste discharge permit contains limitations and a schedule of compliance approved by the EPA.

Frequency of measuring, monitoring, and reporting is dependent on specific discharges.

SCHEDULE: An applicant is to apply for a permit at least 180 days in advance of the date the discharge is to begin. In some cases, EPA may determine that a site visit or extra information is necessary. In such a case, the applicant has 60 days to reply.

ACTIVITY: THREATENED OR ENDANGERED SPECIES CONSULTATION PROCESS

LEGAL CITATION: Endangered Species Act of 1973, Section 7
16 USC 1531, et. seq.

AGENCY/CONTACT: U.S. Fish and Wildlife Service
Endangered Species Office
P.O. Box 4487
Albuquerque, NM 87196
ATTN: John Peterson, Field Supervisor (505) 766-3966
Joel Medlin

Branch of Environmental Quality Services
Bureau of Indian Affairs
Navajo Area Office
P.O. Box M, Mail Code 305
Window Rock, AZ 86515
ATTN: Jim Aralla
Environmental Quality
Services Officer
Merlin Henke (602) 871-5151
Ext. 5314

PROCEDURE: A Federal agency must ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered (T&E) species or its critical habitat. The responsible Federal agency must consult with the Fish and Wildlife Service (F&WS) to determine what effect, if any, the proposed action might have on T&E species.

In most cases, a letter is sent by the Federal agency to the F&WS outlining the proposed action. If the F&WS determines that no T&E species would be adversely affected by the action, the F&WS responds stating their finding and that no further compliance measures are necessary. If the F&WS identifies that any T&E species may be affected, the Federal agency is required to prepare a biological assessment considering the species list s cted by the F&WS.

SPECIAL CONSIDERATIONS: The largest known population of Mesa Verde cactus is located in the Shiprock area. The plant is classified as threatened, and it is protected by the Endangered Species Act of 1973. A study of Mesa Verde cactus in the vicinity of the Shiprock tailings site is complete and consultation with the U.S. Fish and Wildlife Service has been initiated.

Biological survey procedures have been adopted by the Navajo Area Office of BIA. One important consideration of the procedure for black-footed ferrets is that no more than one year should elapse between the time of the field survey and the start of the earth-disturbing activity. The last black-footed ferret survey at the Shiprock site was conducted on October 7, 1983.

SCHEDULE: After obtaining the list of threatened or endangered species from the F&WS, the Federal agency has 180 days or another mutually agreeable time period to complete a biological assessment. The Federal agency requests a Section 7 consultation and the F&WS is required to issue a biological opinion within 90 days.

ACTIVITY: CULTURAL RESOURCE CLEARANCE

LEGAL CITATION: National Historic Preservation Act, 36 CFR 800 and 25 CFR 281

AGENCY/CONTACT:

Branch of Environmental Services
Bureau of Indian Affairs
Navajo Area Office
P.O. Box M, Mail Code 305
Window Rock, AZ 86515
ATTN: Jim Analla (602) 871-5012
Area Environmental Quality Services Officer
Mark Henderson, Area Archaeologist

Navajo Cultural Resources
The Navajo Tribe
P.O. Box 689
Window Rock, AZ 86515
ATTN: Anthony Klessert
Program Manager (602) 871-4941 Ext. 1540

PROCEDURE: Prior to surface-disturbing activities on Navajo Tribal lands, cultural resource clearance must be obtained from the Bureau of Indian Affairs. The person or government agency proposing the activity must contract with an approved archaeologist to conduct a Class III archaeological survey of the land to be affected. Five copies of the survey report and a copy of the environmental assessment for remedial action should be sent to the Bureau of Indian Affairs, Branch of Environmental Quality Services. The BIA solicits the review and recommendations of the Navajo Tribe. The BIA issues a letter of clearance in conjunction with the State Historic Preservation Officer stating stipulations for the proposed activity. Recommendations can range from no stipulations to avoidance or excavation of archaeological features that may have been identified.

SPECIAL CONSIDERATIONS: Cultural resource surveys of the tailings site, borrow site, and adjacent areas have been completed. The survey reports are being reviewed by the BIA.

The discovery of archaeological sites during the course of Federally assisted, permitted, funded, or licensed construction or land alteration must be reported to the Interagency Archaeological Service (IAS) of the U.S. Department of the Interior. If a previously undiscovered site is revealed during the course of construction, the official in charge should halt construction and request an on-site assessment by the IAS. The IAS will respond within 48 hours with a professional assessment of the significance of the site. In consultation with agency officials, the IAS representative makes an on-site decision for (a) salvage, (b) burial, or (c) destruction of the site. The main office of IAS can be contacted at (202) 272-3750. For more information, see 36 CFR 66.

<u>SCHEDULE</u>: Completion of a Class III archaeological survey usually requires two to four weeks, depending upon the size of the area and availability of archaeologists. Review by the BIA usually involves four to six weeks. In cases where significant archaeological features have been identified that may be eligible for inclusion on the National Register of Historic Places, an extended review period should be expected.

ACTIVITY: CONTRACT FOR WATER SERVICE

LEGAL CITATION: Reclamation Project Act of 1939

AGENCY/CONTACT: Bureau of Reclamation
Upper Colorado Regional Office
P.O. Box 11568
Salt Lake City, UT 84147
ATTN: Clifford Barrett
Regional Director
Terry Moore, Economist (801) 524-5452

PROCEDURE: A contract is initiated by sending a letter to the Regional Director, Clifford Barrett, which should include the following information:

(1) Description of the type of water use.

(2) Quantity of water needed.

(3) Schedule of the Project (i.e., date when water will be needed and duration of water use).

(4) Status of compliance with the National Environmental Policy Act.

(5) Evidence that an application for a Permit for Point of Diversion has been filed with the New Mexico State Engineer.

(6) A map showing the location of the point of diversion and point of use.

(7) Application fee of $300.

SPECIAL CONSIDERATIONS: A Point of Diversion Permit from the New Mexico State Engineer must be obtained in conjunction with contract approval by the Bureau of Reclamation.

Authorization of the Navajo Tribe Division of Water Resources may also be required for the diversion of water from the San Juan River. Approval of the Bureau of Reclamation contract will authorize release of water from the Navajo Reservoir for use downstream at Shiprock.

SCHEDULE: Processing for a temporary use contract usually requires approximately 90 days.

ACTIVITY: PERMIT FOR POINT OF DIVERSION FOR CONTRACT WATER

LEGAL CITATION: NMSA, 1978, 72-5, Appropriation and Use of Surface Water

AGENCY/CONTACT: Office of State Engineer, District One
Water Resources Division
New Mexico Natural Resources Department
2340 Menaul Blvd., N.E.
Albuquerque, NM 87107
ATTN: Charles Wohlenberg (505) 841-6323
Basin Supervisor
Bob Rogers (505) 827-6120
Engineer (Santa Fe)

PROCEDURE: The application should include the following information:

(1) Name and address of applicant.

(2) Quantity of water to be diverted.

(3) Name of the person/agency selling the water (Bureau of Reclamation).

(4) Period of use.

(5) Location of point of diversion.

(6) Type of diversion.

(7) Description of the intended use.

(8) Place of use described by legal subdivision.

SPECIAL CONSIDERATIONS: This permit should be obtained in conjunction with a "Contract for Water Service" issued by the Bureau of Reclamation. Together, the permit and contract will authorize diversion of water from the San Juan River for use during the remedial action.

SCHEDULE: The normal processing time is 45 days. This includes publication of a notice in a local newspaper for three consecutive weeks and a 10-day comment period after publication.

ACTIVITY: APPROVAL OF DRILL HOLE OR MONITOR WELL PLUGGING

LEGAL CITATION: NMSA, 1978, 6a-3-6, "Rules and Regulations Governing the Drilling of Wells and Appropriation and Use of Ground Water in New Mexico, 1966"; "Procedures for Plugging and Reporting of Drill Holes in San Juan Structural Basin, May, 1971."

AGENCY/CONTACT: Office of State Engineer, District One
Water Resources Division
New Mexico Natural Resources Department
2340 Menaul Blvd., N.E.
Albuquerque, NM 87107
ATTN: Charles Wohlenberg (505) 841-6323
Basin Supervisor
Bob Rogers (505) 827-6120
Engineer (Santa Fe)

PROCEDURE: When drill holes or monitor wells are to be abandoned, they should be plugged with cement (neat cement slurry, not less than 15 lbs. per gallon), or if drilling fluids are used, they should meet the following minimum specifications:

(1) Ten-minute gel strength of at least 20 lbs/100 sq ft.

(2) Filtrate volume not to exceed 13.5 cc as determined in accordance with RP 13-B, Sections 2 and 3, (low temperature test), "Standard Procedure for Testing Drilling Fluids," Third Edition, February, 1971, American Petroleum Institute.

The hole must be filled from total depth to the land surface with appropriate drilling fluids or cement.

Upon completion of proper hole abandonment, a report shall be filed with the Office of State Engineer. In lieu of direct supervision of the plugging of drill holes by State Engineer Office personnel, the State Engineer ay designate a person who is an employee of the person, firm, or corporation for which the drilling is done, and whose qualifications for such designation are acceptable to the State Engineer.

The report should include a copy of the drill hole log(s) or well log(s).

SPECIAL CONSIDERATIONS: Drill hole abandonment procedures are applicable to any hole in the San Juan Basin with a total depth of more than 10 feet and which has encountered ground water or a water-bearing formation.

SCHEDULE: A report of the plugging procedures should be filed within 90 days of hole abandonment.

ACTIVITY: NOTICE OF INTENT TO DISCHARGE

LEGAL CITATION: New Mexico Water Quality Act, 74-6-1 through 74-6-13, NMSA, 1978. Water Quality Control Commission Regulations, Parts 1 and 3.

AGENCY/CONTACT: New Mexico Health and Environment Department
Environmental Improvement Division (EID)
Ground Water and Hazardous Waste Bureau
Ground Water Section
P.O. Box 968
Santa Fe, NM 87503
ATTN: Maxine Goad, Program Manager (505) 984-0020
Dave Boyer Ext. 281
Water Resource Specialist

PROCEDURE: Any person intending to make a new water contaminant discharge or to alter the character or location of an existing water contaminant discharge shall file a notice with the Water Pollution Control Bureau. Notices shall state:

(1) The name and address of the person making the discharge.

(2) The location of the discharge.

(3) An estimate of the concentration of water contaminants in the discharge.

(4) The quantity of the discharge.

The Bureau evaluates the notice and determines within 60 days whether a ground-water discharge plan will be required. Discharge plans are required for all projects which may cause a discharge to ground water. Approval of a Discharge Plan by the Bureau is required prior to initiating or altering a discharge.

A Discharge Plan is required to contain the following information:

(1) Quantity, quality, and flow characteristics of the discharge.

(2) Location of the discharge and of any bodies of water, water courses, and ground-water discharge sites within one mile of the outside perimeter of the discharge site, and existing or proposed wells to be used for monitoring.

(3) Depth to and total dissolved solids (TDS) concentration of the ground water most likely to be affected by the discharge.

(4) Flooding potential of the site.

(5) Location and design of site(s) and method(s) to be available for sampling, and for measurement or calculation of flow.

(6) Depth to and lithological description of rock at base of alluvium below the discharge site if such information is available.

(7) Any additional information that may be necessary to demonstrate that approval of the discharge plan will not result in concentrations in excess of New Mexico Human Health Standards for ground water or the presence of any toxic pollutant at any place of withdrawal of water for present or reasonably foreseeable future use. Detailed information on site geologic and hydrologic conditions may be required for a technical evaluation of the applicant's proposed discharge plan.

SPECIAL CONSIDERATIONS: The Bureau may require ground-water monitoring including:

(1) Monitoring in the vadose zone.

(2) Continuation of monitoring after cessation of operations.

(3) Submission of reports to the Bureau detailing results of monitoring.

(4) Procedures for detecting failure of the discharge system.

(5) Contingency plans to cope with failure of the discharge plan or system.

(6) Measures to prevent ground-water contamination after the cessation of operation, including post-operational monitoring.

Design and specifications of surface runoff control facilities, waste-water reservoirs, and sewage storage/treatment facilities are subject to ground-water discharge notification requirements. Submittal of conceptual design calculations for EID review will expedite compliance with these requirements.

The New Mexico Human Health Standards for ground water are found in the New Mexico Water Quality Control Commission Regulations as amended November 17, 1983, Part 3-103A.

SCHEDULE: The Bureau determines whether a Discharge Plan is required within 60 days of filing. If a Discharge Plan is required, two to three months additional review time is usually required.

ACTIVITY: AIR QUALITY CONSTRUCTION PERMIT

LEGAL CITATION: New Mexico Air Quality Control Act, 74-2-1 through 74-2-17, NMSA, 1978, as amended 1981. Air Quality Control Regulation 702, "Permits."

AGENCY/CONTACT: New Mexico Health and Environment Department
Environmental Improvement Division
Air Quality Bureau
P.O. Box 968
Santa Fe, NM 87503
ATTN: David Duran, Program Manager
Stationary Source Section
A. S. Shankar, Supervisor
New Source Review Unit (505) 984-0020 Ext. 357

PROCEDURE: A permit application and certificate of registration are filed with the Air Quality Bureau. Information that is needed includes the following:

(1) Name and address of applicant.

(2) Address and location of facility.

(3) U.S. Geological Survey (USGS) quadrangle map showing the location of the facility.

(4) A brief description of the facility and related activities.

(5) Construction schedule.

(6) Inventory of fuel usage.

(7) Inventory of materials processed or handled.

(8) Inventory of air emissions.

(9) List of hazardous or toxic materials that will be emitted or handled.

SPECIAL CONSIDERATIONS: Any proposed new or modified facility that has uncontrolled emissions greater than either 10 pounds per hour or 25 tons per year is required to obtain a construction permit. Emission estimates should be based on emission factors from:

Fugitive Dust Emissions Memorandum
Colorado Department of Health
Air Pollution Control Division
Tom Tistinic September 30, 1981

-OR-

Supplement No. 14 for Compilation of Air Pollutant Emission Factors, Third Edition, May, 1983. U.S. Environmental Protection Agency, AP-42, Supplement 14.

The Air Quality Bureau uses the PAL, CDM, or ISC computer dispersion model to predict the concentrations of contaminants at the Project boundary. If TSP concentrations (predicted by modeling and ambient) are less than 150 micrograms/m^3, then no fugitive dust controls would be required. Water spray and surfactant spray are commonly used to control fugitive dust emissions.

Computer modeling of the projected impacts of the proposed remedial action was completed during preparation of the Environmental Assessment using the ISCST model. Realizing that some differences in air emissions estimates may develop between the concept design and final design, the RAC should discuss with the Bureau the need for further modeling.

SCHEDULE: Applications should be filed with the Bureau a minimum of 60 days prior to commencement of construction. The Bureau determines the completeness of the application within 15 days. A newspaper notice is published followed by a 15-day comment period. The Bureau either grants or denies the permit within 30 days after the application is ruled complete.

ACTIVITY: APPROVAL OF BORROW SITE EXCAVATIONS

LEGAL CITATION: General Surface Restoration Requirements for Sand and Gravel Operations, Navajo Environmental Protection Commission.

AGENCY/CONTACT: Navajo Environmental Protection Administration
Navajo Nation
Window Rock, AZ 86515
ATTN: Louise A. Linkin
Executive Director
Tommy K. Begay, Jr. (602) 871-4941
Environmental Specialist Ext. 1534

PROCEDURE: The plans for borrow material excavations should be outlined in a letter that is sent to the Administration for approval. The plans should comply with the following specifications:

(1) Haul Roads

- Existing haul roads shall be used whenever possible.

- Roads proposed for construction shall not exceed a grade of 8 percent, except for pit ramps which should not exceed a 10 percent grade.

- Other design specifications should comply with Figure 6 of "General Surface Restoration Requirements for Sand and Gravel Operations," Navajo Environmental Protection Commission, June 26, 1980.

- Proposed roads should be no wider than is necessary for the safe operation of equipment.

- Roads that cross dry creeks or arroyos should provide adequate through-drainage either by ramping the road down to the base of the channel or by installing a suitable culvert if the channel will be filled.

- Roads should be designed with the consideration that most will be closed and rehabilitated following completion of the project. Rehabilitation should consist of replacement of stockpiled soil, scarifying of compacted surfaces, and construction of water bars. All disturbed areas should be revegetated if practical.

(2) Borrow Pit Closure and Rehabilitation

- All excavations should be backfilled and recontoured to blend with the surrounding terrain. The site should be restored as nearly as practical to its original condition.

- The disturbed sites should be prepared to provide a seedbed for re-establishment of desirable vegetation and reshaped to blend with the natural contour. Such practices may include contouring, terracing, gouging, scarifying, mulching, fertilizing, seeding, and planting.

(3) Abandonment and Rehabilitation Reports

- Upon completion of required grading and backfilling, the lessee shall make a report to the Administration and request inspection for approval.

- The lessee shall file reports with the Administration when planting is completed. Quarterly reports of reclamation activities are also required.

SPECIAL CONSIDERATIONS: Borrow material excavation requires (1) a lease from the Navajo Land Development Office, (2) approval of the Navajo Environmental Protection Administration, and (3) a Sand and Gravel/Borrow Permit from the Bureau of Indian Affairs, Branch of Real Property Management. Consent of grazing allottees must be obtained prior to approval by the Administration.

SCHEDULE: Review by the Administration can require several weeks to several months, depending upon the complexity of the operation.

ACTIVITY: WATER USE PERMIT

LEGAL CITATION: Navajo Tribal Code

AGENCY/CONTACT: Water Management Department
Division of Water Resources
Navajo Nation
P.O. Box 308
Window Rock, AZ 86515
ATTN: Masud Uz Zaman, Director (602) 729-5281
Steve Bernath

PROCEDURE: The Water Management Department issues water use permits on behalf of the Navajo Tribe in the form of a "Standard Water Purchase Contract." A permit application is initiated by sending a letter and completed draft contract to the Department. The letter should contain the following information:

(1) A description of the proposed use of the water.

(2) The length of time water will be needed.

(3) A schedule of anticipated rates of use for peak, low, and average demand.

(4) A schedule of anticipated rates of overall amount of water required.

(5) The proposed source of water.

(6) The quality of water that is required.

The Water Management Department analyzes the availability of water, existing water quality, and alternative sources and determines whether they will grant tentative approval. Concurrences from other tribal agencies are obtained and the contract is forwarded to the Council Chairman for final approval.

Enforcement of water contracts is the responsibility of the Operations and Maintenance Department of the Water Resources Division.

SPECIAL CONSIDERATIONS: Of the two water sources available for the remedial action, use of water from the artesian well (No. 12T300) near the fairgrounds will be more easily acquired than water from the San Juan River. Obtaining water from the artesian well is subject only to a Standard Water Purchase Contract from the Navajo Tribe. In contrast, diverting water from the San Juan River would require:

(1) A contract to purchase water from the Bureau of Reclamation.

(2) A permit for Point of Diversion from the New Mexico State Engineer's Office.

(3) Possible approval of the Water Management Department of the Navajo Tribe.

Water rights of the San Juan River are being adjudicated in Federal Court, which has resulted in the boundaries of regulatory jurisdiction being unclear for the present time.

A cost of $2.40 per 1,000 gallons of water is the standard charge in tribal water contracts.

SCHEDULE: Approval of a water contract usually requires four to eight weeks of review prior to final approval.

APPENDIX B

GEOMORPHIC STABILITY

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B.1 INTRODUCTION

The Shiprock tailings pile is bounded on the north-northeast side by a 70-foot-high escarpment that extends to the current floodplain of the San Juan River. Although not subject to flooding, the tailings are close to the edge of the escarpment. Therefore, the evaluation of possible long-term bank recession and subsequent encroachment of the San Juan River into the immediate site area over the 1000-year stabilization design life is of major significance.

B.1.1 PROBLEM STATEMENT

The purpose of this evaluation was to discuss and analyze the possible effects of river migration and slope recession on the proposed stabilization in place conceptual design. The following items were addressed:

- o Encroachment toward the site by the San Juan River.
- o Slope recession due to mass wasting.
- o Site protection from slope attack and recession.

B.1.2 METHODS OF CALCULATION

The following calculations and evaluations were performed:

- o A review of existing data and historical aerial photos and a site visit were performed (SHB, 1983) to identify active areas of slope recession and river attack that could impact upon the tailings embankment.

- o Flooding information for the San Juan River was reviewed with regard to stage and discharge.

- o Predictions of slope recession due to mass wasting were made combining values reported in various references pertinent to western arid slopes with site observations.

- o Predictions of slope recession due to attack by San Juan River flows are based on changes noted on the historical aerial photos, slope conditions noted in the field, and estimates of time that the escarpment will be under attack.

B.2 CONCLUSIONS

The slope forming the escarpment will experience gradual recession due to mass wasting and localized erosion. If this slope is undisturbed at the base by river attack, the final slope will have an angle of about 32° from the horizontal. It will probably take much longer than 1000 years for this to be completed.

The river will most likely attack the base of the escarpment adjacent to the pile at some time in the future even though such attack is not now occurring. The duration of attack in the next 1000 years is difficult to evaluate, but for design purposes, a range of 50 to 100 percent of the total time is recommended.

It is not possible to assign a definitive number to the magnitude of total slope recession expected in the next 1000 years due to mass wasting and river attack. However, reasonable estimates can be made based on the following:

- Assuming the San Juan River does not attack the base of the escarpment during the design life of the embankment, a process of normal slope recession would reduce the current slope angle to an extremely stable, gravel-armored slope at an angle of about 32 to 35 degrees. In the area of the embankment, this distance would not exceed about 120 feet and would probably not be completed within the next 1000 years.

- Actual river change over the past 48 years indicates the rate of cliff retreat due to direct river attack ranges between 0.083 and 0.146 feet/year (83 to 146 ft/1,000 yrs). If the direct attack condition exists as much as 50 percent of the time over the next 1000 years, the river would erode the cliff in the area of the embankment from a minimum of 41 feet to a maximum of 73 feet. If the direct attack condition persisted 100 percent of the time, an unlikely worst case, the river would erode the cliff from 83 to 146 feet in the same 1000-year period.

- Combining the erosional effects of direct attack by the river 50 percent of the time and normal slope recession, a setback of 193 feet (73 + 120) would be needed to prevent encroachment into the embankment area. If the 100 percent attack worst case set of conditions is calculated, a maximum cliff retreat rate of 0.146 feet/year would be applied and the total maximum setback requirements would then be about 270 feet (150 + 120).

The top edge of the escarpment is susceptible to localized erosion during runoff events.

The elevation of the pile with respect to the river channel precludes inundation from a Probable Maximum Flood event.

REFERENCES

SHB (Sergent, Hauskins, and Beckwith), 1983. "Site Erosion Evaluation Report, Shiprock Site, UMTRAP," Albuquerque, New Mexico.

APPENDIX C

RADIOLOGICAL SUPPORT PLAN

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C.1 INTRODUCTION

The Uranium Mill Tailings Radiation Control Act of 1978 (PL95-604) gave the responsibility of developing standards for remedial actions to the Environmental Protection Agency (EPA). Section 108 of PL95-604 states that the DOE shall "select and perform remedial actions at designated processing sites and disposal sites in accordance with the general standards" prescribed by the EPA. The EPA standards state:

> "Section 108 of the Act requires the Secretary of Energy to select and perform remedial actions with the concurrence of the Nuclear Regulatory Commission and the full participation of any State that pays part of the cost, and in consultation, as appropriate, with affected Indian Tribes and the Secretary of the Interior. These parties, in their respective roles under Section 108, are referred to hereafter as 'the implementing agencies.'
>
> The implementing agencies shall establish methods and procedures to provide 'reasonable assurance' that the provisions of Subparts A and B are satisfied. This should be done primarily through use of analytical models, in the case of Subpart A, and for Subpart B through measurements performed within the accuracy of currently available types of field and sampling procedures. These methods and procedures may be varied to suit conditions at specific sites."

Subpart B consists of standards for cleanup of land and buildings. Presently, there are six buildings in use on the site with only one requiring limited decontamination. The standards applicable to the project are:

> "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 microR/h."

In addition to the EPA standards for buildings, removable surface alpha contamination shall not exceed 1000 dpm/100 cm^2 (dpm = disintegrations per minute), and total non-removable alpha contamination shall not exceed 5000 dpm/100 cm^2. This limit will ensure that potential airborne radionuclide concentrations will not exceed 10 CFR 20 Appendix B standards and that physical contact with the surfaces by occupants of the structures will not result in a measurable radiation exposure.

As indicated earlier, the standards suggest that the implementing agencies determine what methods and procedures will be used to provide "reasonable assurance" that the standards are met. Reasonable assurance implies that a site-specific analysis is appropriate where the cost of demonstrating compliance with the standards is to be weighed against the health risks or other impacts associated with leaving areas which slightly exceed the standards.

The sections which follow provide the procedures proposed for use at the Shiprock site. Consideration was given to the time required to collect samples and perform the analyses.

C.2 BASIS FOR RADIOLOGICAL SURVEY STRATEGY

The Shiprock site consists of a tailings pile, windblown areas, and other areas contaminated due to the loss of containment in the raffinate pond and tailings pile during mill operations. These other areas are located in an arroyo to the west of the site and on the river floodplain to the north. Excavation to remove the contaminated material from the disturbed site areas near the pile as well as for moving the tailings pile away from the edge of the escarpment will require removal of soil to a depth of several feet below grade. Disturbed site areas will be partially restored to a grade that will control the drainage around the pile and away from the river. The fill material will be uncontaminated and will minimize the potential health effects due to residual contamination.

The windblown, arroyo, and river floodplain areas will be decontaminated by removing the layer of tailings or contaminated soil from the surface. Uncontaminated fill will be placed in decontaminated areas where required.

C.3 REMEDIAL ACTION RADIOLOGICAL SURVEY PLAN

Radiological surveys are performed for three purposes: site characterization, excavation control, and final radiological verification. Site characterization surveys or pre-remedial action surveys are performed to identify volumes of material which exceed the standard. The results are used for planning and engineering design. Excavation control monitoring is performed as the work is being done to guide and control the amount of contaminated material removed. Finally, when excavation control monitoring results indicate that there is a high probability that the area meets the standards, a final radiological survey is carefully performed and the results documented.

C.3.1 SITE CHARACTERIZATION SURVEYS

Radiological surveys have been performed by Bendix Field Engineering Corporation to identify the subsurface boundary of the tailings pile to be excavated as well as the depth and area of windblown tailings on adjacent land. Subsurface evaluations were performed using gamma well logging techniques and by analyzing cores from boreholes. In general, these measurements were made on a 200-foot grid. Additional measurements were performed in areas of radiological interest. The grid points have been identified by a land survey tied to a USGS survey point and all recordable data located by these coordinates.

Radiological surveys performed by Bendix Field Engineering Corporation inside the buildings to determine gamma exposure rates, and the levels and extent of surface contamination have identified two buildings with need for decontamination. These are the old mill shop which is presently being used for long-term storage of NECA equipment, and a very old metal storage shed at the eastern edge of the building complex. The shop will be decontaminated for unrestricted use, while the metal shed will be demolished, with rubble buried along with the tailings material.

C.3.2 EXCAVATION CONTROL MONITORING

Elevated gamma-ray radiation fields will preclude exclusive use of in-situ monitoring devices to estimate the surface radionuclide concentrations in soil on or immediately adjacent to the Shiprock pile. When in-situ measurements cannot be performed, the suggested method for analysis is to take individual or composite samples of soil, seal by canning, and immediately count the sample by gamma-ray spectrometry. Errors associated with this approach will be reduced by taking several samples 30 days prior to starting work to determine calibration factors. These samples will be counted, dried, pulverized, and screened with recanning for subsequent analysis. They will be counted later after the Ra-226 daughters reach equilibrium. Analyses of these prepared samples can then be compared to standards. Several samples will be collected weekly during the remedial action and analyzed to provide a measure of the variation of the calibration factor.

The following text describes procedures to be followed for excavation control monitoring both beneath the tailings pile and in windblown areas.

a. Excavation control monitoring for the areas where gamma-ray exposure ates exceed 20 microR/h

The area to be monitored will be divided by 50-foot grids. Each 50-by-50-foot square will be subdivided into quadrants (visually) by the technicians and four composite samples, each made up of at least four equally spaced samples from each quadrant, will be canned and analyzed. Additional biased sampling may be done where warranted. The standard calls for cleanup to 15 pCi/g in any 15-cm layer for soils 15 cm or more below the surface. Samples will be taken at the exposed surface without concern for the sample depth, other than that they will be less than or equal to 15 cm in depth. Quadrants with composite samples exceeding the 15 pCi/g limit will be clearly marked. Two or more contiguous quadrants which exceed the standard will require further excavation and resampling. An isolated quadrant exceeding the standard will require further remedial action only if the average concentration exceeds 25 pCi/g or if it is practical to remove the additional contamination.

b. Excavation control monitoring for low gamma-ray exposure rate background areas

If the exposure rates in the area to be monitored are less than 20 microR/h, then the area will be divided by 50-foot grids. Each 50- by 50-foot square will be scanned using a properly calibrated hand-held scintillometer (or equivalent) capable of detecting 2 microR/h above background. The scanning shall be done by holding the instrument at approximately three feet above the soils surface and slowly walking lines on approximately 10-foot centers. A site-specific correlation between exposure rate and soil concentration will be performed prior to beginning excavation. The resultant conversion factor will be applied to the exposure rates. Excavation should continue until each 50- by 50-foot square averages less than 5 pCi/g above background for surface excavation or 15 pCi/g above background for deep excavations where backfilling with uncontaminated material is planned. The maximum and minimum values of exposure rates shall be recorded for each 50- by 50-foot parcel. The site-specific correlation between exposure rate and soil concentration will be checked weekly throughout the remedial action.

C.3.3 BUILDING DECONTAMINATION CONTROL MONITORING

In areas of known contamination, as determined by the site characterization surveys, measurements will be performed after each decontamination effort to assess the effectiveness of the effort. For potentially contaminated areas, measurements will be made at a minimum of either 100 percent of the area or at approximately 30 locations for surface areas of less than 500 square feet. In addition, biased measurements will be made in previously contaminated areas or other areas having a high probability of being contaminated.

C.3.4 FINAL RADIOLOGICAL VERIFICATION SURVEY FOR LAND

The final radiological survey will employ a single sampling strategy regardless of the potential for future development. The area to be surveyed will be divided by 10-foot grids. Eleven contiguous 10- by 10-foot grid blocks (approximately 100 square meters total) will be declared a unit parcel. A composite sample for each unit parcel will be constructed by taking 15-cm-deep samples of approximately equal mass at each grid point (19 to 24 samples, depending on the shape of the unit parcel). This sample will be prepared and analyzed for Ra-226 content. Analytical results less than or equal to 5 (surface) or 15 (subsurface) pCi/g above natural background will qualify the unit parcel as decontaminated property. Error limits for measurements must be better than plus-or-minus 30 percent, at the 95 percent confidence level. In selecting the 11 contiguous grid blocks for averaging, an attempt will be made to select areas expected to provide the highest 100-square-meter average. Additional excavation will be required if the results show that contamination in excess of the standard is still present.

If an area to be surveyed is less than that specified above, a minimum of ten, 15-cm-deep samples will be used to make up the composite sample.

Samples taken in the field for analysis will be prepared and analyzed prior to backfilling. The samples will be prepared for laboratory analysis by gamma-ray spectrometry.

C.3.5 FINAL RADIOLOGICAL VERIFICATION SURVEY FOR BUILDINGS

Gamma surveys will be conducted using an instrument capable of detecting 2 microR/h above background. Buildings will be scanned while holding the instrument at three feet above the floor. Maximum, minimum, and average exposure rates will be recorded for each room of the buildings. All areas where the exposure rates exceed 20 microR/h above background will be noted.

Alpha detection instruments will be used to monitor surface contamination. A grid system will be constructed for each room of a structure which has been decontaminated. The grid size will be adjusted such that a minimum of 30 grid points will be defined by using grid lines not more than 30 feet nor less than three feet apart. Measurements will be made at each grid point and other areas of special radiological interest such as floor drains or areas that were the most highly contaminated. Contamination may be averaged over a 10-square-foot area and compared with the allowable limits, as provided in Section C.1. In cases where the total contamination is greater than the limits for removal, measurements for assessing the removable contamination levels will be made.

Radon daughter concentration (RDC) measurements will be conducted in areas of the building where previous data indicate elevated radon daughter concentrations. An annual average radon daughter concentration will be determined for all structures to assure that they meet the standard.

C.4 DATA AND SAMPLE MANAGEMENT

During the cleanup operations, the Remedial Action Contractor will collect data to support excavation control. Data used in declaring an area adequately decontaminated will be documented in a format approved by the Uranium Mill Tailings Remedial Action (UMTRA) Project Office.

Site characterization survey data, excavation control data, and the final radiological survey data will be collected using procedures and analytical methods meeting the requirements of the UMTRA Quality Assurance Program Plan (UMTRA-DOE/AL-400325). All data used in describing the final radiological condition of the site as well as other data as specified by the UMTRA Project Office will be provided in a convenient format for input into the UMTRA Project Data Management System. Data generated in the remedial action will be presented in a report documenting the final radiological condition of the property.

C.5 CERTIFICATION

Certification is a professional judgement by an independent party that the remedial action has been completed according to the Remedial Action Plan and meets the applicable standards.

During the remedial action operations, the Remedial Action Contractor will make available to appropriate Navajo Nation, Federal agencies, or UMTRA Project-designated contractors, data related to the cleanup. In addition, samples collected during the cleanup operations may be split for analyses by these agencies to allow comparison of analytical results. These data, along with any additional data collected at the discretion of the certifying agent, will be used in the final certification report.

APPENDIX D

ENVIRONMENTAL, HEALTH, AND SAFETY PLAN

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D.1 HEALTH AND SAFETY STANDARDS

D.1.1 APPLICABLE REGULATIONS

The Remedial Action Contractor (RAC) shall comply with all applicable Federal and Tribal health and safety regulations and requirements including but not limited to those established pursuant to the Occupational Safety and Health Act (CSHA). Special attention should be given to the following OSHA and other Federal regulations.

1. 29 CFR Part 1910, "Occupational Safety and Health Standards."
2. 29 CFR Part 1926, "Safety and Health Regulations for Construction."
3. 49 CFR 172-174, "DOT Transportation of Hazardous Materials."
4. 10 CFR Part 20, "Standards for Protection Against Radiation" (as cited herein).
5. DOE Orders, as cited herein.

D.1.2 STANDARDS

The RAC shall comply with the radiation exposure standards in Tables D.1.1 and D.1.2, unless Tribal regulations take precedence. In all cases, exposure to workers and members of the public shall be as low as reasonably achievable.

Table D.1.1 Exposure of individuals and population groups in uncontrolled areas

	Annual dose equivalent or dose commitment (rem)[a]	
Type of exposure	Based on dose to points of maximum probable exposure (rem)	Based on average dose to a suitable sample of the exposed population (rem)
Whole body, gonads, or bone marrow	0.5	0.17
Other organs	1.5	0.5

[a]In keeping with Department of Energy policy on lowest practicable exposures, exposure to the public shall be limited to as small a fraction of the respective annual dose limits as is reasonably achievable. Dose commitment is defined as the dose equivalent (rem) received by specific organs during a period of one calendar year, that was the result of uptakes of radionuclides by a person exposed.

(From DOE Order 5480.1)

Table D.1.2 Occupational radiation exposure standards

Type of exposure	Exposure period	Dose equivalent (dose or dose commitment[a] rem)
Whole body, head and trunk, gonads, lens of the eye,[b] red bone marrow, active blood-forming organs.	Year Calendar Quarter	5 3
Unlimited areas of the skin (except hands and forearms), and organ systems (except bone)	Year Calendar Quarter	15 5
Bone	Year Calendar Quarter	30 10
Forearms	Year Calendar Quarter	30 10
Hands	Year Calendar Quarter	75 25

[a]To meet the above dose commitment standards, operations must be conducted in such a manner that it would be unlikely that an individual would assimilate in a critical organ, by inhalation, ingestion, or absorption, a quantity of radionuclide or mixture of radionuclides that would commit the individual to an organ dose that exceeds the limits specified in the above table. Dose commitment is defined as the dose equivalent (rem) received by specific organs during a period of one calendar year, that was the result of uptakes of radionuclides by a person occupationally exposed.

(From DOE Order 5480.1)

[b]A beta exposure below a maximum energy of 700 KeV will not penetrate to the lens of the eye; therefore, the applicable limit for these energies would be that for the skin (15 rem/year).

D.2 PROGRAM REQUIREMENTS

D.2.1 ORGANIZATION AND STAFFING

The Remedial Action Contractor (RAC) shall have, on the site, a qualified individual responsible for health and safety of the workers and public. This individual must be provided properly trained staff and adequate equipment to ensure that the work is done safely. The equipment, number of staff, and staff qualifications shall be commensurate with the scope of construction activities.

The person responsible for health and safety must have adequate access to higher management, independent of construction operations management, to ensure that health and safety concerns are considered.

D.2.2 OPERATING PROCEDURES

Operating procedures shall be developed and documented for all activities where there is a significant safety or health risk and for activities necessary to quantitatively assess radiological or industrial hygiene hazards. Examples are dosimetry issuance and control, air sampling and analysis, and control of personnel access.

D.2.3 WORKER TRAINING

A formal training program, including a discussion of the biological effects from exposure to radiation, shall be provided to all site workers. The program should be of sufficient duration to include discussions of industrial and radiological safety procedures, emergency procedures, and instructions concerning prenatal radiation exposure. Practical demonstrations should be given, when appropriate. Each worker shall pass a written or oral examination with the results documented. The instructor should have available for distribution literature on the biological effects of radiation. The instructor should also provide each worker with the information contained in USNRC Reg. Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure." Initial training sessions will require approximately two hours. Subsequent training sessions will be scheduled at a frequency that ensures continuous health and safety protection for the workers.

D.2.4 RECORDS AND REPORTING REQUIREMENTS

The RAC shall notify the UMTRA Project Manager and the Environment, Safety, and Health Division of any fatality or serious accident as required by DOE and AL Orders 5484.1, "Environmental Protection Safety, Health Protection Information Reporting Requirements." Fatal accidents will be investigated by the state, Federal, or local office having health and safety responsibilities.

A work-related radiation exposure history shall be maintained as required. New employees will complete a radiation exposure history form, and results of bioassays taken at termination shall be obtained from the last employer where exposure to radiation occurred. If previous bioassay information is not available, consideration should be given to providing a whole-body count or other appropriate bioassay prior to permitting the employee to do radiation-related work.

The RAC shall be responsible for posting the OSHA applicability and employee reporting instructions, DOE Form F-5480.1. The RAC shall also be responsible for recording and reporting illnesses and injuries in accordance with OSHA requirements. Copies of these reports shall be forwarded to the UMTRA Project Manager. Recordable occupational accidents and illnesses are those defined in the Occupational Safety and Health Act of 1970, and set forth by the Occupational Safety and Health Administration in 29 CFR 1904.12(c), (d), (e), (f), and applicable part of 1904.12(g).

The RAC shall be responsible for maintaining records of employees' exposures to radioactive or toxic materials or other harmful physical agents. Department of Energy (DOE) Form 5484.8, "Termination Occupation Exposure Report," shall be forwarded to the Contracting Officer's Representative (COR) within 30 days of termination of employment, or within 30 days of the determination of exposure in accordance with Annex A of DOE Order AL-5484.1. Forms 5484.6, "Annual Summary of Whole Body Exposures to Ionizing Radiation," and 5484.7, "Summary of Exposure Resulting in the Internal Body Depositions of Radioactive Materials for CY--," shall be forwarded to the COR by March 15 of each year for the preceding calendar year, in accordance with Annex A of DOE Order AL-5484.1. In addition, all radiation exposure records or a copy of all radiation exposure records will be transferred to DOE upon employee termination or completion of the contract.

The RAC shall notify the UMTRA Project Manager of any unusual occurrence. An "unusual occurrence" is any unusual or unplanned event having programmatic significance such that it adversely affects or potentially affects the integrity of the site or the performance, reliability, or safety of the UMTRA Project. Examples of unusual occurrences are:

- Overflow of an evaporation pond.
- Tailings release into a stream or river.
- Tailings release beyond the site boundary.
- Tailings spill associated with a trucking accident.
- Any major fire or explosion on the site.
- Site flooding.
- Breach of access by unauthorized personnel.
- Acts of vandalism or major theft occurring at the site.
- Any occurrence which could adversely affect the environment or the health and safety of the populace.

The RAC shall submit DOE Form 5484.3, "Supplementary Record of Occupational Injury/Illness," 5484.5, "Property Damage," or SF91-A, "Investigation Report of Motor Vehicle Accident," to the UMTRA Project Manager for each property damage incident involving more than $1000 government loss and for each motor vehicle accident involving more than $250 government loss.

A central file of all enforcement inspections and reports along with violations and abatement actions shall be maintained by the RAC for inspection by the DOE.

A central file will be maintained by the COR, and by contractors, of formal employee health and safety complaints and their disposition. Upon request, these shall be made available for inspection by affected employees or their authorized representatives.

D.2.5 COMPLAINTS

Employees shall be encouraged to report to the contractor, either directly or through their authorized employee representative, any conditions or practices which they consider detrimental to their health or safety or which they believe are in violation of applicable health and safety standards. Such complaints may be made orally or in writing.

Any employee or representative of employees who believes that a condition or practice threatens physical harm or violates health or safety standards, may request an inspection by filing a complaint directly with the local agency having health and safety responsibility.

Any employee or authorized representative of employees who believes that an imminent danger exists that threatens death or serious physical harm, is encouraged to bring this matter to the immediate attention of the appropriate contractor, supervisor, or designated official for resolution. In the event of inadequate corrective action, the employee and/or authorized representative may also contact the local agency having jurisdiction and/or the DOE UMTRA Project Office in Albuquerque (by telephone) and set forth with reasonable particularity the basis for his/her request for an immediate inspection.

DOE, upon receipt of a complaint of inaction concerning alleged imminent danger, or upon receipt of notice of imminent danger, will immediately ascertain whether there is a reasonable basis for the allegation. If it appears to have merit, DOE will dispatch an inspector to the workplace involved. When an immediate inspection cannot be made, DOE will contact the contractor immediately, gather the pertinent details concerning the situation, and if necessary, have affected employees removed from the danger area. DOE will ascertain what steps, if any, the contractor intends to initiate in order to eliminate the danger. DOE will conduct appropriate follow-up activities.

D.2.6 POSTING

Each contractor shall post DOE Form F-5480.1, "Occupational Safety and Health Protection," a poster outlining contractor responsibilities to provide safety and health protection. Each contractor shall also have available in the workplace DOE Form 5480.4, "Occupational Safety or Health Complaint," a form to be used in reporting violations.

The forms required to be posted by this part shall be posted in a sufficient number of places to permit employees working in, or frequenting any portion of, the workplace to observe a copy on the way to or from their workplace.

D.2.7 INTERNAL AUDIT PROGRAM

An internal audit committee made up of the RAC's health and safety manager and others as appropriate shall be established to periodically review the operations and safety-related procedures. A documented report of this review, recommendations, and follow-up actions shall be maintained by the RAC and available for review by DOE.

D.2.8 RESTRICTIONS

An individual under age 18 shall neither be employed in, nor allowed to enter restricted areas where he or she will receive doses of radiation in amounts exceeding one-tenth the standards in Table D.1.2.

All women working in jobs involving possible radiation exposure shall be advised of NCRP Report 39 recommendations, indicating that the intent of the recommendation is to minimize exposure to embryos and fetuses. All such women workers shall be advised of the biological risks to embryos and fetuses exposed to the various expected levels of ionizing radiation; and shall be made aware that specific efforts and attention should be taken to keep radiation exposure of an embryo or fetus to the very lowest practicable level during the gestation period.

Administrative limits shall be used to assure that workers do not exceed the quarterly or annual limits specified in Table D.1.2. Workers who have exceeded administrative limits or standards shall be placed on work restriction until the end of the period of concern.

D.2.9 QUALITY ASSURANCE

Field radiological measurements, sample collection, and sample analyses shall be performed using procedures and methods meeting the requirements of the UMTRA Project Quality Assurance Program Plan. Quality assurance procedures and record-keeping methods must be submitted to the DOE/UMTRA Project Office for approval prior to beginning remedial actions.

Proof of calibration must be available for all laboratory radiation detection instrumentation, and field instruments must be calibrated a minimum of once each year, or more frequently, if recommended by the manufacturer. Prior to each work shift, proper response of field instruments will be ensured using check sources.

Appropriate training must be completed and documented for all personnel involved in sample collection or operation of radiation detection instruments. All records of calibration, training, sample collection, field measurements, and laboratory analyses must be maintained in a clear and concise manner. Records must be checked for accuracy and made available for auditor inspection at any time during the remedial action.

The DOE/UMTRA Project Office, and/or the TAC will conduct periodic surveys during the remedial action to ensure compliance with the Quality Assurance Program Plan.

D.3 CONTAMINATION MONITORING AND CONTROL

To prevent unnecessary spread of contamination, the following requirements are provided regarding the monitoring and control of contamination.

D.3.1 POSTING

Controlled areas shall be established to protect the workers and the general public from unnecessary radiation exposure, and to prevent the spread of radioactive contamination. Controlled areas include, but are not limited, to any work areas in which:

- o Significant portions of the exposed surface contamination exceed an average of 200 pCi/g of Ra-226.
- o The estimated external gamma dose to any individual in that work area exceeds 500 millirem/year.
- o Airborne concentrations of radionuclides exceed quantities provided in DOF Order 5480.1A, Attachment II.
- o Transfer[illegible] surface contamination exceeds 1000 dpm/100cm.

Access to these areas shall be controlled for persons, vehicles, and equipment by fencing the area or using other methods to prevent inadvertent exposure to contaminated material.

Smoking, drinking, and eating are prohibited in controlled areas.

Controlled areas must be conspicuously marked at points of potential access with a sign or signs bearing the radiation caution symbol and the words

CAUTION
RADIOACTIVE MATERIAL

All other applicable posting and labeling requirements set forth in 10 CFR Part 20 must be followed.

D.3.2 ACCESS CONTROL

An access control point will be established and occupied by a health physics technician (hereafter referred to as "technician") during all normal periods of ingress or egress. The access control point will be the only point at which personnel or equipment may enter or leave the controlled areas of the site. Conditions under which personnel and equipment may enter or leave the controlled areas will be controlled by the technician occupying the access control point, under the direction of the site health physicist. Restrictions to be exercised at the access control point are described in the following text.

The technician manning the access control point will maintain a log of personnel and equipment entering and leaving the site. The access control log will function as a checklist at the end of each work shift to ensure that all contractor personnel are out of the controlled area before closing the access control point.

A log of personnel dosimeters assigned to contractor personnel at the site will be maintained by the technician. Dosimeters will be distributed to contractor personnel at the beginning of each work shift and collected at the end of each work shift. The technician will provide general instructions and precautions to personnel, and notify them of any changes in work restrictions which may occur as radiological monitoring data are collected.

A reference file on each contractor employee working at the site will be maintained by the technician. The employee file will serve as a record of each individual's compliance with requirements for working at the site, and exposure accumulated while at the site. The following information and documents will be kept in the file:

- Records of attendance at orientation and training sessions conducted by the health physics staff.
- Records of bioassay samples submitted by the employee and analytical results from the samples.
- Records of dosimeters provided to the employee, and exposure accumulations as indicated by reports from the dosimeter service.

In addition to maintaining complete and current records as specified in Section D.3.2, the technician occupying the access control point will ensure that contractor personnel are provided the appropriate protective clothing for the conditions present in the work environment. Protective clothing requirements will be determined by the site health physicist based upon results of instrument surveys and sample analyses performed in the work environment. Additional guidelines for clothing requirements are provided in Section D.3.6.

Personnel will be required to remove protective work clothing, such as coveralls and boot covers, before leaving the controlled area. The technician or workers will then survey their clothes and exposed skin surfaces for contamination using instrumentation and methods described in Section D.3.3. Persons with detectable surface contamination must undergo decontamination procedures as described in Section D.3.3 and be re-surveyed before leaving the controlled area.

All equipment that has been in contact with contaminated material must be surveyed at the access control point before leaving the controlled area. Equipment will be monitored for removable and fixed contamination, and will be evaluated in accordance with procedures and limits described in Section D.3.4. Heavy equipment which is found to be contaminated must be detoured to the decontamination pad, washed by contractor personnel, and re-surveyed by the access control technician.

D.3.3 PERSONNEL CONTAMINATION MONITORING

Removal of protective clothing at the access control point is expected to minimize potential surface contamination detected during alpha frisking surveys. However, personnel contamination may be detected occasionally and must be removed to prevent dispersal of radioactive material to uncontrolled areas, and to minimize exposure to subcontractor personnel. Therefore, employees leaving the controlled area must be monitored before leaving at the access control point. Procedures for monitoring personnel and removing surface contamination are provided in the following text.

a. Instrumentation

A hand-held pancake G-M probe or proportional counter with a thin window and large detector area is required for personnel monitoring. The window should be thin enough to permit detection of alpha particles having characteristic energies of 3 MeV or greater. The detector should be shielded to reduce sensitivity to background radiation and provide monodirectional detection characteristics. Some form of protection for the detector window should be provided to prevent damage while scanning rough objects such as clothes or equipment.

Alpha scintillation detectors shall be used for personnel monitoring. The detector should be connected to a ratemeter/scaler which has an audible and visual alarm with adjustable setting. An instrument with no alarm may be used if it has a speaker over which the count rate can be heard. A portable counter is not required since monitoring will be done at the entrance of the access control point, and AC power is expected to be available. A cable at least six feet long should be used to connect the detector to the counter so the motions of the surveyor will not be restricted.

b. Monitoring method

Due to the delicate nature of survey instruments and the importance of monitoring, the technician should assure that personnel are properly trained prior to monitoring themselves. Standard procedures for alpha frisking must be followed.

Tools and equipment carried off the site must also be surveyed according to recommendations in ANSI N13.12, "Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for uncontrolled Use."

c. Personnel monitoring procedures

In order to maintain personnel exposure to radiation as low as reasonably achievable, the goal of personnel monitoring is to detect and remove all contamination. Thus, the preferred level is no detectable radioactivity above background. Any levels of activity detected during the survey which are noticeably above normally fluctuating background must be considered an indication of the presence of radioactive contamination. To ensure accurate measurements, a monitor must be able to reliably detect a minimum of 1000 dpm/100 sq cm total activity.

It is anticipated that most cases of personnel contamination will involve loose surface contamination on protective clothing or skin. If clothes are contaminated, the preferred procedure is to remove them, monitor the skin under the affected area, and supply clean coveralls for the employee. The contaminated article will then be washed in the laundry area. Clothes will be returned to the employee after they are decontaminated.

In the event of surface contamination detected on skin, the contaminated area must be washed and monitored again. If decontamination procedures are not effective, the site health physicist should be consulted.

D.3.4 EQUIPMENT MONITORING

As vehicles and equipment are used in the controlled area, radioactive material is expected to accumulate on all surfaces in contact with the contaminated material. Instrument surveys and decontamination procedures will ensure that radioactive materials are not transported to uncontrolled areas. The following instructions apply to vehicles and equipment leaving the controlled area.

a. Instrumentation

Two instrument sets are required for equipment monitoring. A portable instrument is necessary for field monitoring and a swipe counter must be accessible for areas where background radiation levels are high enough to interfere with field monitor readings. The following characteristics are required for the two types of instruments:

Field monitor:

- Hand-held, pancake G-M tube or proportional counter detector.
- Large detector area.
- Thin detector window capable of detecting 3 MeV or greater alpha energies.
- Detector window protected from puncture by wire screen.
- Battery-powered ratemeter/scaler.
- Speaker attached for audible indication of radiation levels detected.
- Meter display for exact indication of radiation levels in counts per minute (CPM).

Swipe counter:

- o Slide tray to accept 2-inch diameter samples.
- o Alpha scintillation detector.
- o Adjustable timer for counting circuit from about 5 seconds to 1 minute, to a maximum of 1 hour.

b. Monitoring methods

The health physics technician will monitor vehicles and equipment which have been in contact with the contaminated material, before allowing them to leave the controlled area.

Vehicles and heavy equipment will be driven to the decontamination pad for monitoring, and cleaning, if necessary. All vehicles shall be cleaned to remove all visible soil prior to leaving a contaminated site. The following criteria shall then be applied:

- o For vehicles potentially in contact with material having Ra-226 concentrations of 200 pCi/g or greater, the tires (and cab interior, if potentially contaminated) shall be monitored and decontaminated to meet the limits described below. Appropriate spot checks shall be made of other potentially contaminated truck surfaces.
- o For vehicles potentially in contact with material having Ra-226 concentrations less than 200 pCi/g, the tires and cab interior will be periodically monitored to meet the limits described below. If contamination in excess of the limits is found, the guidelines in the preceding paragraph shall be used.

Background radiation may cause such high instrument readings that instrument surveys of vehicles are not feasible. When instrument surveys are inadequate, swipe surveys will be performed as an alternative. Results of swipe surveys should be recorded in the Removable Contamination Log, in units of disintegration per minute/100 square cm.

Vehicle surfaces which exceed the limits given in Section D.3.4.c must be washed on the decontamination pad, and additional swipe samples must be collected and counted.

c. Contamination limits

Release criteria for vehicles and equipment leaving the restricted area are:

- o 5000 dpm/100 sq cm total activity, as detected by the instrument survey.
- o 1000 dpm/100 sq cm, as indicated by swipe samples.

In all cases, extensive effort shall be made to reduce contamination to levels as low as reasonably achievable.

d. Decontamination procedures

In the event that equipment or vehicles require extensive decontamination, they will be washed using high-pressure washers or other decontamination methods in the decontamination area. Vehicles will be driven on to the pad for cleaning so that run-off can be contained.

Proper measures will be used to protect the workers and environment during decontamination. Coveralls, boot covers, gloves, and eye protection will be worn to prevent transfer of contamination to clothing, skin surfaces, or eyes. Caution must be exercised to prevent spray from splashing back onto the worker.

When dry, the equipment will be monitored again for surface contamination. If, after two washings, contamination is still evident on the equipment, the site health physicist will be consulted for additional decontamination procedures.

D.3.5 BUILDING DECONTAMINATION AND DEMOLITION

Loose or removable contamination in buildings must be removed or fixed to the surfaces prior to demolition. Decontamination is to be performed by experienced crews supplied with adequate protective equipment (coveralls, respirators, gloves, boots, and eye protection). The decontamination may require that:

- Contaminated water from washdown activities will be used as a tailings dust suppressant or monitored and disposed of in compliance with Section D.5.4.
- Decontamination by use of nuclear grade industrial vacuum cleaners will require strict maintenance of the high efficiency particulate air (HEPA) filter and proper disposal of contents and filters.
- Dosimetry and special urinalysis samples will be specified. When asbestos is present in buildings, monitoring will be initiated as described in Section D.4.1 of this document.
- Application of contamination fixants prior to demolition will be done under the supervision of health physicists who will specify protective clothing and equipment.
- Use of cutting torches, jack hammers, or other equipment for demolition of building structures will require protective equipment for personnel. Appropriate engineering controls will be used to prevent dispersion of contaminated dust or smoke during such activities.

D.3.6 PROTECTIVE CLOTHING AND CHANGE FACILITIES

Protective clothing will be available to contractor personnel to minimize surface contamination of personal clothing. Change facilities will be provided and stocked to accommodate workers in compliance with the following requirements.

a. Protective clothing requirements

Clothing items will be stocked at the access control point in a variety of sizes to fit contractor personnel and will include coveralls, rubber shoe covers, knee-high rubber boots, leather gloves, and cotton gloves.

Additional items may be stocked as considered necessary by the site health physicist.

Coveralls, boot covers, and gloves will be worn by all personnel working in areas having significant quantities of soils or contaminated material containing 200 pCi/g or greater concentrations of Ra-226. Additional work areas having lesser amounts of contamination may also require use of protective clothing, and will be so designated by the site health physicist.

b. Use of change facilities

Change facilities will be located at or near the access control point. These facilities are intended for use by contractor personnel working in controlled areas who are unable to meet surface contamination limits when leaving through access control. Change facilities will include showers and sinks, lockers and benches, soap and towels, toilets, and washers and dryers for laundering protective clothing.

Change facilities will be supplied with portable toilets and hot and cold running water to the sinks, showers, and the laundry. Waste water from sinks, showers, and the laundry will be collected in a sump and sampled prior to spraying on the tailings, or routed to an evaporation pond for treatment and discharge, where applicable.

Workers will be required to shower only if widespread contamination is found on the skin. Localized contamination may be washed off in the sinks. Previously monitored contaminated areas will be re-surveyed after washing.

D.3.7 DOSIMETRY AND BIOASSAY

The dosimetry and bioassay programs provide measurements of personnel external and internal exposure to radiation. These programs will be conducted in the following manner.

a. Personnel dosimetry

Thermoluminescent dosimeters (TLDs) or film badges will be used to provide accurate measurements of personnel exposures to external sources of radiation during remedial actions. All contractor personnel who are expected to work at least 40 hours per calendar quarter in a restricted area (as defined in Section D.3.1) will be issued a dosimeter. Visitors will not be badged unless it is deemed necessary by the site health physicist.

Dosimeters will be worn by contractor personnel while working in restricted areas, and will be returned to the technician at the access control point at the end of each work shift. The technician will store the badges in a lead pig to minimize nonoccupational exposures due to elevated levels of background radiation.

Employees will wear dosimeters on the front of the body, between the neck and waist, unless directed otherwise by health physics personnel. The same dosimeter must be retained by an employee for the entire quarter, unless deemed otherwise by health physics personnel.

A control badge will be provided with each set of dosimeters. The control badge must not be issued to any employee and should be kept in the lead pig used for storing the other badges. Unused dosimeters reserved for visitors and new employees must also be kept in the pig.

Dosimeters will be exchanged quarterly, and read by the dosimeter service which supplies them. The resulting data will be reviewed, recorded, and initialed by the site health physicist and retained on the site until remedial actions have ceased. The site health physicist will note any increases in personnel exposures above the levels usually expected at the site. He will investigate potential causes of elevated exposure rates and, when possible, eliminate the source.

Whole-body dose equivalent rates will be maintained below 3.0 rems/quarter and 5.0 rems/yr. Whenever possible, engineering controls or work procedures will be initiated to maintain worker exposures at levels which are as low as reasonably achievable.

b. Bioassay

Two methods of measuring internal deposition of radioactive materials in workers are to be used. Urinalysis will provide information concerning potential uptake of radioactive material by contractor personnel, and whole-body counting will provide an indication of an individual's body burden.

All personnel who will work at least 40 hours per calendar quarter in a restricted area will submit a urine sample prior to beginning work on the project. An exit sample will be collected upon termination of the individual's work activities at the project, and interim samples will be collected at intervals as required by the health physics staff. Non-routine samples will be required whenever a situation has resulted in a potential overexposure to airborne radionuclides. Additional bioassay may be required for personnel performing jobs where exposures to high airborne radionuclide concentrations are encountered.

Typically, urine samples will be analyzed for Th-230 concentrations. Th-230 is selected as the limiting isotope due to its solubility, radiotoxicity, and its presence in tailings in concentrations comparable to those of Ra-226. At the discretion of the site health physicist, additional analyses may be required, based on data obtained from material in specific work areas.

Analytical results must have a lower limit of detection at least equal to the concentration at which resampling is indicated. Action levels are provided below for thorium and radium.

- Th-230:
  - 0.05 pCi/l - resample
  - 0.1 pCi/l - investigate work conditions
  - 0.2 pCi/l - prohibit employee from working in restricted areas
- Ra-226:
  - 0.5 pCi/l - resample
  - 0.7 pCi/l - investigate work conditions
  - 1.0 pCi/l - prohibit employee from working in restricted areas

Analytical reports from the laboratory will be retained at the project site while remedial actions are in progress, and copies retained thereafter by DOE. Reports will be reviewed by the site health physicist and results which exceed the limit for resampling will be discussed with the employee involved. The employees will initial the laboratory reports to indicate that they have been informed of the potential overexposure.

Whole-body counts may be required for contractor personnel who frequently exhibit excessive radionuclide concentrations in the urine. Personnel whose work has been confined to unrestricted areas due to elevated urinalysis results will be considered by the Radiological Support Contractor for whole-body counting upon termination of employment at the project site. Copies of records of whole-body counts will be retained by the DOE/UMTRA Project Office.

D.3.8 AIR SAMPLING

An air sampling program will be initiated during the preoperational phase and continued during the operational phase of the project. Radionuclide concentrations in the work environment will be monitored and potential occupational health hazards will be evaluated in determining the need for respirators and bioassay.

a. Air particulate sampling

Engineering controls and dust suppression techniques will be used to minimize levels of airborne particulates. Methods such as vehicle speed control and water spray will commonly be in use. However, to ensure that the work environment is not hazardous to workers, air samples will be collected and analyzed in accordance with the following requirements.

Representative work area air particulate samples will be collected using lapel and work area samplers in all work areas where excavated soils average 50 pCi/g of Ra-226 or greater. Additional air particulate samples may be collected during the work shift in the predominant downwind direction relative to excavation activities, using high volume samplers. At the end of each shift, air particulate samples will be stored in containers and marked with the following information:

- o Location of sample.
- o Date sampled.
- o Flow rate and identification number of sampler.
- o Start time and stop time of sample period.

After a delay of at least 24 hours, air filters will be counted for gross alpha levels, using instrumentation described in Section D.3.4 for counting swipe samples. Gross activity levels will be compared to the limit for Th-230. Air concentrations which exceed the limit for soluble Th-230 in the work environment, as given in 10 CFR Part 20 (2×10^{-12} microCi/ml), will indicate the need for additional analyses, and mandatory use of respirators by contractor personnel.

After counting, filters are to be stored in closed containers for future analyses. Samples may be stored together, according to sample location, as long as data regarding the volume of air sampled are retained. At the end of each quarter, the composited filters will be analyzed for concentrations of Th-230 and Ra-226, to provide precise data on radionuclide concentrations in the work environment, and potential levels of internal exposure. Results of isotopic analyses will be compared to limits provided in 10 CFR Part 20 Appendix B, Table 1, and used to provide guidance on the use of respirators.

b. Radon daughter sampling

A sampling program for short-lived particulate radon decay products will be conducted in all work areas. The greatest potential for elevated radon daughter concentrations (RDCs) exists in enclosed areas such as buildings, where ventilation is limited. Radon daughter samples will be collected and evaluated for all buildings which are expected to contain elevated concentrations of radium, radon, or radon daughters, before construction personnel enter such work areas.

If buildings are closed between work shifts, RDCs will be re-evaluated before workers are permitted to enter the building to begin work again. Additional samples will be collected in the building during the work shift as deemed necessary by the site health physicist.

During periods of calm winds or inversions, RDCs may exceed limits in outdoor work areas which contain very high concentrations of Ra-226 in the soil. Such work areas will be evaluated for RDCs on a daily basis.

The modified Kusnetz method of measuring RDCs is recommended as a quick and accurate procedure. Portable instruments can be utilized for sample collection and counting. Other comparable methods may be substituted at the discretion of the site health physicist.

Radon daughter concentrations will be limited to 0.33 working levels (WL) in the work environment. Any work area which exceeds 0.33 WL averaged over the work period must be evacuated until engineering controls can be effected or respiratory protection can be provided. The primary methods of alleviating excessive RDCs in the work environment will be increased ventilation or decreased exhalation of radon gas into the area. Respiratory protection will be resorted to only when other methods are not feasible.

c. Respiratory protection

The respiratory protection program will be administered in such a manner to provide assurance that all workers are properly protected. Personnel will be determined physically fit for wearing respirators through the use of medical history information and, in some cases, a medical examination. A careful evaluation and documentation of the use of respirators will be accomplished by knowledgeable professional personnel.

Respirators, either cartridge types or supplied air types, will be the last resort in attempting to provide a safe work environment for contractor personnel. Engineering controls such as spraying water on dry contaminated materials will be explored before relying on respiratory protection. However, when airborne particulate radionuclide concentrations reach a projected monthly concentration of 25 percent of the applicable regulatory limits, respirators will be used and the following requirements must be met:

- o Employees required to use respirators will be instructed in their use, and informed of the conditions under which they are required.

- Personnel required to use a respirator must be clean shaven to ensure a good seal between the face and the respirator.

- Each worker required to wear a respirator must be qualitatively fit-tested for a specific type of respirator before being issued that type of respirator.

- Respirators may only be used at the request of the site health physicist. He will only require respirators after exhausting all measures for alleviating the conditions requiring respirator use.

- Cartridge-type respirators will be issued for use in atmospheres containing respirable quantities of oxygen, but which are contaminated with excessive concentrations of harmful substances such as radionuclides, chemicals, or particulates.

- Self-contained breathing apparatus (SCBAs) are required in atmospheres which contain less than respirable quantities of oxygen, high concentrations of hazardous gases, or short-lived radon decay products in excess of the administrative or regulatory limits.

- Personnel required to use SCBA-type respirators must pass a physical examination including a pulmonary examination and must not be allowed to work in the airborne contamination area alone.

- Respiratory protection factors and respiratory program details will be taken from "Practices for Respiratory Protection," ANSI Z88.2-1980 (ANSI). Further guidance may be obtained from Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection."

D.3.9 TRANSPORT OF CONTAMINATED MATERIAL

The DOE will comply with the applicable state or Federal regulations regarding the transportation of contaminated material. Site-specific determination of the levels of radioactivity associated with tailings and tailings-contaminated material will be made. If levels do not exceed 2000 pCi/g, the material does not meet the Department of Transportation's definition of "Radioactive Material," and trucks are not required to be placarded.

As a minimum, all trucks or train cars hauling contaminated material shall be tarped for transit. All visible contaminated material shall be removed from the exterior. The vehicles shall be monitored according to guidance provided in Section D.3.4.

D.4 INDUSTRIAL HAZARDS CONTROL

D.4.1 NONRADIOACTIVE AIRBORNE MATERIAL

Monitoring for respirable dust and toxic gases and fumes is required when the average eight-hour dust loading is expected to reach 50 percent of the Threshold Limit Value (TLV). Representative samples of tailings materials will be taken and a weekly composite made and analyzed for lead, arsenic, selenium, quartz, and other toxic or hazardous materials. If limits are exceeded for these toxic and hazardous materials, and concentrations of radionuclides do not require respiratory protection, then exposure to levels below the TLV will be maintained by wearing respirators approved by the National Institute of Occupational Safety and Health (NIOSH). TLVs adopted by the American Conference of Governmental Industrial Hygienists (ACGIH) will be used.

If asbestos is suspected to be present in soils, or in buildings to be decontaminated, then an asbestos monitoring, protection, and record-keeping program will be initiated in accordance with 10 CFR 1910.1001. The eight-hour time-weighted average airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed 0.5 fibers, longer than 5 micrometers, per cubic centimeter of air. Asbestos concentrations will be determined by the membrane filter method at 400-450x (magnification), 4 mm objective, with phase contrast illumination.

D.4.2 NOISE

TLVs for workers will be limited to that specified by ACGIH, 85 dBA for an 8-hour work day and 80 dBA for a 16-hour work day. Noise suppression devices will be used where appropriate, and the use of hearing protective devices will be mandatory for levels above the TLV and encouraged for levels below the TLV. All other guidance in "Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1982," ACGIH, related to noise exposure will be followed.

D.4.3 PERSONAL PROTECTIVE EQUIPMENT

Plans for the use of personal protective equipment will be developed based on projected need. Training shall be provided to employees on the use of such equipment. Such apparatus may include respirators, safety eye glasses or goggles, coveralls, hardhats, gloves, shoe covers, rubber boots, and safety shoes.

D.4.4 FIRE SAFETY

Contractors will maintain a fire prevention and control effort appropriate for the needs at the site. Fire extinguishers will be provided and maintained and employees instructed in their use. Good housekeeping practices and proper storage of flammable and combustible liquids will be required.

D.4.5 CONSTRUCTION SAFETY

Management shall assure that all provisions of 29 CFR Part 1926 are addressed prior to initiating any construction activity. Particular attention shall be paid to Excavations, Trenching, and Shoring (Subpart P); Signs, Signals, and Barricades (Subpart G); and Motor Vehicle, Mechanized Equipment, and Marine Operations (Subpart O). All management shall be familiar with the requirements and direct the workmen accordingly.

D.4.6 SANITATION

Toilet facilities shall be provided in accordance with 29 CFR Part 1926.51.

Potable water for drinking and for washing prior to eating shall be provided for all employees.

D.5 ENVIRONMENTAL MONITORING

An environmental monitoring program will be conducted at the project site and surrounding area. The program will proceed through three phases: preoperational, operational, and post-operational. During the preoperational phase, data will be accumulated to characterize background and unimproved radiation levels in the region.

Operational data will provide documentation of off-site contamination generated by remedial activities at the project site.

Post-operational data will document the reduced levels of contamination which occur after the contaminated materials are properly stabilized. The intent is to document the anticipated reduction in levels of contamination after pile disturbance has ceased.

The environmental monitoring program is designed to monitor non-radioactive particulate concentrations in air, radionuclide concentrations in air, and contaminants in surface water and ground water, where applicable. Monitoring requirements are described in the following sections. Additional requirements may result from the permitting processes outlined in Appendix A, Regulatory Compliance, of the Remedial Action Plan.

D.5.1 PARTICULATES IN AIR

Continuous air particulate sampling is required at points around the site boundary, commencing at least one month before remedial actions at the site. Samples will be collected at nine locations: three along the site boundary in the predominant downwind directions, one at the site boundary upwind, one at the nearest residence, one at the nearest downwind residence, one at the Shiprock high school, one at the old mill classroom building, and one at a background location which is distant enough not to be influenced by site activities.

Filters will be exchanged, analyzed, and evaluated in accordance with the U.S. Environmental Protection Agency (EPA) regulations. Additional radiological parameters may also be evaluated as required by the site health physicist. The following information must be recorded when used filters are collected:

- o Sample location.
- o Sampler flow rate, or volume of air sampled.
- o Start and stop time of sample and dates.
- o Sampler identification number.

After a minimum delay period of 24 hours, samples will be counted for long-lived gross alpha activity using instruments required for swipe samples. Data from gross alpha measurements will be compared to the limit for soluble Th-230 given in 10 CFR Part 20 Appendix B, Table II (8×10^{-14} microCi/ml). Filters which count above the limit will be recounted five days later to allow for the decay of any remaining short-lived isotopes. Filters which still exceed the limit will be sent to the radiochemistry laboratory for isotopic analysis of Th-230 and Ra-226.

Total particulates will be determined and compared to 10 CFR Part 20 Appendix B, Table II limits.

D.5.2 RADON IN AIR

Environmental radon monitors (either PERM or film type detectors) will be placed to provide measurement of periodic average radon concentrations in air, and the data made available within two weeks. In order to provide immediate information, real-time, continuous radon monitors will also be placed at the old mill classroom or downwind residence, and one of the downwind site boundary locations.

A guideline will be set to restrict increases in off-site Rn-222 in air to 3 pCi/l, which equals 1 MPC (maximum permissible concentration). A weekly average of 3 pCi/l will result in 1 MPC-week. Average annual concentrations of radon will be limited to 52 MPC-weeks, with no quarterly average exceeding 26 MPC-weeks. During periods of remedial action, measures will be employed to maintain airborne radionuclide concentrations at levels which are as low as are reasonably achievable.

D.5.3 GROUND WATER

At least one set of preoperational ground-water samples will be collected and archived from monitoring wells located in hydrologically upgradient and downgradient directions. The locations of these wells will be determined by the TAC after evaluation of recently collected water data. Additional sample sets will be collected quarterly throughout the construction period, or more frequently if requested by the site health physicist. Sample collection and sample analyses procedures will conform to the UMTRA Project Quality Assurance (QA) Plan. Samples will be analyzed for Th-230, Ra-226, uranium, and nonradioactive elements and compounds agreed to by the UMTRA Project Office and the Navajo Nation. Other radionuclides will be analyzed if deemed necessary by the site health physicist.

D.5.4 SURFACE WATER

The waste-water retention basin will collect all non-domestic waste water. Since that basin has been designed for evaporation of runoff from at least the 10-year 24-hour storm, no discharge is expected during remedial action. Therefore, sampling and waste-water treatment will not be necessary.

D.6 EMERGENCY PROCEDURES

D.6.1 SEVERE WEATHER ACTION PLAN

A severe weather action plan will be developed by the RAC to prevent extensive off-site dispersal of contamination during periods of high winds or heavy rains. The plan will identify a responsible individual to be available to direct activities previously defined to mitigate the effects of the severe weather. Action levels to limit work and environmental contamination will be specified.

D.6.2 MEDICAL EMERGENCIES

An emergency medical assistance plan will also be developed by the RAC. Approved first-aid kits and equipment will be made available to the supervisors in the field and at the access control point.

Although high levels of contamination on workers are not expected, special care will be taken to decontaminate superficial cuts and abrasions.

Arrangements will be made for the transport and admission of accident victims to medical facilities should the need arise. A medical emergency plan will be developed, and arrangements will be made with local medical facilities to ensure the availability of medical assistance. Medical emergencies involving life-threatening circumstances will be reasonable cause for waiving the contamination monitoring procedures at the access control point. If practical, a health physicist will accompany the injured person and will perform a contamination survey using a portable monitoring instrument, while in transit to the medical facility. Lifesaving procedures will take precedence over the monitoring.

D.6.3 OPERATIONAL PROCEDURES

The RAC will establish operational procedures to be used in conjunction with environmental monitoring results to ensure the health and safety of the general public. Environmental monitoring records will be updated on a weekly basis. Any upward trends in radon concentrations will be identified, and evaluated relative to a quarterly limit of 26 MPC-weeks above pre-remedial action levels, where 1 MPC-week represents exposure to an average of 3 pCi/l of Rn-222 for one week. Increases in radon concentrations which indicate that quarterly limits may be exceeded will result in implementation of one of the following procedures, as appropriate:

I. Continue Normal Construction Activities

- Wet down active working areas.
- Wet down unprotected contaminated areas.

II. Modified Work Stoppage

- o Continue wet-down procedures.
- o Employ wet-down procedure for vicinity property material coming on the site.
- o Stop work in contaminated areas.
- o Continue work in clean areas.

III. Total Work Stoppage

- o Stop work, including bringing vicinity property material on the site.
- o Wet down, use covers, or otherwise secure contaminated portions of the site.
- o Notify the public of the reason for work stoppage.

Airborne particulate radionuclide concentrations will be monitored and maintained below limits provided in 10 CFR Part 20 Appendix B, Table II, Column 1, using similar procedures. The DOE/UMTRA Project Office will be notified immediately in the event that modified or total work stoppage becomes necessary.

APPENDIX E

SITE CONCEPTUAL DESIGN

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E.1 INTRODUCTION

E.1.1 AUTHORITY

The Uranium Mill Tailings Radiation Control Act of 1978, PL95-604, grants the Secretary of Energy the authority and responsibility to perform such remedial actions as are necessary to minimize the radiation health hazards associated with designated inactive mill sites. This report is in partial fulfillment of that authority and responsibility.

E.1.2 PURPOSE OF REPORT

This report provides the maps, drawings, and other information necessary to understand the proposed design of the remedial action for the Shiprock, New Mexico (SHP) site. The Site Conceptual Design (SCD) forms the detailed design part of the Remedial Action Plan. In addition, data relevant to the site are consolidated in the Processing Site Characterization Report (PSCR). There is some duplication of information among these documents to facilitate their use; however, the individual documents are not "stand-alone" comprehensive reports.

The Site Conceptual Design is intended to provide sufficient detail for the reader to evaluate the feasibility and effectiveness of the basic design concepts which have been proposed. These concepts will provide a basis for the schedule and cost estimate to be used in obtaining concurrences at the Federal and Tribal levels along with Federal funding.

The conceptual design will be used by the Remedial Action Contractor (RAC) as part of the basis for the detailed construction design.

E.1.3 CONTENT AND LIMITATIONS

Section E.2 of the report presents a description of the environmental problems at the site and the major elements of the remedial action intended to mitigate these problems. This is followed by a presentation of key design features with supporting rationale (Section E.3), site design criteria (Section E.4), drawings (Section E.5), and preliminary capital cost estimates (Section E.6). Supporting calculation summaries are included as Attachment A.

The Site Conceptual Design has been developed to demonstrate a concept. Although the final design may vary to a limited extent from the present concept, the basic concept presented in this document represents the proposed completed remedial action. Some elements of the design have not been fully developed and are intended for completion during the detailed design.

E.2 DESIGN BASIS

E.2.1 SITE DESCRIPTION

The Shiprock site is located on the Navajo Indian Reservation, approximately one mile south of and across the San Juan River from the main part of the town of Shiprock, New Mexico (Figure E.2.1). Farmington, New Mexico, is approximately 30 miles east (upstream) on the San Juan River. The site is located on an escarpment approximately 70 feet above the river channel and covers 143.6 acres. Four of the original buildings remain on the site and are in use. There are two new buildings on the site. For a detailed description of the Shiprock site as it exists today, the reader is referred to Section 3.0 of the RAP.

E.2.2 DESCRIPTION OF THE PROBLEM

The Shiprock site as it exists today presents three major problems which must be corrected in order to meet the EPA standards.

- o The site contains approximately 1.9 million cubic yards of tailings, contaminated rubble and soil, and does not meet the EPA radon standard of 20 pCi/m^2sec.

- o The tailings are located on an escarpment adjacent to the San Juan River and are potentially subject to release by river encroachment and other surface erosion.

- o The tailings are not presently secure from dispersion by natural and human movement.

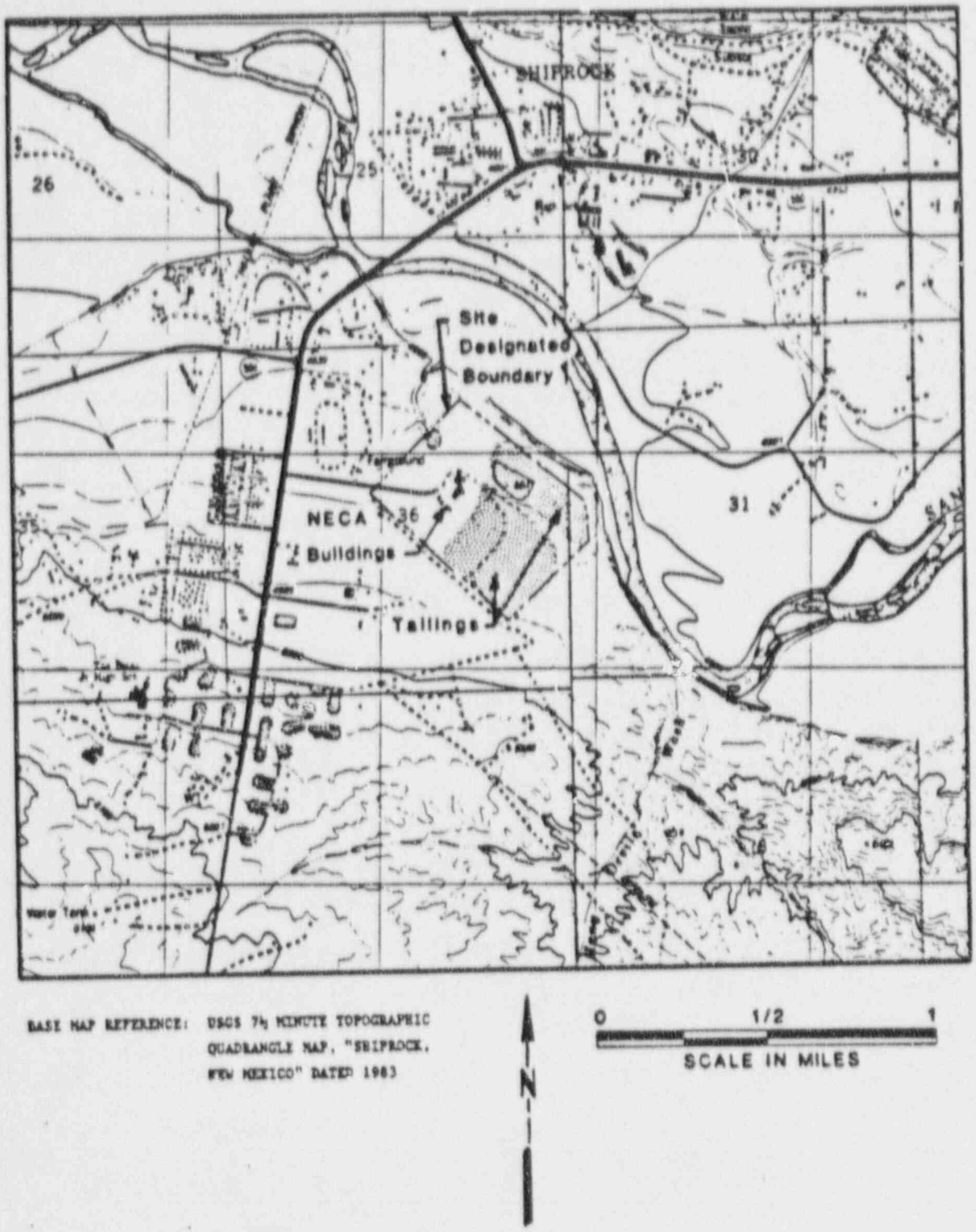
Each of these problems is discussed in more detail in the following paragraphs.

Mitigating measures to alleviate all of these conditions are addressed in Section E.3.

Upon detailed investigation as discussed in Sections E.2.2.2 and E.3.2.7, it was found that the tailings do not present a ground-water problem at the Shiprock site.

E.2.2.1 Radiation

The site presently exhibits some contamination in soils in a few locations surrounding the tailings pile due to windblown dispersion. In addition, there is some surface contamination of the arroyos, the bluff, and the San Juan River floodplain due to wind and water erosion. About 33 acres of floodplain are contaminated to levels above the EPA standards and about 18 acres of other surrounding terrain are contaminated.



BASE MAP REFERENCE: USGS 7½ MINUTE TOPOGRAPHIC QUADRANGLE MAP, "SHIPROCK, NEW MEXICO" DATED 1983

FIGURE E.2.1
SHIPROCK - SITE LOCATION MAP

Approximately 80 NECA and Public Health Service employees regularly work on the site within 700 feet of the tailings piles. The buildings that they occupy are in conformance with the EPA standards except for a small shed behind the shop building and several areas in the former shop building. Additionally, there are several abandoned surface-water tanks on the site that are contaminated.

The radon emissions from the tailings are calculated to average about 110 pCi/m^2sec, which is far in excess of the EPA standard of 20 pCi/m^2sec. Additionally, measured average concentrations at the site boundary exceed the alternate EPA standard of 0.5 pCi/l.

A radiological survey report based upon data collected by Argonne National Laboratory (ANL, 1982) indicates that 16 vicinity properties in the Shiprock area are considered to be contaminated with tailings and recommended for remedial action. Cleanup of these properties is estimated to result in the excavation and relocation of about 16,000 cubic yards of material to the tailings pile.

E.2.2.2 Existing ground water

There are three distinct saturated zones beneath the site. Ground water first occurs as perched water at two locations in the 20-foot-thick alluvial deposits principally near or below the tailings/soils interface. These perched pockets are laterally discontinuous in the vicinity of the tailings pile.

A second perched system is located beneath the site in the upper weathered portion of the Mancos Shale and, to some extent, the lower part of the alluvium. The depth to this ground-water zone varies from about 20 to 50 feet below the natural ground surface and has a thickness of 3 to 30 feet. It is underlain by about 1100 feet of nearly impermeable Mancos Shale with the saturated Gallup Sandstone at a depth of 175 to 250 feet separating the Mancos Shale into upper and lower members. This perched, water-table system in the Mancos Shale is continuous under the site and beyond the site boundaries. Recharge is believed to be at the base of the low hills to the south and southwest of the site. The flow direction is generally toward the northeast and the San Juan River escarpment; however, flow direction under the site is significantly influenced by the thickness and degree of weathering and by irregularities along the bedrock surface. Flow volume beneath the tailings pile is estimated to be about 0.15 gallons per day per linear foot of width. This very low flow volume (222 gallons per day under the entire site) through the perched water table system is confirmed by the occurrences of intermittent seepage along the escarpment. Water from these seeps evaporates almost immediately. For a more detailed discussion of the occurrences and the movement of phreatic ground water, see Attachment A, Calculations Summaries, Section 8.0, Geohydrology.

The third zone consists of two confined aquifers under the site. One is the Gallup Sandstone unit of the Mancos Shale at a depth of about 175 to 250 feet below the site and the second is the Dakota Sandstone at a depth of about 1100 feet. These aquifers are separated from the tailings by several hundred feet of impermeable shale, and are under artesian pressure thus reducing any chances for contamination to a minimum. Additionally, the water of the Gallup Sandstone is considered non-potable in the vicinity of Shiprock.

The water quality of the Mancos Shale perched system near and beneath the pile is characterized by high total dissolved solids (TDS) (12,000 to 35,000 milligrams/liter (mg/l) and high sulfate (4000 to 25,000 mg/l) values. Water quality upgradient of the pile is also characterized by high TDS (19,000 to 31,000 mg/l) and sulfate (7600 to 25,000 mg/l) levels. The total uranium concentrations in the Mancos Shale perched water range from beneath 120 to 2000 pCi/l (0.176 to 2.94 mg/l) beneath the pile and between 20 and 225 pCi/l (0.029 to 0.331 mg/l) upgradient of the pile. The highest reported concentrations of uranium for some upgradient wells may represent residual contamination due to radial flow away from the pile during active milling. Additionally, possibly anomalous concentrations of nitrate and ammonium of other upgradient wells may also be indicative of residual contamination.

The discontinuous perched pockets in the alluvium above the Mancos Shale show water quality similar to that in the shale, 28,000 to 34,000 mg/l TDS; 17,500 to 21,000 mg/l sulfate; and from about 20 pCi/l (0.029 mg/l) uranium off the site to about 725 pCi/l (1.07 mg/l) uranium on the site.

A seep discharging from the escarpment near the site showed only slightly elevated levels of uranium, while most other dissolved constituents were within background ranges. Analyses of San Juan River samples show no indication of surface-water contamination related to this seepage.

In summary, results of field studies indicate that, under present conditions, there is little or no infiltration through the tailings that percolates to the ground water (see Attachment A, Section 8.0, Geohydrology). In these calculations, it is assumed that the total flow (222 gallons per day) in the perched water system is from site surface recharge and none is from upgradient flow. Even under these highly unlikely conditions, the annual average net infiltration, i.e., percolation to the ground water, is 0.04 inch per year. This is less than one percent of the average annual precipitation. Most observed contamination is probably due to the presence of residual plant process water, rather than active leaching following mill closure. This contamination is limited to the zones of unusable shallow perched ground water which evaporates at or near the San Juan River escarpment. Therefore, ground-water protection is not a major problem at the Shiprock site.

E.2.2.3 Geotechnical stability

Although minor remedial measures have been performed in the past, the tailings in their present condition do not meet the criteria for long-term stability. The tailings are located immediately adjacent to an escarpment above the San Juan River. Foundation material below the tailings is stable and not subject to long-term settlement. However, the foundation soil along the escarpment is subject to long-term degradation by mass wasting. The site is susceptible to some amount of undercutting by long-term migration of the river.

Erosional gullies both along the escarpment and near the tailings, while not posing a current problem, could migrate and result in release of tailings.

The site is located within the tectonically stable Colorado Plateau and there is little potential for seismically induced liquefaction of the foundation subsoil or tailings.

E.2.2.4 Security

Under existing conditions the contaminated soils are not secure from physical removal off the site. The site is partially fenced; however, access to the tailings is not effectively controlled and little protection exists against future inadvertent removal.

Although six to 18 inches of pit run rock and soil have been placed over the tailings, the contaminated material at or near the surface is still susceptible to natural erosive forces such as winds and large storm events.

Steep slopes along the edge of the tailings pile, the irregular shape of the emplacement, and the possibility of differential settlement, cause the embankment to be susceptible to channelization and consequent tailings release.

E.2.3 DESIGN OBJECTIVES

The purpose of the remedial action is to stabilize and control the uranium mill tailings and contaminated material in a manner which complies with EPA standards. Consistent with these standards, and project objectives, the following major design objectives have been established:

- o Reduce the average radon flux from the site to levels less than 20 picocuries per square meter per second.

- Design controls to be effective for up to 1000 years with minimum maintenance.

- Prevent inadvertent human intrusion.

- Ensure that existing or anticipated beneficial uses of ground and surface water are not adversely affected.

- Reduce contaminant levels on areas released for unrestricted use to levels which do not exceed 5 picocuries per gram of Ra-226 above background in the top 15 centimeters of soil and do not exceed 15 picocuries per gram above background in any 15-centimeter layer below the depth.

- Reduce radiation levels in habitable buildings to levels which do not exceed 20 microR/h above background and reduce contaminant levels such that radon daughter concentrations do not exceed 0.02 Working Levels (WL).

- Minimize the land area to be utilized by the final disposal area.

- Protect against releases of contaminants from the site during construction.

- Provide runoff and sediment control.

- Minimize areas disturbed during construction and minimize exposure to contaminated materials.

E.2.4 MAJOR ELEMENTS OF THE DESIGN

The principal feature of the design concept is the movement of contaminated materials approximately 300 feet back from the edge of the escarpment and consolidation of the tailings and contaminated soils into a gently contoured embankment in the same general location on the site as the existing two piles. The contaminated materials will be topped with an earthen cover to control radon exhalation and inhibit water infiltration. The cover will be capped with rock to counter the erosional effects of wind and water, to impede inadvertent disturbance by man or animal, and to minimize plant root intrusion.

The escarpment will be contoured and a protective rock layer added to enhance stability. All excavated areas will be backfilled, as appropriate, and graded to promote drainage. The proposed remedial action design is discussed in detail in Section E.3.

E.2.5 PROPOSED FINAL CONDITION

The completed site will be an embankment situated on the southeast half of the present site and covering approximately 76 acres. The completed site will be bounded on the northeast by the San Juan River escarpment, on the northwest by the NECA and Public Health Service facilities, and on the southeast by the NECA borrow area (Figure E.2.2).

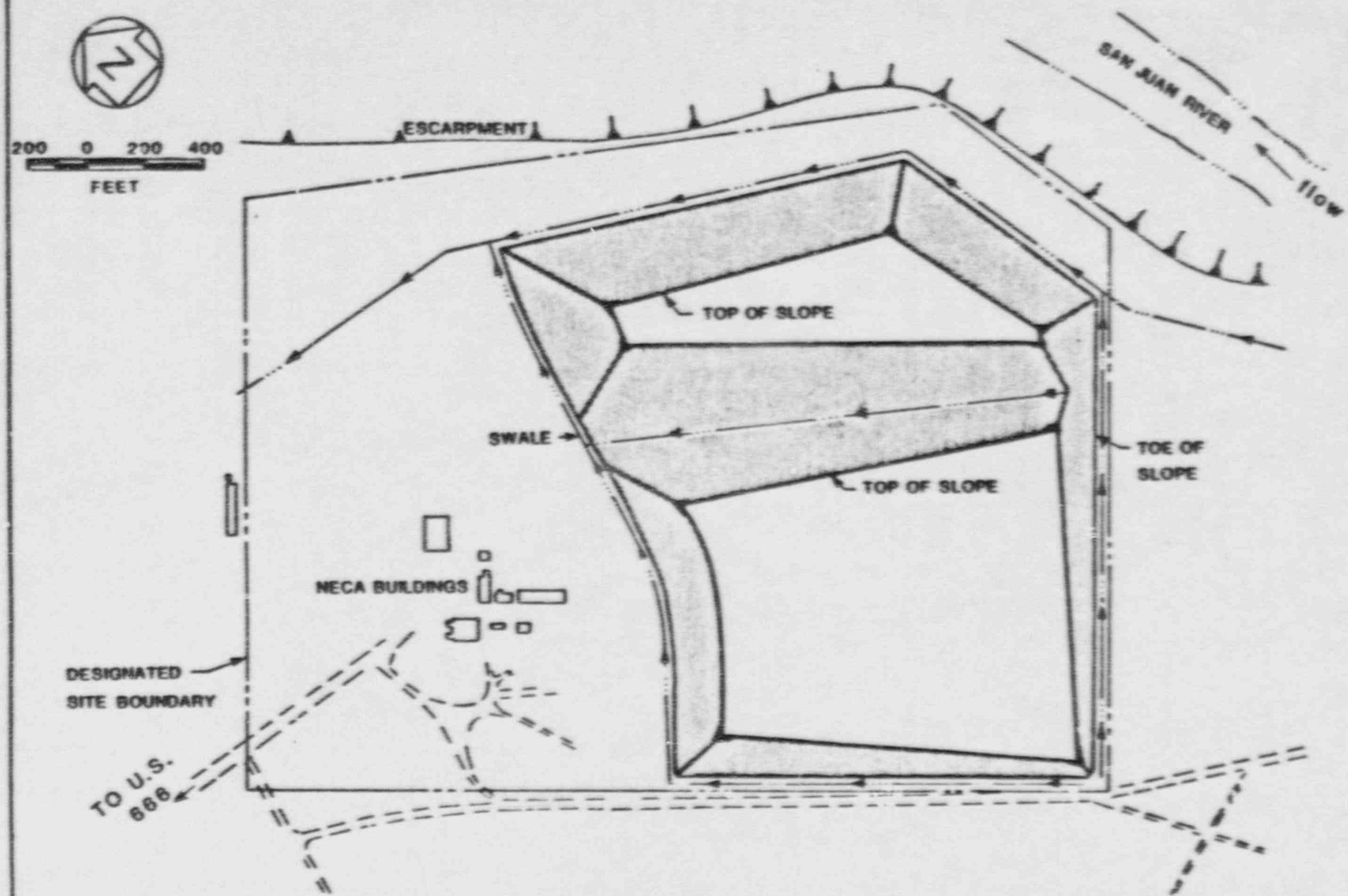


FIGURE E.2.2
FINAL CONDITION - SHIPROCK SITE

The materials used from the borrow area for cover materials range from sandy clay to sandy silt to silty sand. In order to be conservative, the silty sand was used to calculate the radon coefficients for determining the cover thicknesses. For the purpose of consistency, it should be assumed and stated that the overall mixture will be a "silty sand" - this is consistent with soil profiles represented in the PSCR (1984).

The total embankment area will cover about 76 acres and will be approximately 50 feet above the surrounding terrain. Sideslopes of the embankment will have a maximum slope of 1 vertical to 5 horizontal. The top and sides will be covered with a layer of silty sand approximately seven feet thick with an additional layer of pit run rock at least one to 1.5 feet thick on the sides and one foot thick on the top for erosion protection.

The erosion barrier will tie into an unpaved access road which will loop the bottom of the embankment. A security fence with warning signs on the fence and gate will enclose the embankment and roadway. Drainage channels adjacent to the embankment will provide drainage and divert surface drainage around and away from the embankment.

The top of the escarpment adjacent to the embankment will be stabilized, regraded to slope away from the edge, and armored with rock as necessary, so as to inhibit long-term degradation.

After decontamination, the remaining areas of the present site except for the floodplain will be restored with uncontaminated soil to the approximate elevation and recontoured as necessary for surface drainage. The floodplain will be graded and revegetated to maintain its status as a designated wetland. Approximately 68 acres of the present site will be released and available for continuing unrestricted uses.

E.3 DESIGN FEATURES

E.3.1 INTRODUCTION

Included in this section is a brief description of the major features of the design. Sections E.3.2 and E.3.3 discuss the permanent and temporary construction design features, respectively, including the rationale for and results of the design. The calculations summaries, Attachment A, provide the detailed backup for the design rationale.

E.3.2 PERMANENT DESIGN FEATURES

E.3.2.1 Layout

The completed site will be an embankment surrounded by drainage ditches and an access road, situated on the southeast half of the present site (see Figure E.5.3 in Section E.5) and covering approximately 76 acres. The completed site will be bounded on the northeast by the San Juan River escarpment, on the northwest by the NECA and Public Health Service facilities, and on the southeast by the NECA borrow area.

E.3.2.2 Decontamination and restoration

Material excavated from the top of the escarpment, the floodplain at the bottom of the escarpment, windblown areas, adjacent arroyos and ditches, and vicinity properties will be combined in the embankment. Decontamination or demolition of several structures is anticipated (BFEC, 1983) and the contaminated rubble will also be added to the embankment. Volumes of contaminated materials to be consolidated in the embankment are discussed in greater detail in Attachment A, Section 1.0, Earthwork Volumes.

Areas of excavation will be restored with uncontaminated fill, as required, or graded for drainage.

E.3.2.3 Embankment construction

The embankment is designed to provide long-term stability as well as maximize radon control.

Any relocated tailings will be placed in lifts and compacted. Areas of slimes deposits will be covered and compacted first so that settlement will occur before cover placement. Consequently, differential and total settlement will not affect the integrity or longevity of the embankment.

Organic materials such as demolition debris and grubbing vegetation will be evenly distributed throughout the lower lifts of tailings placement, and represent less than five percent of the total volume of the lift. Rubble pieces will be placed in the lower portions of the embankment and surrounded with compacted tailings.

Limiting the embankment slopes to 1 vertical to 5 horizontal will provide the embankment with a factor of safety against slope failure of greater than 2.5 and will reduce the potential effects of erosion. (See Attachment A, Section 10.0, Slope Stability and Seismic Risk Evaluation, and Section 4.0, Erosion Protection Design.)

Approximately 928,000 cubic yards of tailings will be relocated. The excavation and relocation will be sequenced to place lesser contaminated "sands" over higher contaminated "slimes." Lesser contaminated soils and windblown soils (from areas to be decontaminated) will be placed over the regraded tailings. This will provide a greater degree of isolation for the more highly contaminated materials. (Additional data on the distribution of radium in the tailings and windblown soils are included in Attachment A, Section 1.0, Earthwork Volumes.)

E.3.2.4 Cover construction

The radon exhalation rate from the embankment will be reduced to EPA standards by a compacted soil cover. The cover is designed to remain intact for 1000 years and will prevent exposure of contaminated materials.

A compacted silty sand layer approximately seven feet thick will serve as a radon barrier. The compaction of the silty sand will produce a soil barrier that retains moisture and retards radon gas diffusion. The rock cover will reduce the potential for drying of the compacted silty sand by trapping dew and condensation. Consequently, the top one foot of the silty sand was assumed to stabilize at a moisture content of five percent, by weight, and below that, 7.5 percent moisture was assumed for the radon barrier calculations. These values are consistent with moistures in undisturbed similar soils in the Shiprock area (Ref. Attachment A, Section 2.0, Radon Barrier Thickness). Compaction techniques and radon retardation properties of the cover materials are discussed in more detail in Attachment A, Section 1.0, Earthwork Volumes, and Section 2.0, Radon Barrier Thickness.

A rock layer over the radon barrier layer will protect the embankment cover from erosion. Severe rainfall events could have the potential to develop gullies on the steeper (20 percent) sideslopes of the embankment and erode away the radon barrier soil unless protected by the rock layer. One such potential rainfall event is commonly referred to as a Probable Maximum Precipitation (PMP). A PMP is defined as the maximum precipitation that could occur from the most severe combination of meteorological conditions that are reasonably possible in a region. For the Shiprock area, the one-hour PMP is eight inches (USDOI, 1977). A rainfall intensity of 24 inches per hour for a period of five minutes was used for design of the erosion barrier (NRC, 1983). A minimum of a one-foot-thick layer of 0.5-inch mean diameter rock on the two percent topslopes, and a 1.5-foot-thick layer of three-inch mean diameter rock on the 20 percent sideslopes will protect the embankment from the results of a PMP (see Attachment A, Section 4.0, Erosion Protection). The rock layer will also protect the embankment from wind erosion.

Eleven test pits (see Figure 7.2, in the PSCR) were dug within the borrow site area. The soil profiles consisted of varying depths of sand, gravel, and cobbles overlain by several feet of silty sand. The silty sand will be used for the radon barrier and the materials below the silty sands will be used for the rock erosion barrier. The material ranges from fine sands and silts up to cobbles six to eight inches in diameter. The gravels and cobbles are a mixture of quartz and granite.

Although no tests were run on the rock erosion material, it is assumed that the material will need to be put through a series of filters in order to obtain the required grain size.

It is the opinion of the TAC geologist that the rock will be of suitable durability to resist weathering over the long-term duration of the project. In order to verify the durability of the rock before it is used for construction, the following tests will be run by the RAC and shall meet the criteria specified:

- ASTM C131 or C535: "Resistance to degeneration of aggregate by abrasion and impact in the Los Angeles machine." The stone shall not have a percentage loss of more than 40 after 500 revolutions.
- ASTM C88: "Soundness of aggregates by use of sodium sulfate or magnesium sulfate." Stones shall not have a loss exceeding 10 percent after five cycles.

Plant root intrusion and burrowing animals will be discouraged by the rock cover. If roots or burrowing animals do penetrate the rock cover, the seven feet of radon barrier soils will prevent exposure of contaminated materials.

E.3.2.5 Escarpment reconstruction

The worst-case prediction of escarpment slope recession due to a combination of San Juan River meander and mass wasting indicates a need to remove tailings and contaminated subsoils from the edge of the escarpment and to regrade the escarpment in order to prevent possible long-term undercutting of the final embankment.

The contaminated materials will be moved at least 300 feet back from the edge of the escarpment. This will assure non-disturbance of the embankment for at least 1000 years and also allow sufficient additional space for the embankment cover and drainage swale. Gully formation in the escarpment top will be prevented by regrading the top of the escarpment to provide a two percent slope away from the escarpment edge thus directing surface-water runoff away from the escarpment edge into a drainage ditch 230 feet from the edge of the escarpment (see Attachment A, Section 3.0, Site Drainage). After controlled fill has been placed in the arroyos, the top of the escarpment will be stabilized, regraded, covered with a seepage barrier of Mancos Shale, and armored with rock erosion protection to inhibit long-term degradation. The final slope of the reconstructed arroyos will be 2 horizontal to 1 vertical or steeper. See Figure E.5.5 in Section E.5 for a section through the stabilized escarpment. The relocation of tailings, combined with escarpment stabilization measures, will prevent potential long-term disturbance of the embankment (see Attachment A, Section 11.0, Site Geomorphology).

E.3.2.6 Site drainage

The drainage of the embankment area along with general site grading will ensure long-term tailings stability. Drainage ditches will intercept runoff water that now flows over the edge of the escarpment, causing erosion. The ditches have triangular cross sections with sideslopes of 1 vertical to 5 horizontal. They have gentle slopes and depths great enough to carry the PMP. Rock erosion protection in the ditches will prevent damage to the embankment cover and contaminant exposure. The ditches will drain to an arroyo west of the site. To prevent the formation of gullies that could headcut into the embankment, the areas close to the embankment will be sloped gently and covered with rock erosion protection as required. (See Attachment A, Section 3.0, Site Drainage, and Section 4.0, Erosion Protection Design.)

E.3.2.7 Ground-water protection

The existing ground water at the site is described in Section E.2.2.2 and Section 8.0, Geohydrology, of Attachment A. Calculations in Section 8.0, Attachment A, demonstrate that little (0.04 inch per year) or no precipitation is infiltrating into the site and percolating to the shallow ground water under existing conditions.

The final embankment cover system will be much less permeable and much thicker than the present cover. Moisture infiltration through the embankment and into the shallow ground water will be virtually eliminated.

The small volume of shallow water present in the upper formations is of unusable quality and moves slowly toward the escarpment where it evaporates. The lower artesian aquifers are separated from the tailings by a thick, virtually impermeable layer of Mancos Shale.

Because there is essentially no probability of future contamination of any usable source of ground or surface water, no additional ground-water protection measures are considered necessary.

E.3.2.8 Flood protection

The Probable Maximum Flood (PMF) of the San Juan River is estimated to have a peak flow rate of 844,000 cubic feet per second which would result in a rise in water elevation of 26 feet. The embankment location on top of an escarpment that is 70 feet above and overlooking the wide floodplain provides the natural protection necessary to isolate the tailings from a PMF event (see Attachment A, Section 12.0, Flood Analysis). Most of the drainage area adjacent to the site will be diverted through the borrow area to Dead Man's Wash (also called Many Devils Wash). This, combined with other site drainage features, will protect the embankment from a PMP on adjacent drainage basins.

E.3.2.9 Site access

After remedial action is complete, permanent fencing will be placed around the entire site. The fence will be six-foot-high chain link topped with three strands of barbed wire, and will be secured with a locked gate. The access gate will be located near the NECA borrow area access road. A 20-foot-wide road will circle the embankment, inside the fence, allowing access to all of the embankment for custodial inspection purposes.

E.3.3 CONSTRUCTION FEATURES

E.3.3.1 Layout

Construction activities will be performed in an area including the site and adjacent areas (see Figure E.5.3 in Section E.5). The staging area will be adjacent to the NECA access road, west of the NECA buildings. The proposed borrow area is south and east of the site. A waste-water retention basin will be constructed west of the tailings piles and an equipment decontamination pad will be located adjacent to the tailings piles and the staging area. Drainage ditches and a construction fence will surround the tailings piles.

E.3.3.2 Site access

Construction fences will surround the staging and the embankment areas. Equipment will be decontaminated prior to leaving the embankment area. The construction fences will provide control of traffic entering and leaving the site, and prevent unauthorized traffic from entering the area.

E.3.3.3 Staging area facilities

During construction operations, temporary facilities will be required for construction workers along with supervisory, engineering, administrative, security, and radiation monitoring personnel. The facilities will consist of office space, showers and change facilities for all personnel working on the site, and include provisions for laundering contaminated clothing. Portable construction toilets will be provided for on-site workers. Equipment will be stored in the staging area.

E.3.3.4 Utilities

All existing utilities within the site area must remain active during the proposed remedial action. The existing six-inch gas line on the southwest perimeter of the stabilized embankment will need to be protected or relocated prior to remedial construction and borrow activities in that area.

Precautions will be taken during construction to prevent damage to existing lines. All known existing utilities are located and identified in Figure E.3.1. Potable water for personnel needs is available from the Navajo Tribal Utility Authority through the four-inch water supply line that serves the NECA facilities. This water supply is adequate to supply showers, laundry, and drinking water. Water for dust suppression, vehicle wash, and compaction will need to be pumped from the San Juan River or from an artesian well near the fairgrounds northwest of the site to supplement the existing supply line.

E.3.3.5 Drainage, erosion control, and waste-water retention basin

During remedial action, all drainage from the site will be effectively blocked from reaching any waterways. Areas disturbed by construction activities will be graded so that runoff will drain, via ditches or other means, to a waste-water retention basin. Drainage ditches will be lined with erosion resistant materials. In addition, the ditches will be designed and maintai- o carry the 10-year storm event for the area tributary t channel. Runoff from land outside of affected areas will be diverted away from the site. Diversions will be designed and maintained to prevent runon to unreclaimed areas from the 10-year storm event (see Attachment A, Section 3.0, Site Drainage).

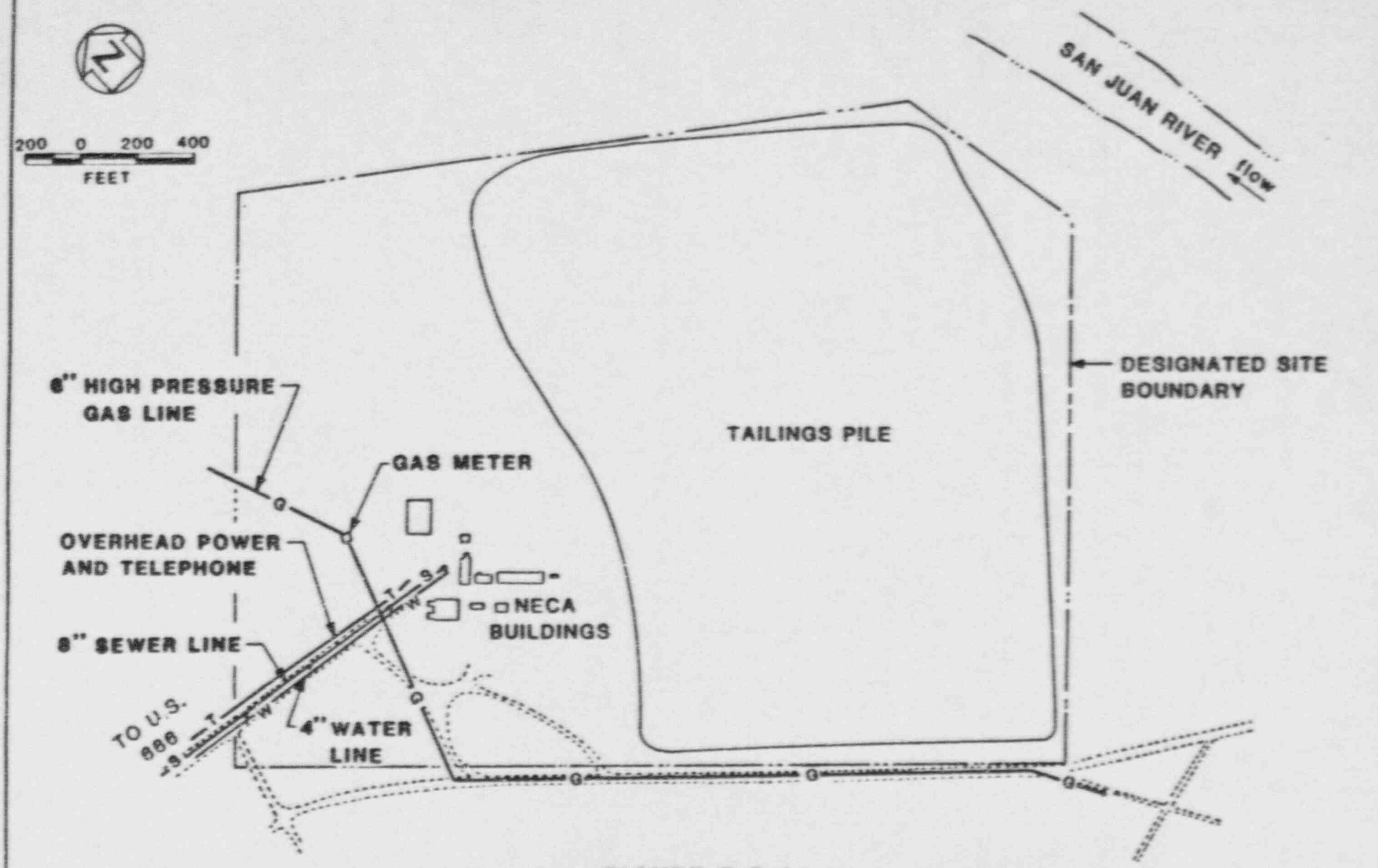


FIGURE E.3.1
EXISTING UTILITIES FOR THE SHIPROCK SITE

Construction activities in the floodplain will be scheduled for the low-flow periods. Flood or runoff water, trapped by construction activities, will be pumped or otherwise transported to the waste-water retention basin.

The waste-water retention basin will receive waters resulting from:

- o Decontamination activities including equipment washing and truck washdown.
- o Runoff from contaminated materials.
- o Laundry waste from washing protective clothing.
- o Shower and wash basin waste water.

The retention basin capacity (6.4 acre-feet) will provide storage for the 10-year 24-hour storm runoff (4.8 acre-feet) as well as sediment storage capacity for the life of the project (0.3 acre-feet). Excess capacity is provided so that sediment will not be removed until the end of the project. The emergency outlet from the basin will safely pass the 25-year storm peak runoff (85 cubic feet per second) with one foot of freeboard (see Attachment A, Section 5.0, Waste-Water Retention Basin). Uncontaminated Mancos Shale excavated during basin construction will be recompacted to form a liner or will be used in the escarpment reconstruction.

E.3.3.6 Equipment decontamination pad

A decontamination pad with holding pond and recirculating pump will be provided to wash contaminated equipment, thereby preventing contaminated materials from being carried out of the area.

E.3.3.7 Dust control

Dust generated by excavation, earth movement, vehicle use, temporary materials stockpiling, and similar activities will be controlled and minimized by the use of Best Available Control Technology (BACT). Special care will be taken to control dust created by building decontamination or demolition and the temporary stockpiling or mixing of contaminated materials.

It is anticipated that water with a water-based surfactant sprayed under moderately high pressure (from trucks and hoses) will be adequate to control dust. In addition, hoses will be available for areas of excavation.

The sources for dust suppression water will include impounded tailings water, surface runoff, and water pumped from the San Juan River or an artesian well. Recycled water will be used as available.

The schedules for spraying the roads and pile areas will vary daily and will be determined on an hour-by-hour basis. The frequency of spraying will increase as combinations of low soil moisture and high wind speed conditions are encountered.

E.3.3.8 Ramp to floodplain

A construction ramp will be built east of the tailings piles in an existing arroyo. It will be graded to a slope no greater than eight percent to allow construction equipment access to the floodplain. The ramp will also provide access for the reconstruction of the arroyos from below.

E.3.3.9 Borrow area

The proposed borrow area covers approximately 88 acres and can supply all of the materials required for construction of the embankment cover, escarpment reconstruction, rock erosion control, and site restoration. The east portion of the proposed borrow area is currently the NECA borrow area. Mesa Verde Cactus (threatened species) and archaeological sites are located south of the proposed borrow area, as shown in Figure E.3.2. Control of personnel access and equipment traffic will be necessary in order to avoid disturbances of these areas. Based on test pit and borehole sampling, the proposed borrow area is estimated to contain 1,212,000 cubic yards of silty sand and sandy silts, 593,000 cubic yards of sandy gravel with cobbles, and virtually unlimited quantities of Mancos Shale (see Attachment A, Section 1.0, Earthwork Volumes).

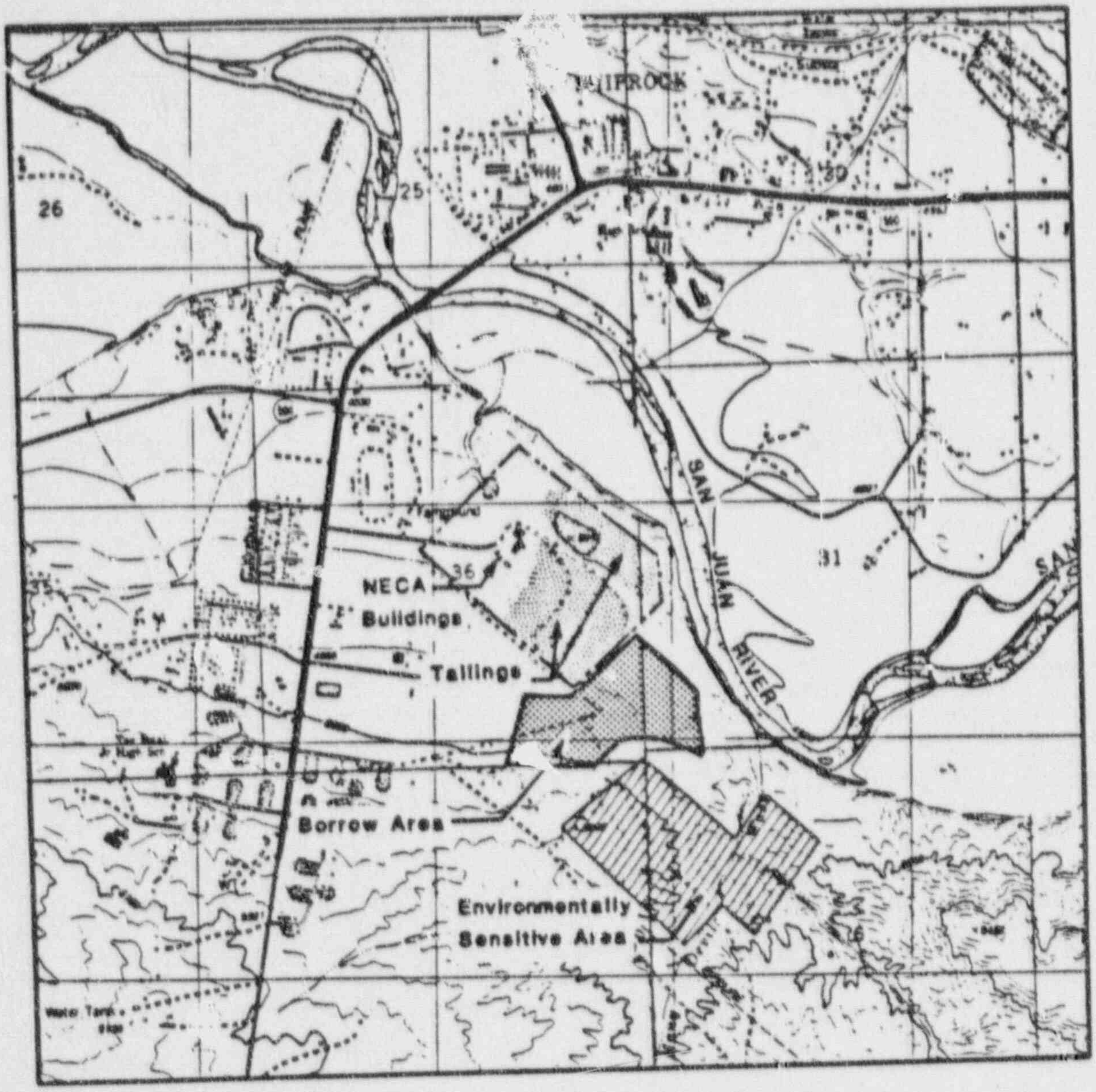
E.3.3.10 Construction sequence

The following construction sequence is outlined as a possible means of accomplishing the remedial action.

Initially, a site security system will be set up and coordinated with staging and vehicle decontamination areas. This will provide control of traffic entering and leaving the site, and prevent unauthorized traffic from entering the area.

The next major item of site preparation will consist of construction of a waste-water retention basin. Materials excavated from the basin area will be stockpiled for later use as fill. Site preparation also includes construction of drainage and erosion control measures.

Concurrent with these initial activities, the building decontamination and demolition process (as necessary) can also



BASE MAP REFERENCE: USGS 7½ MINUTE TOPOGRAPHIC QUADRANGLE MAP, "SHIPROCK, NEW MEXICO" DATED 1983

FIGURE E.3.2
SHIPROCK SITE AND SURROUNDING AREA SHOWING BORROW AND ENVIRONMENTALLY SENSITIVE AREAS

be performed. However, the movement of rubble from any demolition will not begin until a sufficient area has been opened within the tailings embankment to allow final placement.

The initial work on the embankment will involve the relocation of material away from the edge of the escarpment and the steep sides of the existing piles toward the center. At the same time, equipment will be able to excavate tailings (as necessary) from the floodplain and windblown areas and add them on top of the tailings embankment.

The cover construction will begin when all the contaminated materials are in place. The cover materials will be obtained from the adjacent borrow area, placed in lifts, and compacted to the design thickness of seven feet. Drainage ditches will be excavated around the embankment. The final stages of remedial action will involve overall site drainage grading; placement of rock cover over the embankment, in the drainage ditches and on the top of the escarpment; restoration and revegetation of disturbed areas, as appropriate; and construction of an access road and security fence around the embankment.

E.4 SITE DESIGN CRITERIA

E.4.1 INTRODUCTION

The Project Site Design Criteria (SDC) is a separate document (UMTRA-DOE/AL-050424.0049) that is to be used in conjunction with the SCD, by the Remedial Action Contractor (RAC), as the basis or guideline for preparation of the final design documentation for the UMTRA Project sites. The SDC provides guidance on the operating procedures, formats for drawings, specifications, calculations, schedules and cost estimates, and minimum design constraints to be incorporated in the final design documents.

It is further intended to provide sufficient criteria for the reader to understand the constraints, procedures, codes, and standards to be used during the design and performance of the remedial actions at the UMTRA Project sites. Additional design criteria and instructions specific to the Shiprock site are included in the following sections.

E.4.2 DESIGN INSTRUCTIONS

This site conceptual design and the Project site design criteria have been developed for use as a guide for the detailed design task. In no instance are they to be interpreted as precluding good engineering judgement and professionally-accepted procedures.

The conceptual design and these criteria were developed using the information available at the date of issue. The data and information available as of this date do not necessarily represent all of the data required for the Shiprock detailed design. The design engineer will examine the data provided relative to Shiprock and will bring any additional data needs or questions to the attention of the UMTRA Project Office in a timely manner prior to the start of design.

The design engineer will not proceed with the detailed design of a particular aspect of the project until all questions regarding that aspect of the conceptual design have been resolved.

E.4.3 SPECIFIC DESIGN CRITERIA

There are two areas regarding special consideration for the Shiprock Remedial Action. First, because of the archaeological sites and threatened species in close proximity to the borrow area, as shown in Figure E.3.2, the remedial action shall be conducted so that these areas are not damaged or disturbed. Specifically, the RAC shall institute and maintain controls appropriate to prevent intrusion into these areas by construction equipment or personnel.

Additionally, portions of the floodplain below the escarpment are considered to be wetlands as defined by Section 404 of the Clean Water Act. Consequently, the RAC shall incorporate the requirements of the

U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, and EPA into the plans for the removal of contaminated materials from this area and subsequent area restoration.

E.5 DRAWINGS

The conceptual design for the remedial action plan at Shiprock has five drawings associated with the package. These drawings include a Title Sheet, Location Map, Vicinity Map and List of Drawings, Plot Plan, Grading Plan, and Sections. Copies of the drawings are located in this section of the report.

UNITED STATES
DEPARTMENT OF ENERGY

UMTRA

URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT

CONCEPTUAL DESIGN

SHIPROCK, NEW MEXICO

Figure E.5.1

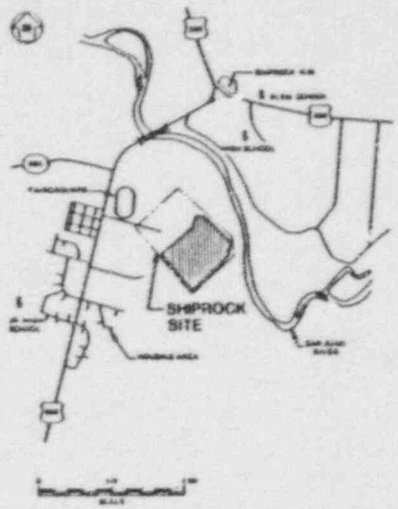
U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

SHIPROCK SITE
SHIPROCK, NEW MEXICO
TITLE SHEET

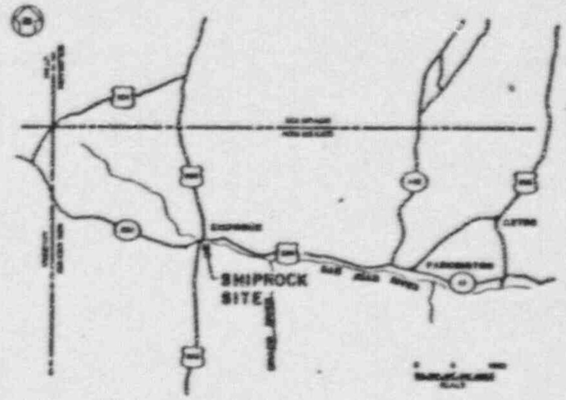
0		ISSUE FOR APPROVAL
A		ISSUE FOR REVIEW
NO	DATE	REVISIONS

JACOBS ENGINEERING GROUP INC.
JACOBS - WESTON TEAM
ALBUQUERQUE, NEW MEXICO

PROJECT NO. DE-AC04-82AL14056
SHP-PS-40 0001



VICINITY MAP



LOCATION MAP

LIST OF DRAWINGS

1. TITLE SHEET
2. LOCATION MAP, VICINITY MAP & LIST OF DRAWINGS
3. PLOT PLAN
4. GRADING PLAN
5. SECTIONS

Figure E.5.2

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

SHIPROCK SITE
SHIPROCK, NEW MEXICO
LOCATION MAP, VICINITY MAP
& LIST OF DRAWINGS

B		ISSUE FOR APPROVAL
A		ISSUE FOR REVIEW

JACOBS ENGINEERING GROUP INC.
JACOBS - WESTON TEAM
ALBUQUERQUE, NEW MEXICO

PROJECT NO. DE-AC04-82AL14086

DRAWING NO. SHP-PS-40-0002


NOTES
LEGEND
U.S. DEPARTMENT OF ENERGY
SHIPROCK SITE
SHIPROCK, NEW MEXICO
PLOT PLAN
TRUE NORTH
SAN JUAN RIVER
EMBANKMENT
AREA
TOP OF SLOPE
TOE OF SLOPE
PUBLIC HEALTH SERVICE
ENTRANCE GATE
STAGING & DECONTAMINATION AREA
CUTOFF WALL
EXISTING GAS METER
EXISTING OVERHEAD POWER AND TELEPHONE
FEET

Figure E.5.3

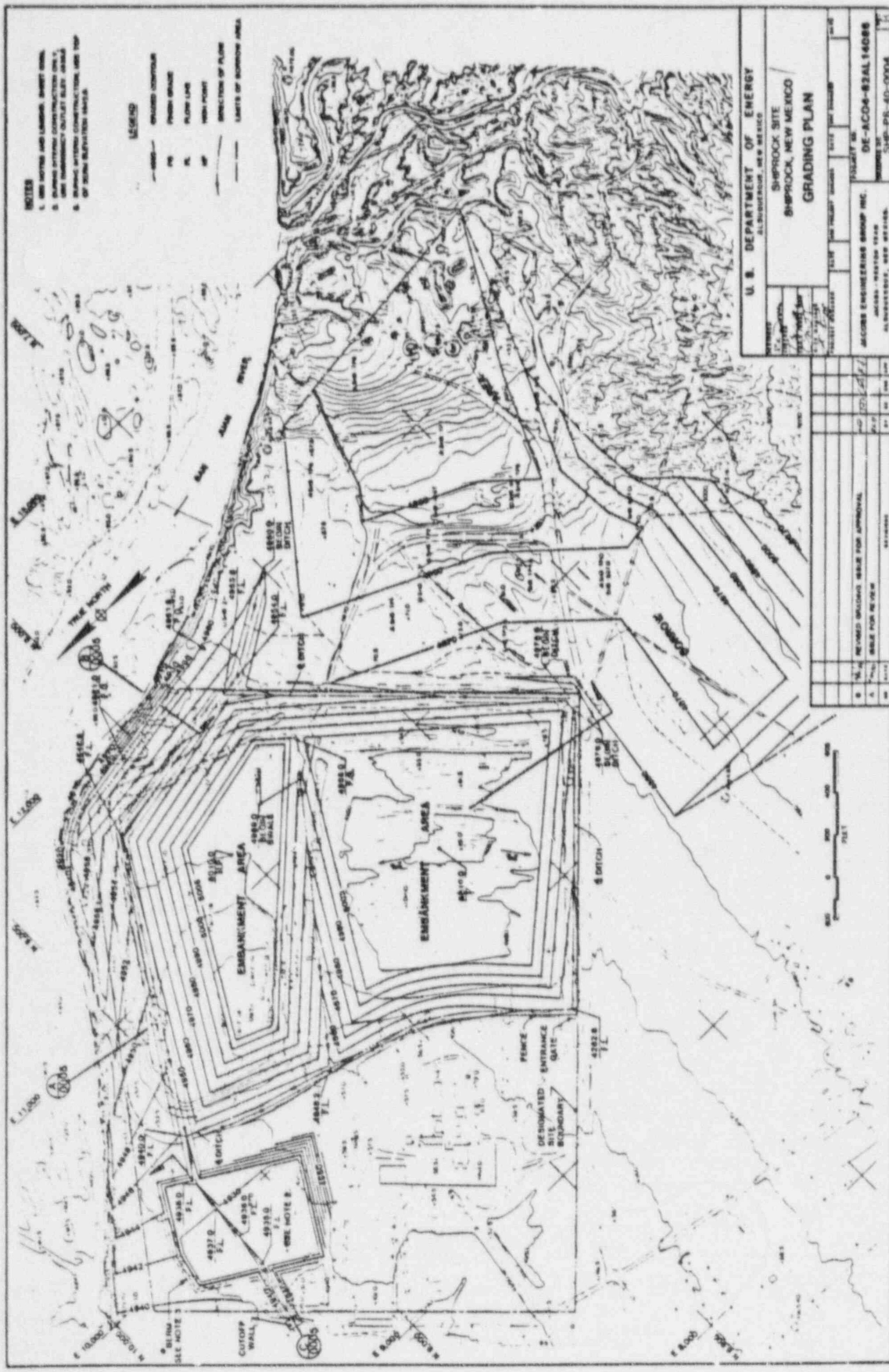

U.S. DEPARTMENT OF ENERGY
SHIPROCK SITE
SHIPROCK, NEW MEXICO
GRADING PLAN
EMBANKMENT AREA
EMBANKMENT AREA
TRUE NORTH
DESIGNATED SITE BOUNDARY
ENTRANCE GATE
FENCE
CUTOFF WALL

Figure E.5.4

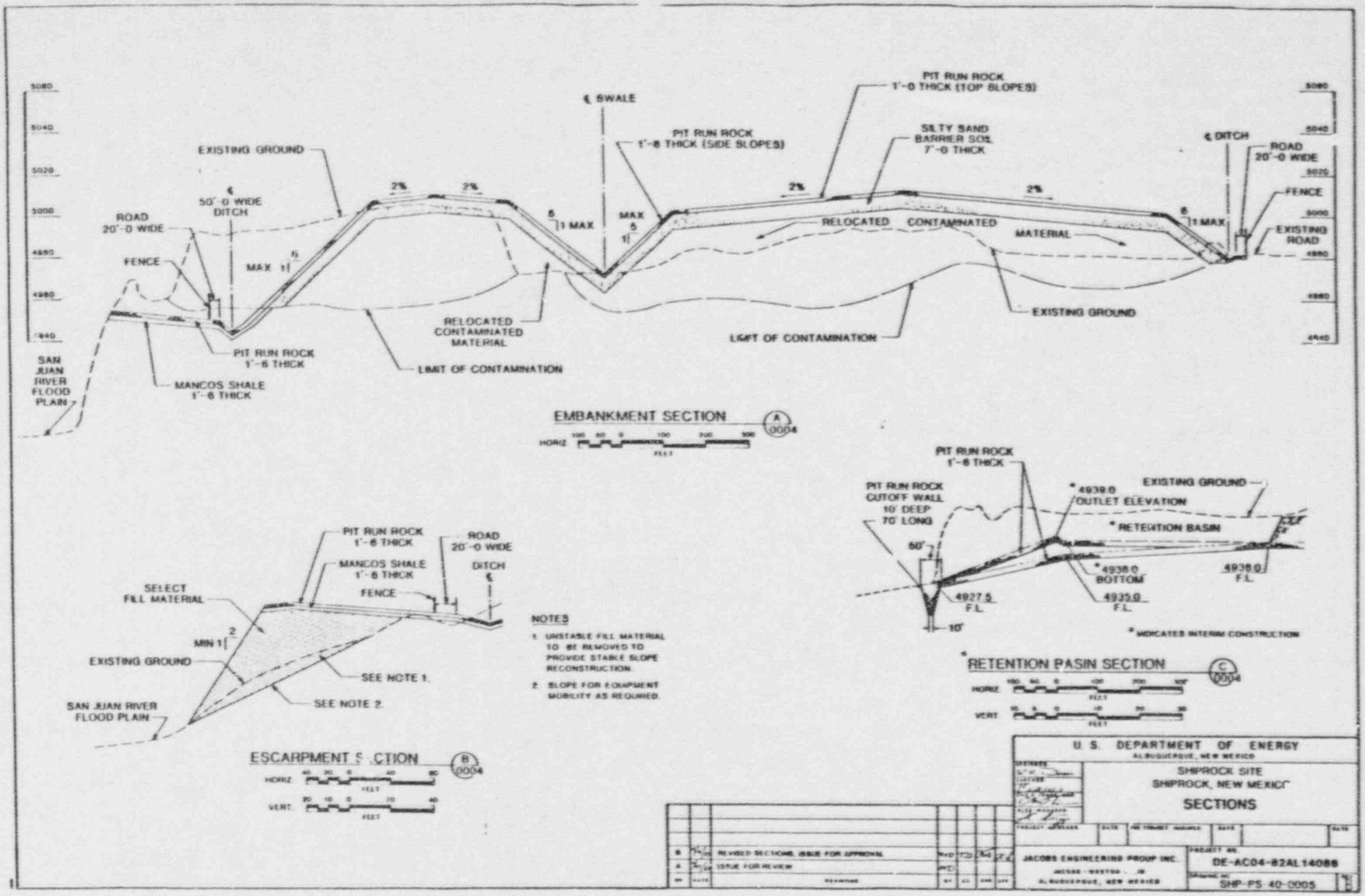

EMBANKMENT SECTION
ESCARPMENT S CTION
RETENTION PASIN SECTION
NOTES
1. UNSTABLE FILL MATERIAL TO BE REMOVED TO PROVIDE STABLE SLOPE RECONSTRUCTION.
2. SLOPE FOR EQUIPMENT MOBILITY AS REQUIRED.
PIT RUN ROCK 1'-0 THICK (TOP SLOPES)
PIT RUN ROCK 1'-6 THICK (SIDE SLOPES)
SILTY SAND BARRIER SOIL 7'-0 THICK
RELOCATED CONTAMINATED MATERIAL
LIMIT OF CONTAMINATION
EXISTING GROUND
ROAD 20'-0 WIDE
FENCE
EXISTING ROAD
50'-0 WIDE DITCH
MANCOS SHALE 1'-6 THICK
SAN JUAN RIVER FLOOD PLAIN
SELECT FILL MATERIAL
SEE NOTE 1.
SEE NOTE 2.
PIT RUN ROCK CUTOFF WALL 10' DEEP 70' LONG
*4939.0 OUTLET ELEVATION
*RETENTION BASIN
*4938.0 BOTTOM
4935.0 F.L.
4938.0 F.L.
4927.5 F.L.
* INDICATES INTERIM CONSTRUCTION
U.S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
SHIPROCK SITE
SHIPROCK, NEW MEXICO
SECTIONS
JACOBS ENGINEERING GROUP INC.
DE-AC04-82AL14086
SHP-PS-40-0005
REVISED SECTIONS, ISSUE FOR APPROVAL
ISSUE FOR REVIEW

Figure E.5.5

E.6 PRELIMINARY CAPITAL COST ESTIMATES

The construction cost for the processing site remedial action described in this document, including field supervision, is estimated to be $9,580,000, as summarized in Table E.6.1. A detailed distribution of the construction cost is given in Table E.6.2. This cost does not include any monies for:

- o Property acquisition.
- o Engineering design.
- o Construction management except for field supervision and monitoring at the site.
- o Vicinity properties remedial action.
- o Overall management and supervision.

Total cost estimate of the Shiprock remedial action is contained in Section 5.7 of the Remedial Action Plan.

A more definitive estimate of the capital cost will be prepared after the detailed design has been completed.

Table E.6.1 Summary of construction costs - Shiprock SIP

Item	Cost ($000)
Site preparation	400
Tailings pile	2,060
Pile cover	3,800
Stabilize escarpment	760
Decontamination	30
Site restoration	170
Security	90
Supervisory and field services	2,270
Total	$ 9,580

Table E.6.2 Detailed construction costs - Shiprock SIP

Item	Cost
SITE PREPARATION	
1. Mobilization (lump sum)	120,000
2. Roads (lump sum) o Upgrade and maintain existing roads	60,000
3. Staging area (lump sum) o Laydown and parking facilities	20,000
4. Demolition (lump sum)	-0-
5. Site earthmoving o Clear and grub (30 acres) o Evaporation pond (26,000 cy) o Drainage (35,000 cy) o Ramp to floodplain (27,000 cy)	200,000
Site preparation total	$ 400,000
TAILINGS PILE	
1. Consolidate material o Mill site, windblown, and vicinity properties (91,000 cy)	240,00
2. Contour pile (930,000 cy)	1,820,000
Tailings pile total	$ 2,060,000
PILE COVER	
1. Silty sand (1,147,000 cy)	3,305,000
2. Pit run rock (172,000 cy)	495,000
Pile cover total	$ 3,800,000

Table E.6.2 Detailed construction costs - Shiprock SIP (Continued)

Item	Cost
STABILIZED ESCARPMENT	
1. Cut and grade (35,000 cy)	60,000
2. Fill and grade (131,000 cy)	345,000
3. Shale cover (34,000 cy)	265,000
4. Pit run rock cover (34,000 cy)	90,000
Stabilize escarpment total	$ 760,000
DECONTAMINATION	
1. Equipment washdown (lump sum)	
Decontamination total	$ 30,000
SITE RESTORATION	
1. Fill material (46,000 cy)	120,000
2. Vegetate (40 acres)	50,000
Restoration total	$ 170,000
SECURITY	
1. Perimeter fence (7600 LF)	
Security total	$ 90,000
SUPERVISORY AND FIELD SERVICES	
1. Field staff o Site superintendent o Field engineer o Office manager o Safety engineer o Schedule/cost engineer o Secretary	655,000

Table E.6.2 Detailed construction costs - Shiprock SIP (Concluded)

Item	Cost
SUPERVISORY AND FIELD SERVICES (Continued)	
2. Field services o Additional labor o Security o Survey crew o Inspection	440,000
3. Field health services o Health physics manager o Access control technicians o Truck monitors o Laboratory services o Equipment and miscellaneous o Land survey o Final certification	830,000
4. Temporary facilities o Field office o Field office expenses o Change and shower unit o Temporary utilities o Temporary sanitary facilities o Insurance o Consumable supplies o Laundry and operation o Mobile equipment o Fencing, barricades, signs, and miscellaneous	345,000
Supervisory and field services total	$ 2,270,000
CONSTRUCTION COST TOTAL	$ 9,580,000

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ATTACHMENT A

CALCULATIONS SUMMARIES

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 EARTHWORK VOLUMES

I. PROBLEM STATEMENT

This section summarizes three separate sets of calculations involving earthwork at the site. The calculations and their purposes are identified as follows:

A. Site and Embankment Earthwork

1. Verify that the embankment is sized sufficiently for the estimated contaminated material.

2. Provide quantities for cost estimating purposes.

B. Contaminated Material

1. Provide a location and quantity of contaminated material for approximate limits of excavation.

2. Provide an average Ra-226 profile of the regraded tailings and windblown materials for the radon barrier thickness calculation (Section 2.0, Radon Barrier Thickness).

3. Provide quantities for cost estimating purposes.

C. Borrow Material

1. Identify a potential borrow source with an estimate of available quantity.

2. Evaluate the borrow material properties for use as the radon barrier layer and for erosion protection.

3. Recommend design criteria for placement of the radon barrier.

II. METHODS OF CALCULATION

A. Site and Embankment Earthwork

1. The available embankment volume, the cut and fill material around the embankment, and other various quantities were estimated using the average end area method. This method calculates volume between two cross-sections by averaging the two sections and multiplying by the distance between them.

2. The embankment cover and other various quantities were estimated by multiplying the appropriate thickness by the areal extent involved.

B. Contaminated Material

1. In general, the remedial action plan calls for excavating or covering all materials in excess of 15 pCi/g. Radiological data (FBDU, 1981; Bendix, 1983a) were used to determine the extent of windblown and mill yard contamination. An analysis of drill log data (MSRD, 1982) was made to locate the physical interface of the tailings and natural ground. Radiological data (Brewer et al., 1982) were then analyzed to determine the depth to which contamination has migrated. It was assumed that large construction equipment would be used for excavation. Therefore, estimated volumes may be somewhat larger than that which might be expected if more effort were made to segregate the soils according to contamination levels.

2. The average Ra-226 profile of the regraded tailings was found using laboratory analysis of 348 samples (Bendix, 1983b) from 84 borings (MSRD, 1982) (Figure 1.1). The slimes fraction of the tailings have a higher Ra-226 content than the sands fraction and it was assumed that the areas of predominantly slimes (Figure 1.2) would be excavated separately and placed first in the areas requiring the most fill. Any predominantly sand areas would then be excavated and placed in the top six or more feet of the recontoured pile. The average Ra-226 profile of the regraded tailings was then found by averaging the Ra-226 concentration at each depth increment for all of the borings. This results in the overall recontoured pile having an average Ra-226 value representative of sands to a depth of 10 feet.

   The average Ra-226 content of the windblown materials was calculated by averaging the analysis of several hundred samples (Bendix, 1983a).

C. Borrow Material

1. The potential borrow material area is adjacent to and southeast of the site. The available borrow volumes were calculated using the average end area method where the volume between horizontal sections is found by averaging section areas and multiplying by the depth between them.

2. Field data (DOE, 1982) were used to evaluate potential borrow materials. The chosen area was investigated further by drilling seven test holes and digging 10 test pits in May, 1983. Bulk samples were obtained and returned to Sergent, Hauskins, and Beckwith Engineering's soil laboratory in Albuquerque, New Mexico, for testing (TAC, 1983).

3. Laboratory tests consisting of classification, grain size distribution, remolded permeability, and moisture-density relationships were performed.

III. CONCLUSIONS

A. Site and Embankment Earthwork

The estimated total volume of contaminated materials in the tailings piles area is 1,943,000 cubic yards. The estimated volumes of earthwork required to complete the remedial action are summarized in Table 1.1.

B. Contaminated Material

The areas of cut and fill of the embankment are shown in Figure 1.2. The areas of windblown contamination are shown in Figure 1.3. The estimated volumes of contaminated material from windblown areas and the mill yard are summarized in Table 1.1. The average Ra-226 content of the regraded tailings is shown in Table 1.2. These values have been averaged for each 2.5 feet in depth below the ground surface and are classified as to material type based upon the average Ra-226 value. Actual soils contained in the reconstructed pile will range from slimes to sand at any particular location or depth. The average Ra-226 content of the windblown materials is 47 pCi/g.

C. Borrow Material

1. The potential borrow materials range from silty sands (SM) and sandy silt (ML) to sandy gravel with cobbles (GW-GM) to Mancos Shale (GC-CL). The borrow area is estimated to contain 1,212,000 cubic yards of silty sands and sandy silts and 593,000 cubic yards of sandy gravel with cobbles. The available volume of Mancos Shale is very large although excavation could be difficult at less weathered (deeper) depths.

2. The laboratory remolded hydraulic conductivity values for the silty sand and sandy silt ranged from 0.2 to 20.0 feet per year. The Mancos Shale values were in the order of 10^{-7} to 10^{-9} cm/sec. It is reported that field hydraulic conductivity values can be 10 times higher than lab determined values for cohesive, fine drained soils (Daniel, 1981; Folkes, 1982).

3. The radon barrier layer materials (silty sand (SM) and sandy silt (ML) soils) should be treated in the following manner to achieve the design hydraulic conductivity values, densities, and moisture contents.

   a. Compact to a minimum dry density of 95 percent of the standard Proctor density (ASTM D698).

   b. Compact between optimum moisture content and three percent above optimum moisture as determined by the standard Proctor test (ASTM D698).

4. If Mancos Shale (GC-CL) is used as uncontaminated fill or for escarpment seepage barrier, the following procedures should be followed:

a. Rip and track weathered Mancos Shale in the borrow area with crawler mounted bulldozers and wet in-place as much as practicable prior to transporting.

b. Monitor placement and compaction of Mancos Shale materials to prevent nesting of large fragments and to obtain a uniform compacted soil mass.

c. Use sheeps foot roller to compact Mancos Shale materials.

d. Compact to radon barrier criteria (3a. and b., above) for seepage barrier.

5. Volumetric shrinkage of the silty sands and sandy silts is expected to be less then 20 percent from in-situ to compacted conditions.

IV. REFERENCES

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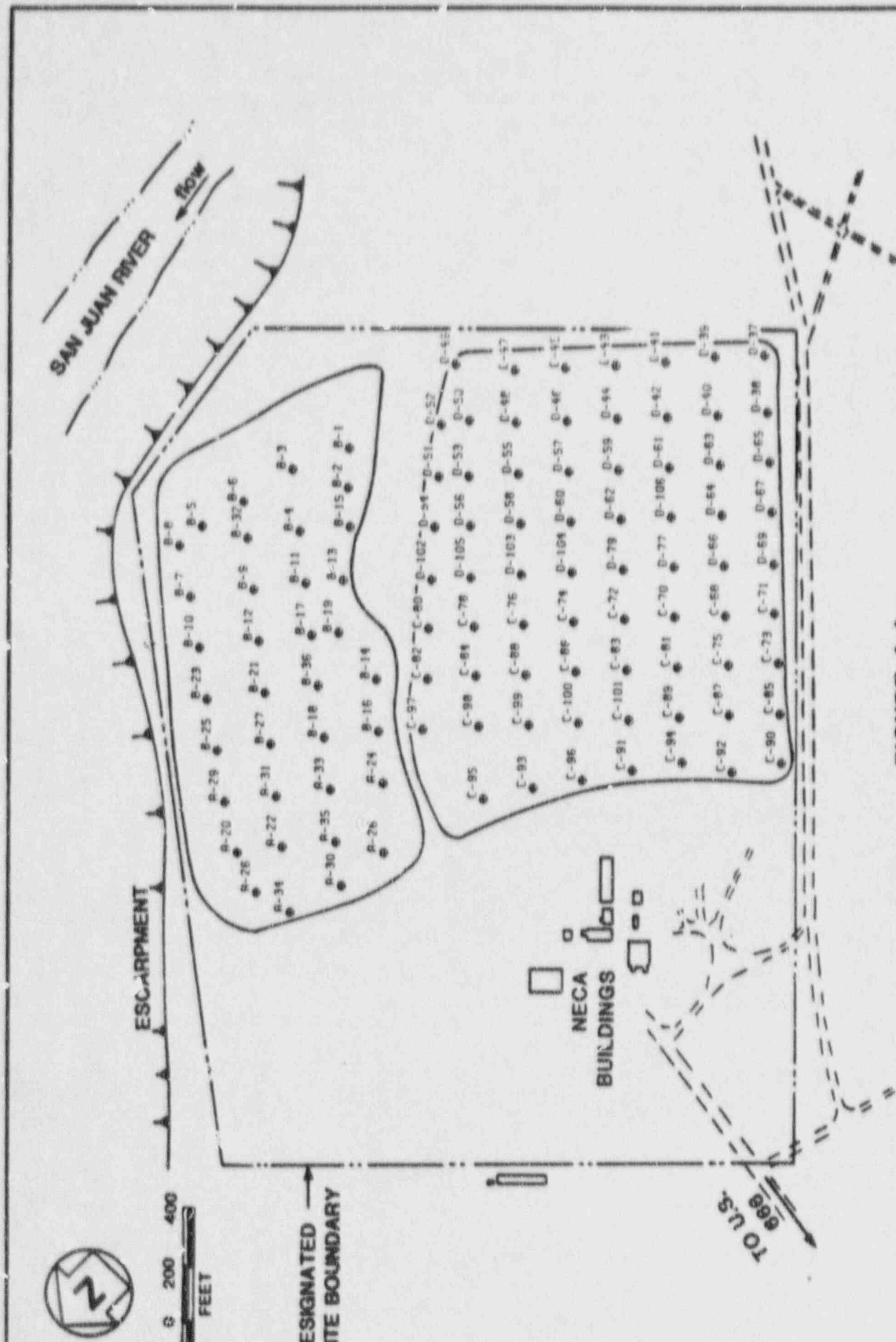


FIGURE 1.1
BORING LOCATIONS
SHIPROCK SITE

(Adapted from MSRD, 1982.)

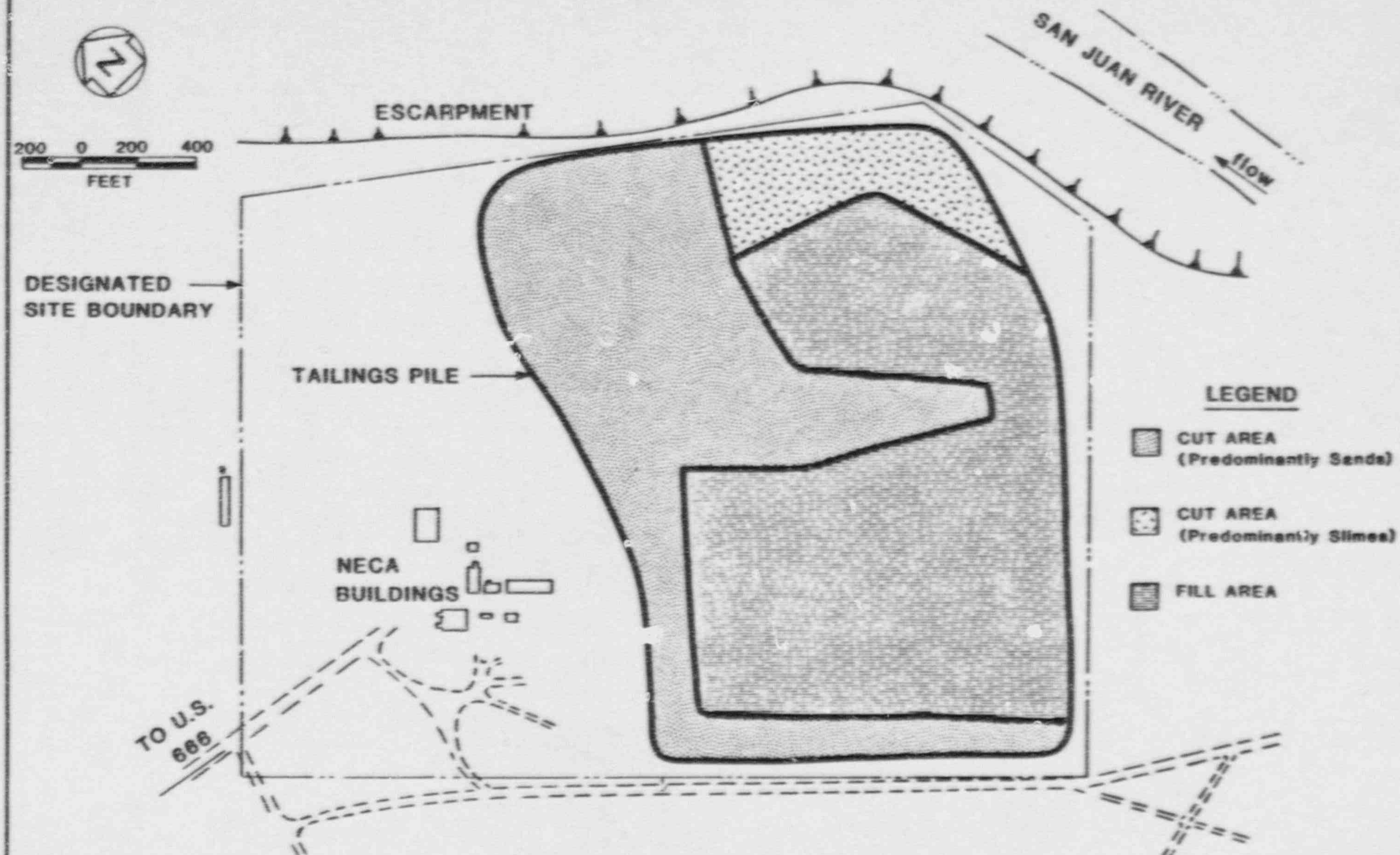
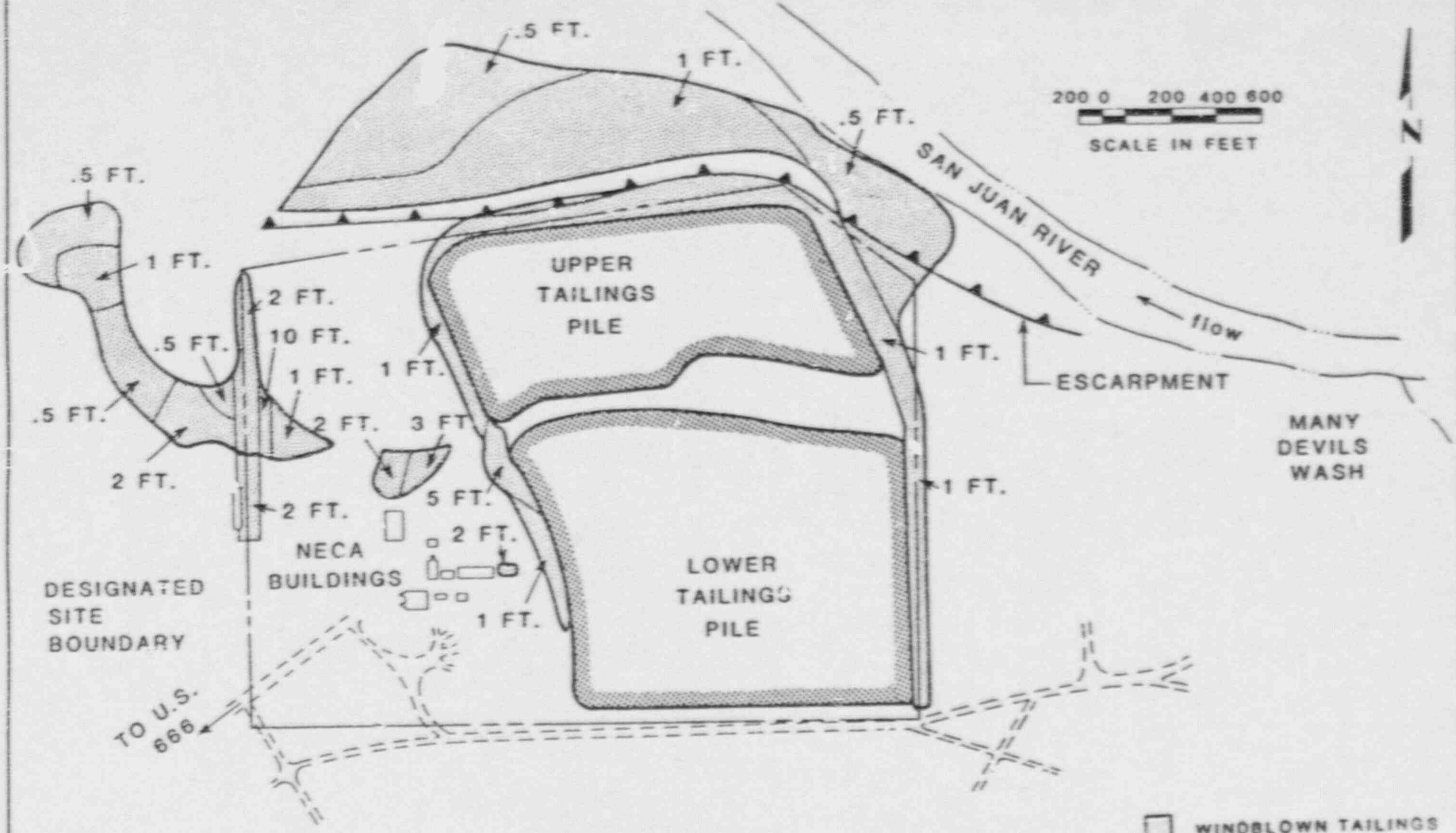


FIGURE 1.2
SHIPROCK TAILINGS
CUT AND FILL FOR REGRADING



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SHP-01-0008

FIGURE 1.3

WINDBLOWN CONTAMINATION ON AND ADJACENT TO THE SHIPROCK SITE

Table 1.1 Earthwork quantities

Item	Quantity
1. Embankment cover:	
7'-0" thick silty sand barrier soil	1,147,000 cy
Pit run rock	
top (1'-0" thick)	52,800 cy
sides (1'-6" thick)	104,200 cy
2. Contaminated material to be relocated	930,000 cy
3. Windblown and mill yard contaminated material to be relocated	75,000 cy
4. Vicinity properties	16,000 cy
5. Escarpment cover	
Pit run rock (1'-6" thick)	34,000 cy
Mancos Shale (1'-6" thick)	34,000 cy
6. Escarpment preparation:	
Cut material	35,000 cy
Fill material	131,000 cy
7. Floodplain restoration select material	41,000 cy
8. Drainage control	
Pit run rock (1'-0" thick)	14,400 cy
9. NECA area restoration	5,000 cy

Table 1.2 Average radium-226 profile for regraded tailings

Depth of tailings (ft from surface)	Predominant[a] composition	Average Ra-226 (pCi/g)
0-2.5	Sands	398.3
2.5-5.0	Sands	396.4
5.0-7.5	Sands	371.4
7.5-10.0	Sands	360.2
10.0-12.5	Slimes	790.7
12.5-15.0	Slimes	495.5
15.0-17.5	Mixed	462.2
17.5-20.0	Mixed	308.3
20.0-22.5	Mixed	485.7

[a]Based on the average Ra-226 values.

2.0 RADON BARRIER THICKNESS

I. PROBLEM STATEMENT

The tailings at the Shiprock, New Mexico, site encompass about 72 acres. The two piles will be reshaped and contoured into a uniform configuration and will ultimately occupy approximately 76 acres. Windblown contamination from the surrounding area will be placed on top of the pile to help reduce the required amount of cover material for radon emission control. In order to meet the EPA flux standard of 20 $pCi/m^2 sec$, an earthen cover of locally available borrow material will be placed on top of the tailings.

II. METHODS, DATA, AND ASSUMPTIONS

The RAECO model (Rogers et al., 1981a) is utilized to calculate the thickness of cover material required on the site. The model and input parameters are described in the following sections.

A. RAECO Model

The development of the model begins with the following diffusion equation:

$$D \frac{d^2 C(x)}{dx^2} - K_d C(x) + \frac{Q(x)}{P} = 0 \qquad (2\text{-}1)$$

where

$C(x)$ = radon concentration in the material pore space at position x

K_d = radon decay constant

$Q(x)$ = radon source at position x

D = diffusion coefficient

P = porosity

This equation describes a system in which radon transport occurs through a one-dimensional radon concentration gradient. Upon solving this differential equation, the result for any layer (i) is:

$$C_i(x) = A_i \exp(a_i x) + B_i \exp(-a_i x) + S_i \qquad (2\text{-}2)$$

where

A_i, B_i = constants defined by boundary conditions

$a_i = (K_d/D_i)^{\frac{1}{2}}$

$S_i = Q_i/(K_d P_i)$

From Fick's Law, the radon flux, $J_i(x)$ is:

$$J_i(x) = -D_i P_i \frac{dC_i(x)}{dx} \qquad (2\text{-}3)$$

D_i = diffusion coefficient of layer i
P_i = porosity of layer i

Substituting C_i from equation (2-2) into equation (2-3), yields for the flux exiting layer i:

$$J_i\ (x) = -D_i P_i a_i\ ((A_i \exp\ (a_i x) - B_i \exp(-a_i x))) \qquad (2\text{-}4)$$

This equation applies to all layers in a multi-layer system and the RAECO model will analyze a system with up to 100 layers. The flux and concentration boundary conditions yield a complete set of equations for the constants A and B. These formulate a matrix which, when solved, gives the flux that will result from an assumed cover thickness. RAECO can vary the cover materials to obtain the optimum cover thickness that will meet the radon flux standard and/or any minimum cover thickness requirements.

The reader is referred to the RAECO manual (Rogers et al., 1981b) for a complete analysis of the RAECO model.

B. Input Parameters

There are a number of input variables that are required to calculate the final radon flux through the cover and the cover thickness. These parameters are:

- Diffusion coefficients of tailings and cover, D_t, D_c.
- Porosities of tailings and cover, P_t, P_c.
- Pile thickness, X_o.
- Background radon concentration, C_b.
- Radon source term of tailings and cover, Q_t, Q_c.

Each of these parameters will be addressed in the following calculation section. The source of each value will be identified along with the value itself.

III. CALCULATION

A. Diffusion Coefficients

The cover thickness required to attenuate the radon emissions from the pile is greatly dependent on the diffusion coefficient of the material used for cover. Also, the amount of radon which is released from the tailings is dependent on the diffusion coefficient of the tailings. Therefore this parameter is the most critical for the RAECO model analysis.

The cover material will be silty, sandy soil excavated from an area adjacent to the site. Rogers & Associates Engineering Corporation (RAE), measured diffusion coefficients of this material from six test pits; the results are shown in Table 2.1 (pages 17 and 18). In-situ measurements of soil moistures have been made in the Shiprock area (Rogers et al., 1981b). Annual average moistures in a similar soil as the candidate cover material ranged from five percent at a depth of 1.3 feet to eight percent at a depth of 4.2 feet. The location where measurements were taken had no rock covering nor vegetation. These soil moistures are also consistent with an estimate of 7.7 percent obtained from an engineering correlation using Shiprock climatological parameters and a soil texture parameter representative of the cover soil (Rogers and Nielson, 1981). Based upon this information, it has been estimated that the top foot of soil cover under the rock cover will maintain a moisture content of five percent, and soil cover materials below one foot will have a moisture content of 7.5 percent. The data in Table 2.1 were used to determine the diffusion coefficients in the cover soil. Based on these data, the diffusion coefficient of the top foot of soil cover is 0.025 cm^2/sec, the remainder of the soil cover has a diffusion coefficient of 0.017 cm^2/sec.

Test pits were also dug in the tailings and samples were taken. RAE measured the diffusion coefficient at varying moisture contents for each of the samples and these data are in Table 2.2 (page 19). For modeling purposes, the tailings pile has been divided into 10 separate layers, the top five layers consist of sands, the next two layers are slimes, and the bottom three layers are mixed sands and slimes. The tailings sand diffusion coefficient is 0.039 cm^2/sec, based on a moisture content of 6.5 percent determined by the same methods used for cover materials. The diffusion coefficient for slimes is 0.022 cm^2/sec based on a moisture content of 9.5 percent, and that for the sand/slime mixture is 0.042 cm^2/sec based on 7.4 percent moisture. The windblown material, the top layer on the pile, is assumed to have the same diffusion coefficient as the tailings sands.

The RAECO model requires diffusion coefficient data input in the form of the effective diffusion coefficient, which is the diffusion coefficient multiplied by the porosity of the material. The porosity P is calculated from:

$$P = 1 - \frac{W}{W_w SG}$$

where

W = Dry bulk density (g/cm^3) (as shown in Tables 2.1 and 2.2).
SG = Specific gravity of the soil (dimensionless) as shown in Tables 2.1 and 2.2.
W_w = Density of water = 1.0 g/cm^3.

Table 2.3 presents the diffusion coefficient, porosity, and effective diffusion coefficient for each layer of the tailings and radon control cover.

Table 2.3 RAECO model diffusion coefficient input

Material	Diffusion coefficient (cm^2/sec)	Porosity	Effective diffusion coefficient Dxp (cm^{2}sec)
Tailings sand	0.039	0.41	0.016
Tailings slimes	0.022	0.44	0.0097
Tailings sand/ slime	0.042	0.35	0.015
Windblown	0.039	0.41	0.016
Silty sand cover (top foot)	0.027	0.33	0.0089
Silty sand cover (below 1 foot)	0.016	0.33	0.0053

B. Tailings Thickness

The tailings piles will be contoured and reshaped in such a way that, for modeling purposes, the tailings pile can be treated as nine layers of tailings each 2.5 feet thick. The windblown contamination will be an additional layer of seven inches. These thicknesses are direct input to the RAECO model.

C. Background Radon Concentration

In the vicinity of the Shiprock pile, three background radon monitors were set up and 24-hour samples taken. The readings ranged from 0.66 pCi/l to 0.98 pCi/l with an average radon concentration of 0.8 pCi/l (FBDU, 1981). This average value was input to the RAECO model as a background radon concentration.

D. Radon Source Term

The radon source term, Q, is given by the following expression (Rogers and Nielson, 1981):

$$Q = R \times W \times E \times K_d$$

where

R = Average radium-226 concentration (pCi/g)
W = Dry bulk density (g/cm^3)
E = Emanating power
K_d = Radon decay constant (2.1×10^{-6}/sec)

The average Ra-226 concentration in the final configuration of the embankment was calculated in Section 1.0. It is presented in Table 2.4 (page 20) as supporting information for the calculation of the radon source term.

The average dry bulk density for each layer was obtained from the test results in Table 2.2 and is also given in Table 2.4.

The emanating power of the tailings sample was measured and the averages of the results are shown in Table 2.4.

Using these values the source term for each tailings layer was calculated and is in the last column of Table 2.4.

IV. RESULT

Using the inputs outlined in the previous section, the RAECO model indicates that 188 cm of silty sandy soil are required to reduce the radon flux below 20 pCi/m^{2}sec. For construction purposes and to be conservative, a minimum of seven feet of radon attenuation cover is used. In addition, material will be added for erosion control. The material necessary for erosion control is not accounted for in the radon attenuation calculation.

V. REFERENCES

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Table 2.1 Radon diffusion coefficients of cover [illegible]

Test pit	% Moisture (% dry/weight)	Density (g/cm^3) dry	Specific gravity	% Sat	D (cm^2/sec)
#1 0-2½'	1.6	1.74		9	4.5×10^{-2}
	3.5	1.74		20	3.7×10^{-2}
	6.6	1.74	2.498	38	3.6×10^{-2}
	6.7	1.73		38	4.3×10^{-2}
	12.5	1.75		73	2.9×10^{-3}
	12.8	1.75		75	4.3×10^{-3}
#2 2-7½'	2.3	1.75		12	3.0×10^{-2}
	3.0	1.74		15	1.9×10^{-2}
	7.6	1.71	2.654	37	2.9×10^{-2}
	7.6	1.71		37	3.0×10^{-2}
	13.0	1.74		65	9.9×10^{-3}
	13.6	1.73		68	4.2×10^{-3}
#3 7-11'	2.6	1.82		14	2.2×10^{-2}
	3.8	1.82		20	2.0×10^{-2}
	5.1	1.82	2.796	27	2.1×10^{-2}
	5.6	1.82		29	2.2×10^{-2}
	12.6	1.82		66	4.6×10^{-3}
	12.7	1.82		66	8.9×10^{-4}
#3 11'-15'	2.6	1.79		17	4.1×10^{-2}
	3.4	1.79		22	3.5×10^{-2}
	7.1	1.79	2.478	46	3.4×10^{-2}
	7.6	1.78		48	2.8×10^{-2}
	10.9	1.79		70	1.2×10^{-2}
	11.1	1.79		72	1.6×10^{-2}
#4 1-10'	3.0	1.71		15	4.2×10^{-2}
	3.2	1.77		18	2.1×10^{-2}
	3.5	1.66		16	2.7×10^{-2}
	5.5	1.77	2.617	30	2.4×10^{-2}
	6.5	1.77		36	1.8×10^{-2}
	12.8	1.77		70	6.1×10^{-3}
	13.2	1.77		72	4.0×10^{-3}
#8 (Shale)	3.4	1.85		18	2.0×10^{-2}
	3.5	1.84		19	1.8×10^{-2}
	5.4	1.85	2.82	29	2.2×10^{-2}
	6.1	1.84		32	1.6×10^{-2}
	12.2	1.85		66	8.0×10^{-4}
	13.0	1.85		70	9.8×10^{-4}

Table 2.1 Radon diffusion coefficients of cover material (Concluded)

Test pit	% Moisture (% dry/weight)	Density (g/cm^3) dry	Specific gravity	% Sat	D (cm^2/sec)
#2 - 9½-11'	2.4	1.75		12	3.9×10^{-2}
Many Devils Wash	3.8	1.74		19	2.9×10^{-2}
	5.8	1.76	2.67	30	1.7×10^{-2}
	6.6	1.74		33	3.0×10^{-2}
	12.5	1.76		65	1.5×10^{-3}
	13.6	1.74		68	1.0×10^{-3}

Ref. K. K. Nielson, 1983a.

Table 2.2 Radon diffusion coefficients of Shiprock tailings

Test pit	% Moisture (dry)	Density (g/cm^3) dry	Specific gravity	% Sat	D (cm^2/sec)
TP-1 Slimes	11.5	1.38		36	2.3×10^{-2}
TP-1 Slimes	11.7	1.38		37	2.1×10^{-2}
TP-1 Slimes	16.0	1.37	2.466	49	2.5×10^{-2}
TP-1 Slimes	16.8	1.39		54	2.2×10^{-2}
TP-1 Slimes	26.7	1.40		86	6.0×10^{-4}
TP-1 Slimes	29.5	1.39		94	5.1×10^{-4}
TP-2 Sands	6.0	1.50		22	4.0×10^{-2}
TP-2 Sands	6.8	1.50		25	3.8×10^{-2}
TP-2 Sands	9.3	1.51	2.55	34	3.8×10^{-2}
TP-2 Sands	9.4	1.51		35	1.9×10^{-2}
TP-2 Sands	13.3	1.51		49	1.0×10^{-2}
TP-2 Sands	13.5	1.51		50	9.8×10^{-3}
TP-2 Sand/slime	6.8	1.61		31	4.8×10^{-2}
TP-2 Sand/slime	7.2	1.59		31	4.3×10^{-2}
TP-2 Sand/slime	9.7	1.61	2.51	44	3.0×10^{-2}
TP-2 Sand/slime	9.7	1.61		44	2.1×10^{-2}
TP-2 Sand/slime	11.5	1.59		50	2.7×10^{-2}
TP-2 Sand/slime	13.8	1.61		62	8.3×10^{-3}
TP-3 Sand/slime	6.5	1.68		33	4.0×10^{-2}
TP-3 Sand/slime	7.2	1.67		35	4.1×10^{-2}
TP-3 Sand/slime	9.7	1.70	2.53	50	2.9×10^{-2}
TP-3 Sand/slime	9.9	1.70		51	1.8×10^{-2}
TP-3 Sand/slime	12.9	1.71		68	7.1×10^{-3}
TP-3 Sand/slime	13.4	1.71		71	5.9×10^{-3}

Ref. K.K. Nielson, 1983b.

Table 2.4 Tailings source terms for RAECO

Tailings depth (ft)	Predominant[a] material type	Average Ra-226 (pCi/g)	Density g/cm^3	Emanating[b] power	Source term Q, (pCi/cm^3-sec)
Windblown	Sand	47.0	1.51	0.14	0.000021
0-2.5	Sand	398.3	1.51	0.14	0.00018
2.5-5.0	Sand	396.4	1.51	0.14	0.00018
5.0-7.5	Sand	371.4	1.51	0.14	0.00016
7.5-10.0	Sand	360.2	1.51	0.14	0.00016
10.0-12.5	Slime	790.7	1.38	0.16	0.00037
12.5-15.0	Slime	495.5	1.38	0.16	0.00023
15.0-17.5	Sand/slime	462.2	1.65	0.28	0.00045
17.5-20.0	Sand/slime	308.3	1.65	0.28	0.00030
20.0-22.5	Sand/slime	485.7	1.65	0.28	0.00047

[a]Based on the average Ra-226 value.

[b]Ref. K.K. Nielson, 1983c.

3.0 SITE DRAINAGE

I. PROBLEM STATEMENT

The purpose of this calculation is to determine the characteristics of site drainage during and after remedial action for appropriate erosion and sediment control measures. The following design situations were analyzed:

- During remedial action - site runoff from a 10-year 24-hour storm event for sizing of the waste-water retention basin.
- During remedial action - drainage ditch flow velocities during a 10-year 24-hour storm event to determine the need for ditch erosion protection.
- During remedial action - site runoff from a 25-year storm event for design of the waste-water retention basin emergency spillway outlet.
- After remedial action - drainage ditch flow rates from the 100-year and PMP storm events for appropriate design of swales and erosion protection; and the PMP rainfall intensities and sheet flow rates on the tailings embankment for use in the erosion protection design of the embankment cover system.

II. METHODS OF CALCULATION

Site runoff and flow rates were determined using the rational method (AISI, 1971, 1980) based on the appropriate rainfall intensities of the various storm events. The rainfall intensities for the 10-year and 100-year storm events were determined with use of the Precipitation - Frequency Atlas of the Western United States (NOAA, 1973). The PMP rainfall intensity was determined using charts from the "Design of Small Dams" (U.S. Department of the Interior, 1977) and data from the "Staff Technical Position WM-8201" (NRC, 1983). Ditch velocities were determined using the Manning formula and appropriate input parameters.

III. CONCLUSIONS

A. During remedial action, the sedimentation basin will require a minimum storage capacity of 4.8 acre-feet for direct runoff.

B. During remedial action, drainage ditch velocities will be erosive and therefore erosion resistant material will be required.

C. During remedial action, the emergency spillway outlet of the wastewater retention basin will be designed for a flow rate of 85 cfs.

D. The following summarizes the maximum ditch flow rates which can be expected after remedial action:

Ditch[a]	Flow rate (cfs) 100-year	PMP
D-1	39	297
D-2	48	374
D-3	82	624
D-4	35	256
D-5	12	96
D-6	89	696
D-7	166	1321
D-8	166	1321

[a]See Figure 3.1 for ditch locations.

The PMP flow rates were used to design erosion protection for the ditches. The one-hour PMP for the Shiprock area is eight inches. The five-minute rainfall intensity on the embankment is 24 inches per hour.

E. The PMP rainfall intensity on the embankment is 24 inches per hour. The PMP sheet flow rates on the embankment cover are 0.27 cfs/ft width on the topslopes and 0.33 cfs/ft width on the sideslopes. These flow rates were used in the design of erosion protection for the tailings embankment.

For summaries of erosion protection designs, refer to Section 4.0 of this attachment.

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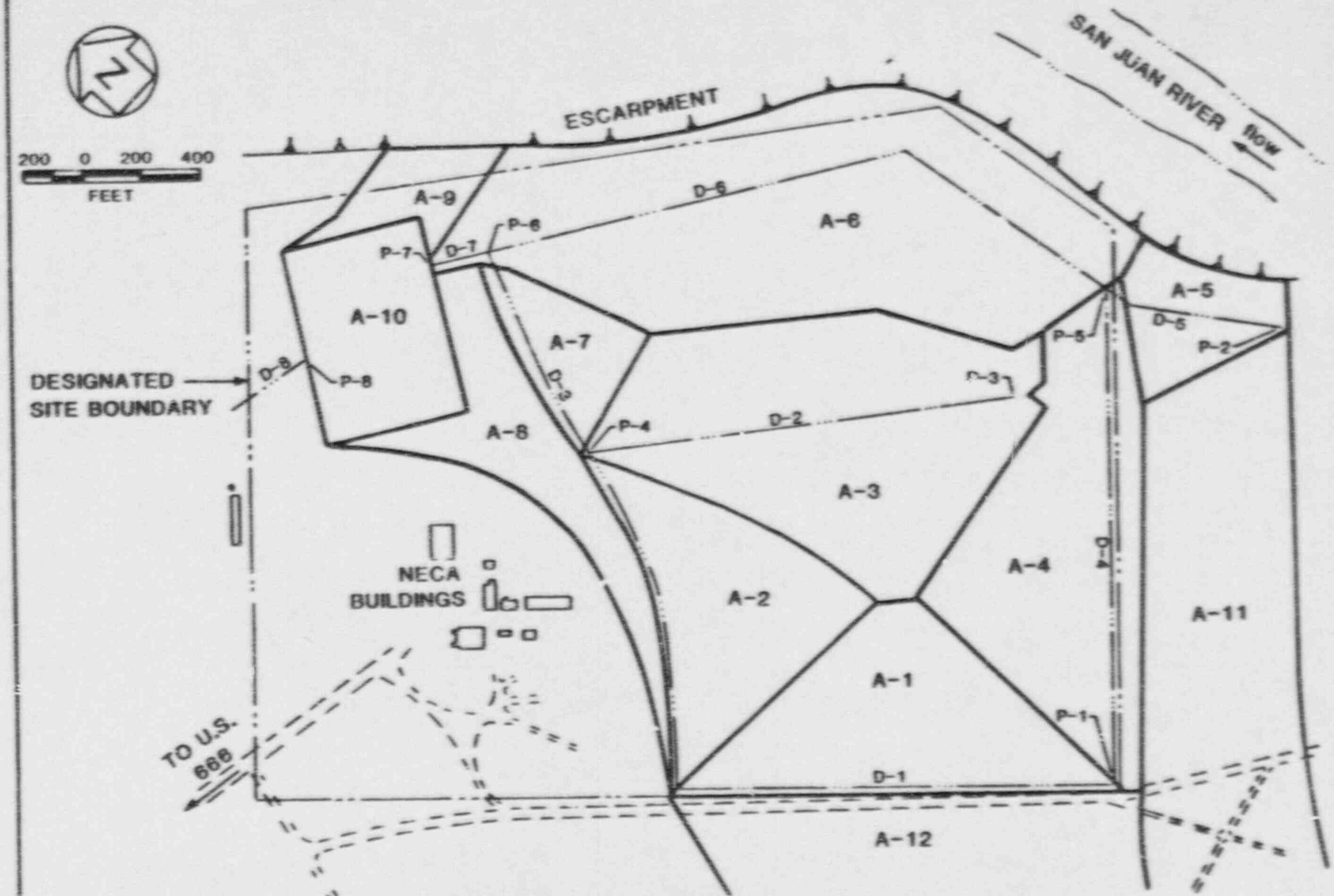

FIGURE 3.1
DRAINAGE AREAS, DITCHES AND CALCULATION POINTS
SHIPROCK SITE

SHP-03-0004

4.0 EROSION PROTECTION DESIGN

I. PROBLEM STATEMENT

The Shiprock remedial action must be designed such that the embankment has long-term protection against the effects of erosion. Specifically:

A. The embankment top and side rock layers will be designed to prevent sheet erosion under PMP conditions.

B. The drainage ditches that surround the embankment will be designed to carry the PMP runoff without overtopping or significant erosion.

II. METHODS OF CALCULATION

A. Flow Rates

Flow rates for the PMP were taken from the site drainage calculations (Section 3.0, Site Drainage).

B. Sideslope Erosion Protection

The rock size on the embankment sideslopes was determined using rockfill hydraulic design techniques because of the steep, 20 percent, slope (Stephenson, 1979). The rock size required to resist the expected sheet flow was set equal to the 50 percent finer rock diameter. No additional safety factor was applied to this size since the method itself has an embedded safety factor.

C. Topslope and Ditch Erosion Protection

Flow hydraulics for the embankment topslopes and ditches (Figure 4.1) were calculated using Manning's equation and U.S. Army Corps of Engineers (COE, 1970) methods which relate relative submergence of the roughness element and the hydraulic radius to the friction coefficient and boundary shear stress. The safety factors method was used to find the stability of a given rock size. This calculation was iterated for various rock sizes and the rock size for a safety factor greater than 1.0 was found. The stable rock size was set equal to the 30 percent finer size to ensure "self-armoring" of the cover and ditches.

Manning's equation:

$$y = (1.49/n)R^{2/3} S^{1/2}$$

where:

$n = R^{1/6}/(23.85 + 21.95 \text{ Log}(R/k))$
y = depth of flow (feet)
n = Manning's friction coefficient
R = hydraulic radius (feet)
S = slope
k = equivalent roughness height (feet)

Shear stress formula:

$$t = K_2 V^2$$

where:

K_2 = $62.4/(32.2 \text{ Log } (12.2y/D_{50}))^2$

t = boundary shear stress (psf)

V = vertically averaged velocity (fps)

D_{50} = theoretical spherical diameter of average stone size (feet)

III. CONCLUSIONS

A. Rock Protection Requirements for the Embankment Top and Sideslopes

Location	Rock size requirements (inches)	Thickness (ft)	PMP design sheet flow rates (cfs/ft)
Top	$D_{30} \geq 0.33$ inches $D_{50} \geq 0.5$ inch $D_{100} \leq 1.0$ inch	$\geq 1.5 \times D_{100}$	0.28
Sides	$D_{50} \geq 3.0$ inches $D_{100} \leq 6.0$ inches	$\geq 1.5 \times D_{100}$	

Damage to the cover is unlikely even in the PMP event.

B. Rock Protection for the Ditches

Ditch	PMP flow rate (cfs)	Side-slope	Flow depth (ft)	D_{50} rock size (inches)	Velocity (fps)
D-1	297	1v:5h	3	4	7
D-2	374	1v:5h	3	10	9
D-3	624	1v:5h	4	5	8
D-4	256	1v:5h	3	5	7
D-5	96	1v:5h	2	2	6
D-6	696	1v:5h	4	3	7
D-7	1321	1v:5h	5	6	9
D-8	1321	1v:5h	5	10	11

Rock sizes at ditch junctions and bends will be determined during final design using EM 1110-2-1601 criteria (COE, 1970).

The following filter criteria will be used in final design:

$$\frac{D_{15}\text{ filter}}{D_{85}\text{ base}} < 5$$

$$\frac{D_{50}\text{ filter}}{D_{50}\text{ base}} < 40$$

$$4 < \frac{D_{15}\text{ filter}}{D_{15}\text{ base}} < 40$$

It is anticipated that one filter layer will be required on the topslopes and sideslopes. The gradations of the filter layers will be determined during final design once the grain size distribution of the radon barrier material is defined. Filter layers, where required, are in addition to the radon barrier thickness of seven feet.

All required rock sizes are available within the existing NECA lease area although selective borrowing or screening may be required for the larger sizes.

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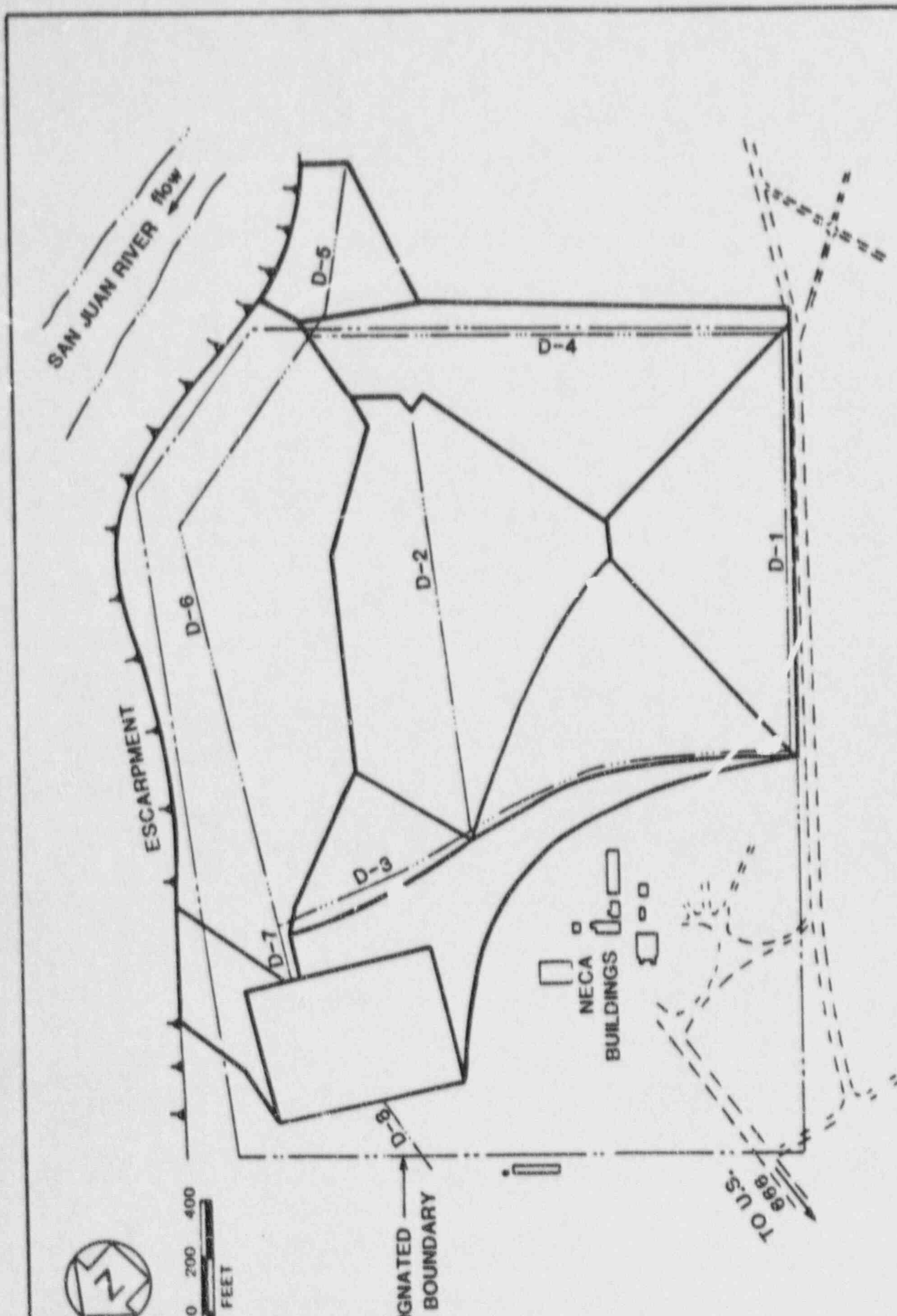

FIGURE 4.1
DRAINAGE DITCHES
SHIPROCK SITE

5.0 WASTE-WATER RETENTION BASIN

I. PROBLEM STATEMENT

The purpose of this calculation is to analyze the required storage capacity of the waste-water retention basin for runoff, dewatering, and other sources of waste water. The calculation also analyzes requirements for freeboard allowance and emergency spillway outlet capacity.

II. METHODS AND ASSUMPTIONS

A. Sediment Storage Volume

The sediment storage volume was determined by calculating the soil loss during the 1.5-year construction period. Typical Shiprock tailings grain size distributions (Hartley et al., 1981) and area weighted scope-length factors were used in the Modified Universal Soil Loss Equation (Israelsen et al., 1980) to find the soil loss over the project life. A sediment delivery ratio of 1.0 and bare soil conditions were assumed. The bulk dry density of the sediment was assumed to be 90 pounds per cubic foot.

B. Storm Runoff Storage Volume

The runoff resulting from the 10-year 24-hour precipitation event was added to the required sediment storage volume. See Section 3.0, Site Drainage, for details.

C. Miscellaneous Storage Volumes

It was assumed that flows to the basin from excavation dewatering, equipment decontamination, worker showers, laundry facilities, and other waste streams will be negligible and were disregarded for this analysis.

D. Emergency Outlet

The emergency outlet was designed to pass the peak flow resulting from a 25-year precipitation event with one foot of freeboard on the pond. The 25-year peak flow calculation is found in Section 3.0, Site Drainage. A triangular emergency outlet ditch with 10:1 sideslopes and a three percent gradient was selected, and the flow depth was calculated using reservoir outlet hydraulic techniques (Chow, 1959).

E. Evaporation

The rate of evaporation in the basin was calculated using average lake evaporation data (U.S. Weather Bureau, 1959) and precipitation data

(Gabin and Lesperance, 1977). Monthly precipitation was subtracted from seasonal lake evaporation to find the net evaporation rate from the basin of 30 inches/year. Seepage was considered insignificant.

III. CONCLUSIONS

A. The design storage volume of the basin is 6.4 acre-feet. It will hold the 10-year 24-hour runoff (4.8 acre-feet) and the sediment volume for the construction period (0.3 acre-feet). Excess capacity is provided as a safety factor and sediment removal will not be required until the end of the construction period. The basin will cover 6.4 acres and will have one foot of storage depth to the emergency outlet.

B. The ponded depth above the emergency outlet elevation at passage of the peak 25-year precipitation event (85 cfs) is estimated to be two feet. Adding one foot of freeboard results in a required total basin depth of four feet.

C. The runoff resulting from the 10-year 24-hour precipitation event will evaporate in two summer months.

IV. REFERENCES

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6.0 WASTE-WATER TREATMENT

Waste-water treatment facilities are not expected to be required at Shiprock due to the low amount of precipitation, high evaporation rate, and the recycling of wash waters for compaction and dust suppression. All waste water will be retained and evaporated.

7.0 GROUND SETTLEMENT PROJECTIONS

I. PROBLEM STATEMENT

The purpose of this calculation is to estimate the magnitude and time rates of ground settlement beneath and in the embankment. Any potential for differential settlement was evaluated with regard to impacts on the integrity of the embankment and cover and recommendations for construction.

II. METHODS OF CALCULATION

A. Estimated magnitudes of settlement of existing tailings, fill, and natural non-plastic to low-plastic alluvial soils were based on elastic compression and consolidation of saturated and partially saturated materials.

B. Compression estimates were from Earth and Earth-Rock Dams (Sherard et al., 1963).

C. Consolidation data (CSU, 1982) from the Shiprock site were used.

D. No data are available to estimate time-rates of settlement.

III. CONCLUSIONS

A. Settlement in foundation fill and native soils due to the total load from the rehandled tailings and cover should be less than three inches.

B. Settlement in foundation materials will be elastic compression due to the granular nature of the materials and low degree of saturation.

C. Settlement in foundation materials will occur very rapidly after loading and will not be sufficient to cause distress in the cover system.

D. Settlement in rehandled tailings will also be less than three inches total and should not cause distress to the cover materials.

E. Settlement in the existing tailings is difficult to predict due to material variability and drainage characteristics. Settlement in the sandy tailings will be less than one foot maximum, while settlement in areas containing slime deposits, such as in the eastern portion of the upper pile, could be as much as 2 to 2.5 feet.

F. Since the settlement of the slimes is time dependent, these areas should be filled first and allowed to settle while the remainder of the pile is constructed. Soil cover should be placed over slime areas after other areas are covered or after settlement has essentially stopped.

IV. REFERENCES

Sherard et al. (J. L. Sherard, R. J. Woodward, S. F. Gizienski, and W. A. Clevenger), 1963. Earth and Earth-Rock Dams, New York, New York.

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8.0 GEOHYDROLOGY

I. PROBLEM STATEMENT

The purpose of these calculations is to support an evaluation of the physical and chemical characteristics of past, present, and projected ground-water regimes and to evaluate the potential for and magnitude of contaminant migration. The evaluation includes consideration of the following factors:

A. Conceptual overview.
B. Selection of methodology.
C. Physical characterization of existing hydrogeologic conditions.
D. Physical characterization of post-remedial action conditions.
E. Chemical characterization of existing hydrogeologic system.
F. Chemical characterization of post-remedial action conditions.
G. Design requirements/conclusions.

II. METHODS AND CALCULATIONS

A. Conceptual Overview

The hydrogeologic setting of the Shiprock tailings is conceptualized as a slow-moving, laterally and vertically limited contaminated ground-water system. The contaminated ground water is known to abut or overlie potentially usable ground-water resources which are available in quantities ranging from small to large, which range in quality from poor to good, and which are separated from the upper contaminated ground water by a thick sequence of relatively impermeable Mancos Shale. The deeper ground-water system (Gallup Sandstone) exhibits an upward gradient as evidenced by artesian wells penetrating the system.

B. Methodology

In order to refine the conceptual model of the local hydrogeology and analyze design requirements, calculations must be done to help characterize the site and to predict future fluctuations in the hydrogeologic regime. Based on the conceptualization as a sluggish system with no major stresses on the system in the present or future, and limited data on post-remedial action stresses, the most suitable methodology for evaluating the hydrogeology is a qualitative analysis buttressed by simple calculations. Simulation of the hydrogeology using numerical models would be of limited benefit and doubtful accuracy due to the complex nature of the system and limited spatial and temporal data.

Hydrologic information about the ground-water regime at the Shiprock site is based on data from test pits (Figure 8.1) and test borings

(Figure 8.2). The test borings were converted to observation wells, for which construction details are given in Table 8.1. The static water level in each of the observation wells was measured and a contour map of the perched water table in the Mancos Shale was prepared (Figure 8.3). The contour map was used to determine a hydraulic gradient, which was used to calculate the volumetric flow and the flow velocity using Darcy's Law (see below). Slug tests performed in selected wells were used to calculate values of hydraulic conductivity. Packer tests in selected wells were used to determine the variation in hydraulic conductivity with depth; estimates of the saturated thickness of the Mancos Shale are based on these variations. Water-quality analyses were made on samples taken from 20 of the 26 wells.

C. Physical Characterization of the Existing System

Beneath the Shiprock site are about 20 feet of fine to coarse-grained alluvial soils overlying the interbedded shales and sandy shales of the Mancos Formation. Ground water occurs as perched water at various locations in the alluvial deposits near or below the tailings/soils interface. Laterally discontinuous perched pockets were identified in the vicinity of the tailings pile. A laterally continuous perched system is located in the upper portion of the Mancos Shale and underlies the site at depths of about 20 to 50 feet below the natural ground surface. This saturated zone in the Mancos Shale has a thickness of between three and 30 feet and lies above unsaturated Mancos Shale materials. Locally, both the upper Mancos and the overlying alluvium are saturated. Locally there are "pockets" of saturated alluvium overlying the less permeable shale, with a separate layer of saturated shale below. Representative profiles through the tailings and adjacent areas are shown in Figures 8.4, 8.5, 8.6, and 8.7; the locations of the profiles are shown in Figure 8.2. The perched "pocket(s)" in the alluvium were identified by a vertical hydraulic head differential of greater than 10 feet in paired wells and corroborated by observation of seepage along the top of the shale at these and other locations (Dames and Moore, no date; Hans, 1977a; Hans, 1977b). These observations may mean that flow in the shale is semi-confined in places. Well 3, completed in alluvium and the top of the Mancos Shale, had a measured static water level of 4949 feet above mean sea level. Well 3A, completed in Mancos Shale only, had a measured static water level of 4938 feet above mean sea level. Potentiometer 11/1 was completed in Mancos Shale with a measured static water level of 4935 feet above mean sea level. Potentiometer 11/2 was completed in alluvium with a measured static water level of 4947 feet above mean sea level. Table 8.1 contains water level and well construction data and Figure 8.3 shows the locations of the wells and potentiometers.

The fractured zone of the Mancos is underlain by partially saturated, competent Mancos Shale. Based on limited data, the percent saturation of the competent Mancos ranges from about 70 to 80 (Dames and Moore, 1982), thus indicating the water in the upper Mancos Shale is perched on a zone of partially saturated bedrock.

This perched or water-table system in the Mancos Shale generally is continuous under the site and beyond the site boundaries. Recharge is believed to be to the south and southwest where small ephemeral stream channels exit from moderately dissected low hills. These minor channels (less than one foot in width) spread and dissipate as they encounter the silty terrace which abuts the tailings. The net flow direction is toward the northeast and the San Juan River escarpment. Discharge that does reach the escarpment as seeps, because the discharge rates are so low and the evaporation rate so high, has been observed to evaporate at the escarpment face. In the vicinity of the tailings, the distance between the recharge area and the escarpment varies from about 1600 feet to about 4700 feet. The system is bounded to the northwest and southwest by small washes which incise the Mancos Shale and probably intercept local ground-water flow. The total area of the local system is in the range of 250 acres (Figure 8.8).

The direction of the flow of this system is significantly influenced by the thickness and degree of weathering of the weathered zone and by irregularities in the bedrock surface. This influence is shown in the water-surface map (Figure 8.3); the irregularity of the saturated zone in the Mancos Shale is evident from the results of the packer tests (Table 8.2). The shallow system is also characterized by a low permeability and sluggish flow. Data indicate that some monitoring wells require several months to recharge after being pumped for water sampling. Excavations to the bedrock surface have shown that the flow in the Mancos Shale is carried in a few fractures (Hans, 1977b); this is consistent with the performance of the wells. Due to the granular nature of the alluvial soils beneath the pile, there probably is communication between the discontinuous and continuous perched water systems. The lateral extent of the discontinuous perched zone in the alluvium is not known, thus locations where vertical communication between perched zones and the perched system in the shallow bedrock may occur are also not known.

Ground water in the deeper sedimentary rocks beneath the site is separated from the tailings by the 175 to 250 feet of relatively impermeable upper Mancos Shale. The first water-bearing formation beneath the Mancos Shale is the Gallup Sandstone (Callahan and Harshbarger, 1955). Water in the Gallup Sandstone is artesian, and the hydraulic gradient is upward between the Gallup Sandstone and the upper Mancos Shale.

The Gallup Sandstone is not a usable aquifer in the Shiprock area, as the water is non-potable (Callahan and Harshbarger, 1955). The only usable water-bearing formation in the area is the Dakota Sandstone, separated from the tailings by about 1100 feet of relatively impermeable, unsaturated Mancos Shale. The Dakota Sandstone also is artesian. Thus downward migration of contaminants from the tailings is effectively precluded by the thick sequence of impermeable unsaturated shale and the artesian pressure in the underlying water-bearing formations.

Historic hydrologic conditions near the Shiprock site are reported in a study made during active milling operations (United States Public Health Service, 1962). Observations made in 1960 found six seeps with flows between 0.5 and 20 gpm and significant levels of contamination (up to 4.8 mg/l = 3264 pCi/l dissolved uranium). These seeps were found at distances up to 2500 feet from the site, both north and south of the site. The source of the seeps was probably leakage from the poorly-lined waste ponds noted by the Public Health Service. Much of the present contamination in the perched systems can probably be attributed to residual remnants of this leakage. The present hydrologic regime is much different from that which existed during milling. Without the driving source of the waste ponds, the discharge of the seeps has declined to a fraction of their former discharge rates (see above).

The discharge through the weathered Mancos Shale evaporates at or before the escarpment face as verified by field observation (TAC, 1983). The seeps along the escarpment consist of moist, weathered shale from which the water evaporates as fast as it discharges. Most of the seep areas consist of dark, highly fractured rock with no visible water flowing. One seep with measurable discharge was located east of the tailings and with gypsum crystals lining the escarpment face. The seepage consisted of droplets issuing from joints of the shale at a rate of about 0.08 ft^3/day. This discharge soaked into the sloughed, shale debris and did not flow away from the escarpment.

Based on the above observations, little, if any, ground water leaves the escarpment. Therefore any contaminants contained in the ground water accumulate in the escarpment as the ground water evaporates. The potential for contaminant migration away from the site vicinity is negligible.

1. Calculation of values of effective porosity

   Values of the dry bulk density of the shallow water-bearing zone, the weathered upper Mancos Shale, are known from moisture-density test data on core samples (DOE, 1982). Using values of dry bulk density (Table 8.3), values of the net porosity can be calculated using the following formulas (Lambe and Whitman, 1969):

   To determine the bulk void ratio, e:

$$W_d = \frac{G}{1+e} (w)$$

   where

   W_d = dry bulk density of material

   G = specific gravity of material (assumed to be 2.7 for fractured Mancos Shale)

   w = unit weight of water (62.4 lbs/ft^3)

next, solving for the net porosity, n:

$$n = \frac{e}{1+e}$$

Calculated values of net porosity are shown in Table 8.3.

Table 8.3 Dry bulk densities and corresponding net porosities in Mancos Shale

Boring number	Sample depth (ft)	Dry bulk density (lbs per cf)	Net (total) porosity
1	13.0	111	0.34
4	19.5	104	0.38
5	13.8	100	0.41
6	36.3	149	0.12
7	38.3	149	0.12
10	45.7	144	0.15

Representative total porosity values for shales are generally 0.05 to 0.20 (Freeze and Cherry, 1979), although values can be higher in fractured zones, which is descriptive of the Shiprock site. Representative values of effective porosity for siltstone are about 1/3 the values of total porosity (Todd, 1980). Using this 1/3 proportion, and using the lowest values of net porosity from Table 8.3, the effective porosity for the water-bearing Mancos Shale can be calculated as:

$$n_e = (1/3) \times n$$

$$= (1/3) \times 0.12$$

$$= (0.04)$$

where

n_e = effective porosity
n = net (total) porosity

This value of porosity will give conservatively high values of flow velocity because the lower the porosity, the higher the flow velocity.

For the more highly fractured areas, as around Well No. 5, the effective porosity can be calculated as follows:

$$n_e = (1/3) \times n$$

= (1/3) x 0.41

= (0.136)

This value of porosity will give a conservative value of volumetric flow through more highly fractured zones of the shale.

2. Calculation of ground-water flow volumes and velocities using Darcy's Law

Shallow ground water near the Shiprock site generally flows from south to north/northeast with variations in directions from west to northeast (Figure 8.3). Volumetric flow under the tailings can be calculated using Darcy's Law (Davis and DeWiest, 1966):

$$Q = KA \frac{(h_1 - h_2)}{dl}$$

where

Q = flow rate (ft^3/day)
K = hydraulic conductivity (ft/day)
A = cross-sectional area of water-bearing zone (ft^2)
h_1 = hydraulic head at upgradient side of tailings (ft above MSL)
h_2 = hydraulic head of downgradient side of tailings (ft above MSL)
dl = distance between points where h_1 and h_2 are measured

The use of this equation assumes flow through the entire section (average flow) rather than flow through discrete fractures. Field reconnaissance of the escarpment showed no evidence of seeps with measurable discharge. The lack of measurable discharge at the escarpment indicates that the volume of flow under the tailings is low, and also indicates that there is probably not a large, continuous fracture system(s) conducting water to the escarpment. This evidence supports the use of an average flow rather than fracture flow analysis as a conservative approach.

A fracture flow analysis would calculate a volumetric flow rate using a higher value of hydraulic conductivity and a lower value of cross-sectional area. Slug test data indicate that the hydraulic conductivity would be higher by a factor of 10 or less; geometric and geologic considerations indicate that the cross-sectional area would be decreased by a factor of 10 or more. The resultant calculated value of volumetric flow rate for fracture flow would be equal or less than the flow rate considering an average flow. Therefore, the use of an average flow is a conservative approximation.

For the Shiprock tailings, the flow rate can be calculated using the following values:

- o $K = 0.20$ ft/day, the geometric mean conductivity calculated from 26 slug tests (TAC, 1983).

- o A, the cross-section area, is calculated by multiplying the saturated thickness of the water-bearing zone times the width of the zone, perpendicular to flow, for which the discharge is being calculated. For the weathered Mancos Shale at the Shiprock site, the saturated thickness was estimated based on the variation of hydraulic conductivity with depth as shown in packer permeability tests (DOE, 1982) (see Table 8.2). The saturated thickness is the distance between the static water level in the boring and the depth at which the hydraulic conductivity reaches a value of zero. The geometric mean of the values of saturated thickness is 11.9 feet. The distance across the tailings roughly parallel to the equipotentials is about 1750 feet (Figure 8.3). Therefore the cross-sectional area is:

$$A = 11.9 \times 1750$$
$$= 20{,}825 \text{ ft}^2$$

- o Taking the equipotentials of 4942 feet and 4922 feet as representative of the upgradient and downgradient bounding contours for the tailings (Figure 8.3):

$$h_1 = 4942 \text{ feet}$$
$$h_2 = 4922 \text{ feet}$$

- o The distance between the potentiometric contours 4942 feet and 4922 feet is 2800 feet, thus:

$$dl = 2800 \text{ feet}$$

The discharge can now be calculated:

$$Q = (0.20 \text{ ft/day})(20{,}825 \text{ ft}^2)\frac{(4942-4922) \text{ ft}}{2800 \text{ ft}}$$
$$= 29.75 \text{ ft}^3\text{/day}$$
$$= 222 \text{ gallons per day}$$

The average flow velocity through the weathered Mancos Shale can be calculated using the discharge through Area A and the effective porosity n_e (Bear, 1979):

$$V = Q/n_eA$$
$$= (29.75 \text{ ft}^3\text{/day})/(0.04)(20{,}825 \text{ ft}^2)$$
$$= 0.035 \text{ ft/day}$$
$$= 13 \text{ ft/year}$$

A more conservative, albeit unrealistic estimate of volumetric discharge can be made by using higher values of effective porosity and hydraulic conductivity. Inflections in the potentiometric surface (Figure 8.3) indicate that there may a more permeable zone near Well 5, which has among the highest values of hydraulic conductivity and porosity. Using the values to calculate volumetric discharge:

$$Q = KA \frac{dh}{dl} n_e$$

$K = 3.4$ ft/day

$A = 26$ feet thick x 680 feet wide

$\frac{dh}{dl} = \frac{14}{2800}$ from Well No. 7 to Well No. 1

$n_e = 0.136$, from calculation above

$Q = 40.8\ ft^3/day$

The average flow velocity would be less than that calculated assuming average flow.

$$V = Q/A/n_e$$

$$= 6.2 \text{ ft/day}$$

This approach probably grossly overestimates the volume of fracture flow, because it probably overestimates the effective area of fracture flow. Indications of the conservativeness of this calculation are:

- Little discharge is evident from the Mancos Shale outcrop along the escarpment.

- Discharge through fracture zones is known to be directly related to discharge from the outcrop, and is easily cut off (Hans, 1977a).

- An alternate water level map, drawn by ignoring the measurement for Well No. 7 (known to be somewhat isolated from the other wells) produces no inflection in the potentiometric surface (Figure 8.9).

- Packer tests indicate that permeability in the shale decreases rapidly with depth. Values of hydraulic conductivity calculated with slug tests probably are indicative of permeability in the upper portion of the saturated shale.

The alternate water level map indicates that there may be large zones in the shallow system through which flow is largely ineffective, as along the axis of Wells No. 7 and 11. If the flow through much of the system is ineffective, the calculated volumetric flows may greatly overestimate actual flow rates.

3. Calculation of bounding maximum value of infiltration and percolation to the ground water

The maximum value of net infiltration (i.e., infiltration that percolates to the ground water) can be estimated by assuming that all of the water flowing under the tailings is derived from downward vertical recharge. This assumption is quite contrary to the actual physical situation at the Shiprock site. However, it does allow calculation of a maximum value of net infiltration:

$$I_{max} = Q/A_t$$

where

I_{max} = maximum value of infiltration

Q = flow under pile (29.75 ft^3/day, from above)

A_t = area of tailings (72 acres = 3.14 million ft^2)

thus

$$I_{max} = (29.75\ ft^3/day)/(3.14 \times 10^6\ ft^2)$$

$$= 9.5 \times 10^{-6}\ ft/day$$

$$= 3.5 \times 10^{-3}\ ft/year$$

$$= 0.04\ inches/year$$

The actual infiltration rate must be much less than this as can be determined by examining Figure 8.3. This conclusion follows because hydraulic head gradients indicate that most if not all of the flow under the tailings can be accounted for by inflow from off the site. Thus it can be concluded that there is little if any infiltration passing through the tailings to the ground water.

The low value of calculated net infiltration is supported by:

1. The high potential evaporation rate in the Shiprock area.
2. The low average annual precipitation.
3. The relatively deep water table.
4. The minor seasonal fluctuations of measured static water levels in the perched, saturated zone.

Data collected by representatives of Lawrence Berkeley Laboratory at the Riverton, Wyoming, uranium tailings pile indicate that generally a vertical ground-water divide exists in the partially saturated tailings (Tokunaga and Narasimhan, 1982). This divide is between three and six feet below the surface. Moisture above the divide will tend to move upward, while moisture below the divide will tend to move downward. After a snowmelt or a significant precipitation event, this divide is eliminated. At these times, moisture movement will be downward through the entire partially saturated zone. Field studies at Riverton showed that the ground-water divide will be reestablished within hours or days once the source of water at the surface ceases. Only moisture that moves past the reestablished ground-water divide will percolate to the ground water. The rest of the moisture will move back toward the surface and evaporate or be transpired by plants. Although there are clear differences between the Riverton tailings and the Shiprock tailings, a comparison of the two sites provides some indication of the hydrologic regime at Shiprock.

The hydrologic conditions at Shiprock are less favorable for percolation of infiltration to the ground water than the conditions at Riverton. The perched water table at Shiprock is approximately 30 feet below the land surface compared to approximately 10 feet at Riverton. The deeper water table would suggest a deeper vertical ground-water divide. (Thus moisture would have to move downward probably six feet shortly after a snowmelt or precipitation event to eventually percolate to the ground water.) In addition, the deeper water table would allow steeper vertical hydraulic gradients which would cause very low values of hydraulic conductivity. Measured ambient soil moisture (on a weight basis) ranged from 3.5 to 9.2 percent for a study near the Shiprock site at depths from 41 to 127 cm (Rogers et al., 1981). These low values of hydraulic conductivity would greatly limit the rate of downward moisture migration.

The potential evapotranspiration rate for the Farmington-Shiprock area was reported as 39.5 inches per year and the average annual precipitation was measured as 7.0 inches (Gabin and Lesperance, 1977). It is unlikely that a significant amount of infiltration would percolate to the ground water with a potential evapotranspiration rate greater than five times the average annual precipitation. The minor fluctuations in measured static water levels further support the lack of recharge to the ground water. Most of the differences in measured water levels, for a given well, are within the range of fluctuations due to measurement error or changes in barometric pressure due to diurnal fluctuations (see Table 8.4, following Section 8.0 Figures).

D. Physical Characterization of Post-Remedial Action Conditions

Static water levels in the continuous perched zone under the tailings are below the bottom of the tailings and, in fact, below the top of the Mancos Shale surface (Figure 8.4). Net infiltration through the tailings is negligible at present (see above). Therefore, the planned remedial action of covering the tailings with a less permeable cover than is presently there will further reduce flow to the ground water beneath the site. The planned remedial action will have a negligible effect on the ground-water regime, therefore it can be concluded that the ground-water regime after remedial action will be very similar to the existing ground-water regime.

E. Chemical Characterization of the Existing Hydrogeologic System

For the terrace system, representative existing water-quality data are presented in Table 8.5, for sampling locations representing upgradient, on-pile, and downgradient discharge points. As can be seen from the table, water quality in the perched zone in the Mancos Shale is characterized by high levels of total dissolved solids (TDS) and sulfate. The ranges of these constituents near and beneath the pile are 12,000 to 35,000 mg/l TDS and 4000 to 25,000 mg/l sulfate. Water quality upgradient of the pile ranges from 19,000 to 31,000 mg/l TDS and 7600 to 25,000 mg/l sulfate. The total uranium concentrations in the Mancos Shale perched water ranged from about 120 to 2000 pCi/l (0.176 to 2.94 mg/l) beneath the pile to about 20 to 225 pCi/l (0.029 to 0.331 mg/l) upgradient of the pile. The highest uranium concentrations reported for some upgradient wells may represent residual contamination due to radial flow away from the pile during active milling.

Table 8.5 Representative water quality of the Shiprock site[a]

Sampling location identification	Location relative to tailings	TDS[b,c]	SO_4[c]	Se[c]	U[d]
9GT	Upgradient	34,600	25,000	0.27	21.1
5	Below-pile	31,200	19,000	0.01	1040
2	Downgradient	20,300	15,000	0.05	1984
Seep (E. of site)	Downgradient (discharge area)	26,100	14,000	0.62	47.6

[a]Samples taken October, 1983.
[b]TDS = total dissolved solids.
[c]in mg/l.
[d]in pCi/l.

Among the minor metals (as defined by Davis and DeWiest, 1966), only selenium and copper were consistently found in every water sample, with traces of chromium found in a few upgradient wells. Selenium is presented in Table 8.5 as a representative metal. As can be seen from the table, there is no apparent relation between the dissolved concentrations of metals and the position with respect to the pile, and minor metals do not appear to be found in the shallow ground-water contamination at the Shiprock site.

A determination of background water quality is necessary to characterize the existing ground-water system and to predict future impacts due to the migration of existing contamination. Although the concentrations of uranium in some upgradient wells are within the range of concentrations reported for uncontaminated shallow ground water, possibly anomalous concentrations of nitrate (up to 4300 mg/l) and ammonium (up to 3660 mg/l) at these same wells may be indicative of contamination. The possible actions for doing further assessment of background water quality in the terrace system include:

- o Install and sample monitoring wells further upgradient from the tailings.
- o Obtain water-quality information from a similar hydrogeologic system.

Both of these actions have been evaluated and discarded because they have doubtful benefit due to a variety of factors.

At least 50 percent of the 250-acre shallow system is known to be contaminated, and the system is known to be contaminated for at least 50 percent of the distance from the former raffinate pond area to the recharge area. It may be that there is little or no uncontaminated ground water within the shallow system. Because there is less than a 2000-foot distance between known contamination and the lateral boundary of the system, the benefits of drilling wells further upgradient are in doubt. It should also be noted that the water quality in a ground-water system is related to the length of the flow path and the transit time of the water (Freeze and Cherry, 1979). In a slow moving ground-water environment such as the terrace system, the water quality very near the recharge zone may not be representative of background quality further downgradient. Water quality in a marine-origin shale, such as the Mancos, should change substantially as the water moves through the shale due to chemical reaction which occurs during ground-water migration.

The possibility of obtaining water-quality data for a similar hydrogeologic system, and being confident that it is representative of the terrace system underlying the tailings, is also doubtful. Along the San Juan River between Kirtland (upstream) and the Colorado border (downstream), examination of USGS orthophotoquad sheets has shown that river terraces are used extensively for irrigated agriculture, from which return flow would greatly influence the water quality in any terrace ground-water system. The drainage areas of washes draining onto the terraces vary widely in magnitude. The drainage area contributing to the terrace area near the tailings is relatively small, so that it may be less flushed than other ground-water systems in San Juan River terraces.

Ground water in alluvial systems in the Shiprock area might offer another clue to the background quality in the terrace system. However, the quality of alluvial ground water on the Navajo Reservation varies tremendously, from less than 200 ppm total dissolved solids to as much as 47,000 ppm (Cooley et al., 1969). On the basis of the general use of San Juan River terraces for irrigation, the relatively small drainage area to the terrace near the tailings, and the extreme variability in shallow water quality in the area, it may be impossible to find a similar hydrogeologic setting to provide defensible background water quality for the shallow terrace system at Shiprock.

Water quality in the San Juan River alluvium adjacent to the tailings is expected to be similar to the quality of the river, which can be characterized as good. Although it is expected that the tailings have had no impact on the river alluvium, the river alluvium has been sampled to verify this. Although there is historic evidence of seepage or discharge of contaminated water onto the alluvium (United States Public Health Service, 1962), it is expected that the relatively active flow through the alluvium would have diluted any contamination to below detectable concentrations. The river alluvium has been sampled to verify this.

F. Chemical Characterization of Post-Remedial Action Conditions

The hydrologic regime after remedial action is expected to be essentially the same as the present regime (see above). Because there appears to be little or no infiltration or seepage from the tailings into the shallow ground water, there will be no driving force for the addition of dissolved constituents to the ground water. Thus, it is anticipated that the geochemical nature of the post-remedial action system should be virtually the same as at the present.

III. CONCLUSIONS

A. A perched water table is present in the weathered bedrock of the Mancos Shale. This system is recharged by ephemeral runoff south and southwest of the site. Thus, this ground-water system will exist without change after remedial action.

The perched ground-water flow is controlled by the depth of the weathered bedrock and the erosional remnants existing in the bedrock materials.

B. The shallow ground-water zone in the weathered bedrock is characterized by very slow flow, low volume, a saturated thickness of only a few feet, low hydraulic conductivity, and poor water quality. Thus, this water-bearing zone is not a usable aquifer.

C. The maximum possible rate of net infiltration through the tailings is low (0.04 inch/year). The physical setting of the hydrologic regime of the site shows that actual net infiltration must be much less than that. Thus, there is little or no net infiltration through the tailings, and there is negligible potential for continued leaching of contaminants.

D. Planned remedial action will not affect significantly either infiltration or ground-water flow in the Mancos Shale. The post-remedial action ground-water regime will be the same as the present regime.

E. Ground-water discharge at the San Juan River escarpment evaporates at the point of discharge. There is negligible potential for contaminant transport away from the site vicinity.

F. Usable aquifers in the Shiprock area are separated from the tailings by hundreds of feet of unsaturated, impermeable bedrock, with an upward hydraulic gradient, precluding contaminant migration into usable aquifers.

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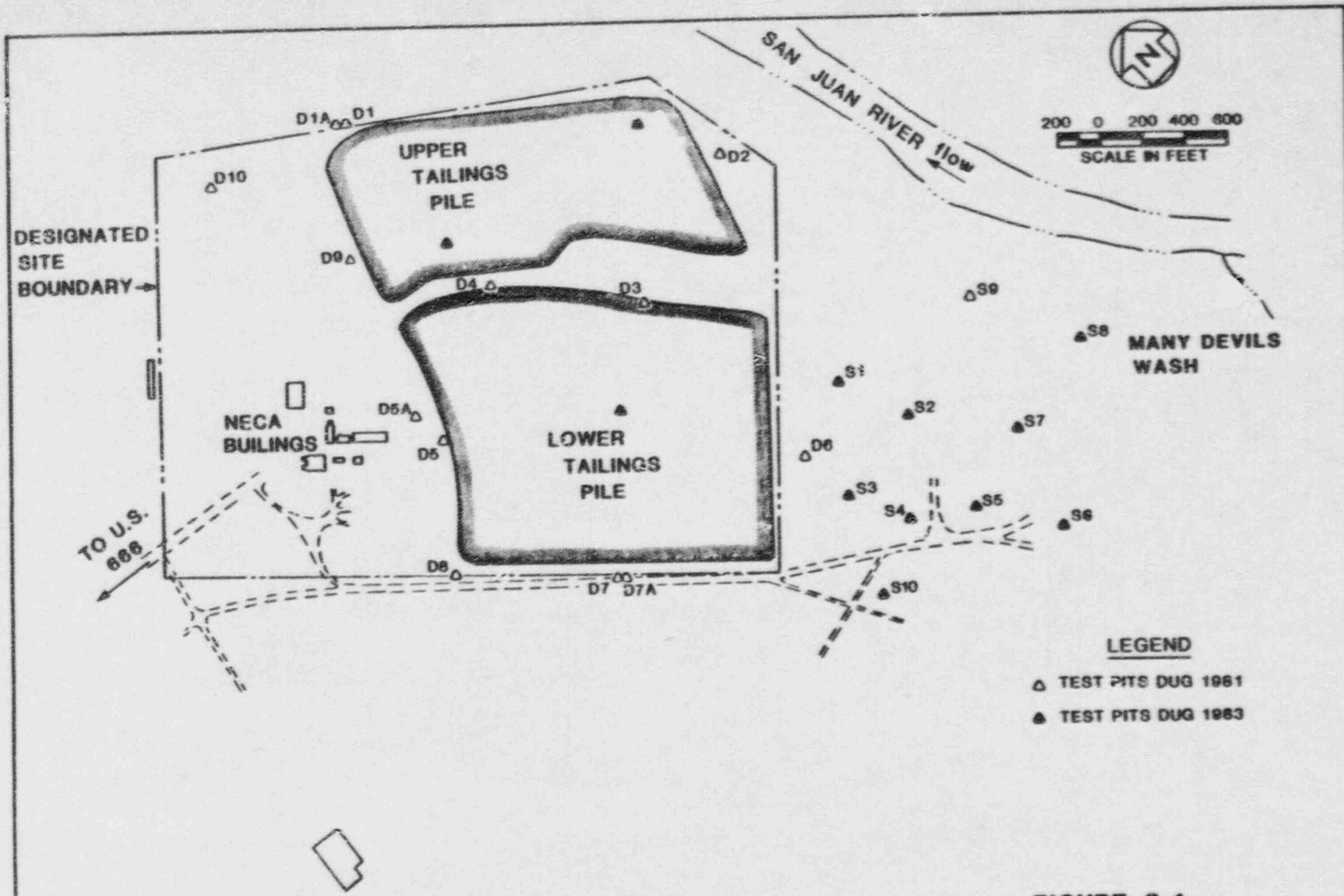


FIGURE 8.1
TEST PIT LOCATIONS
SHIPROCK SITE

SHP-08-0016

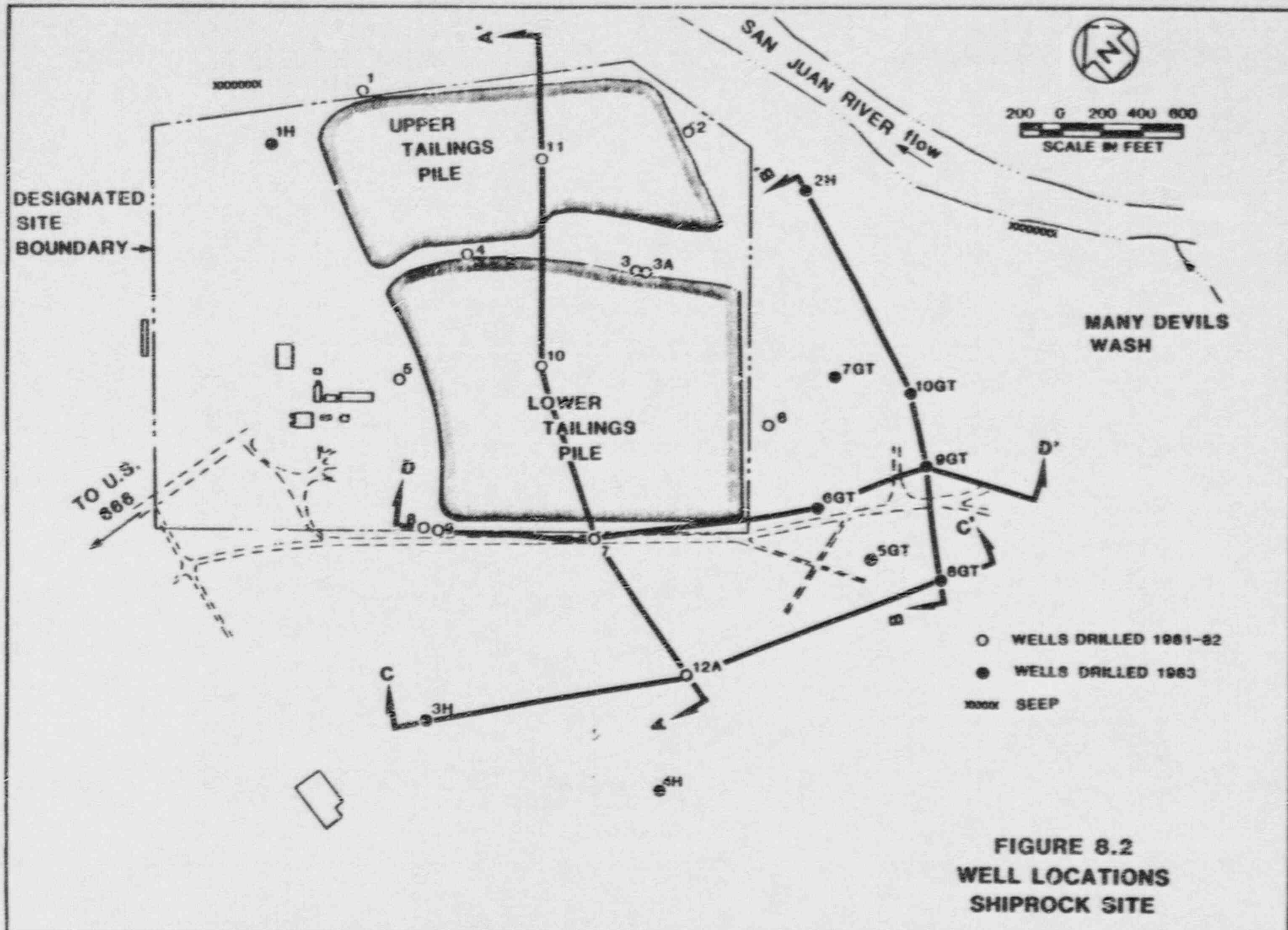


FIGURE 8.2
WELL LOCATIONS
SHIPROCK SITE

SHP-08-0017

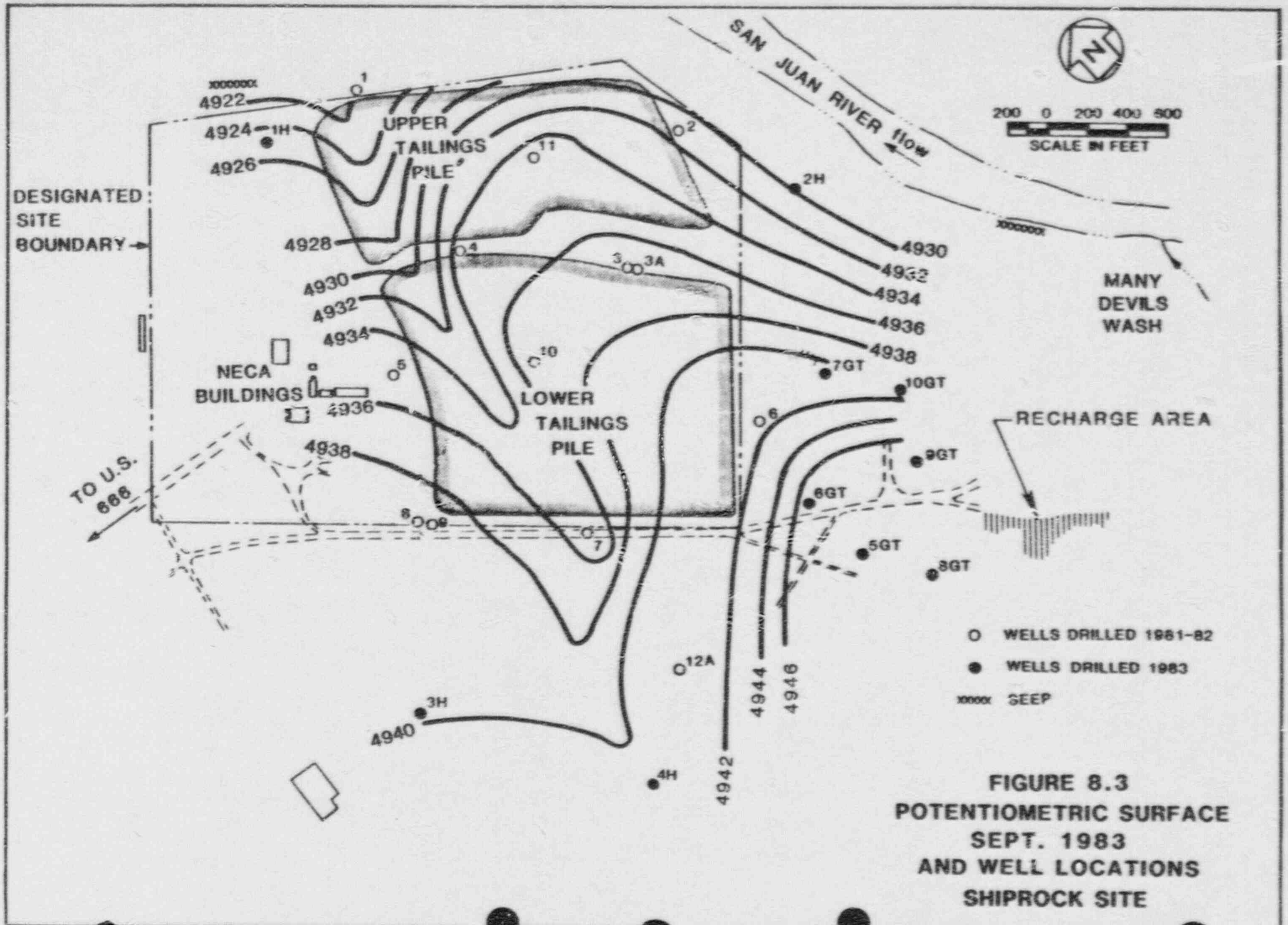


FIGURE 8.3
POTENTIOMETRIC SURFACE
SEPT. 1983
AND WELL LOCATIONS
SHIPROCK SITE

SHP-08-0018

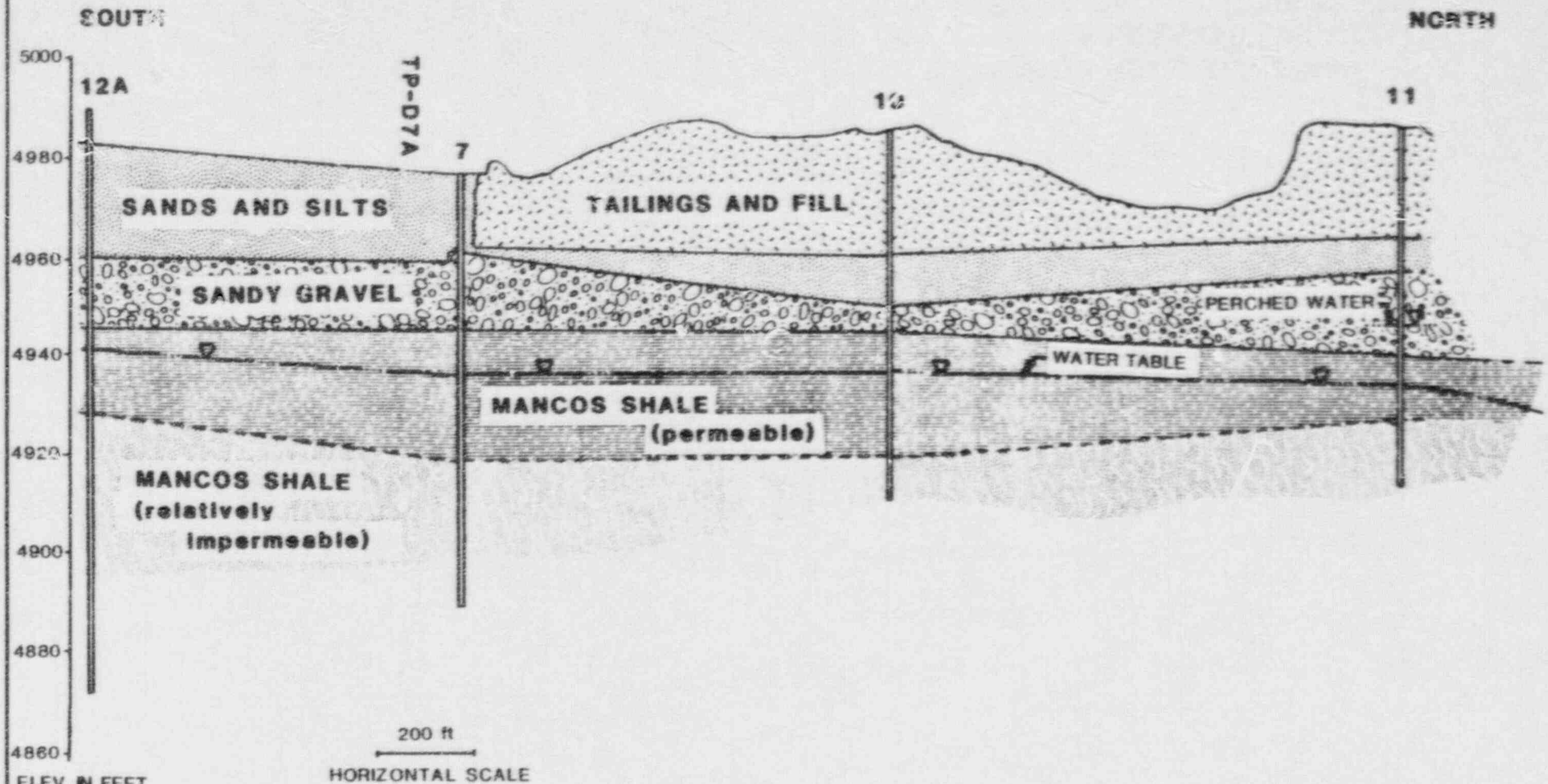


FIGURE 8.5
PROFILE A - A'
EXISTING STRATIGRAPHY

SHP-08-0019

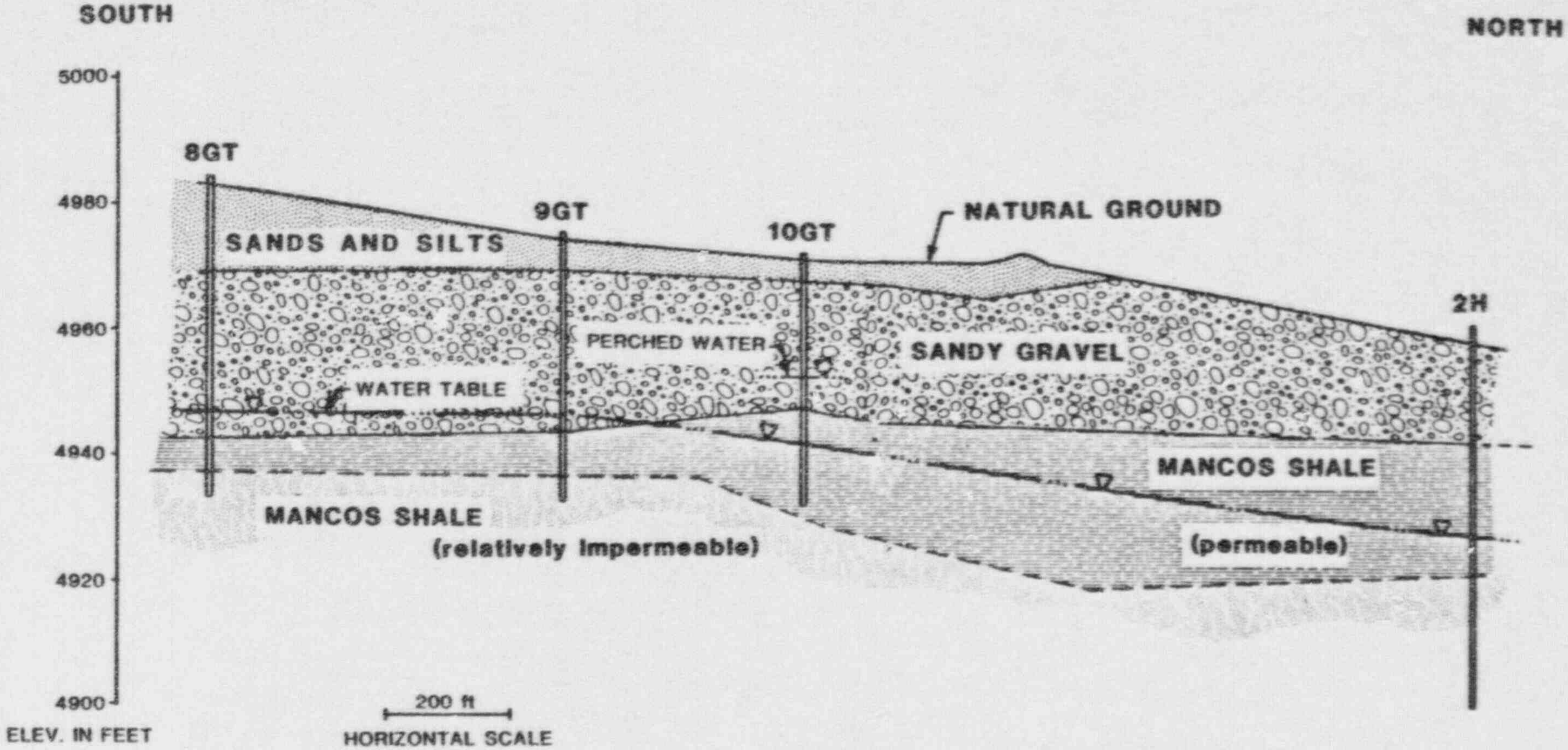


FIGURE 8.5
PROFILE B - B'
EXISTING STRATIGRAPHY

SHP-08-0020

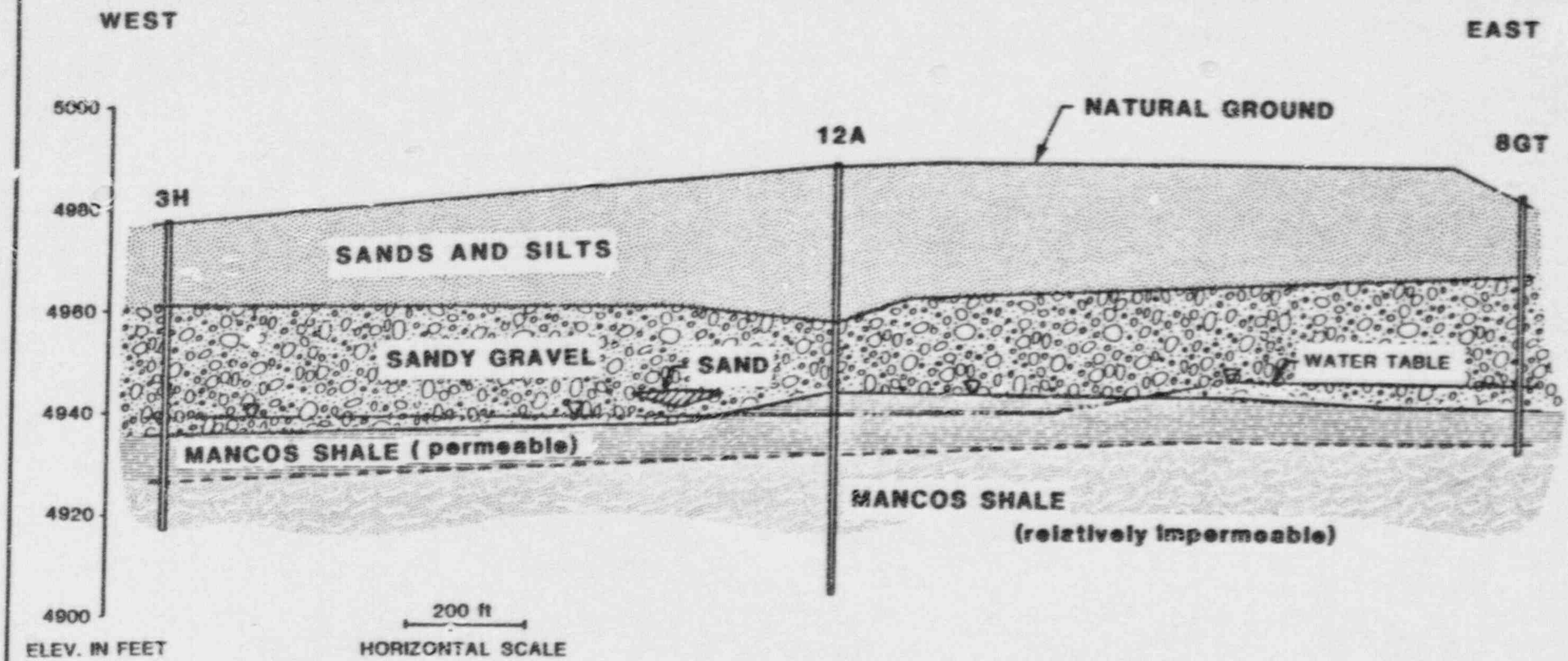
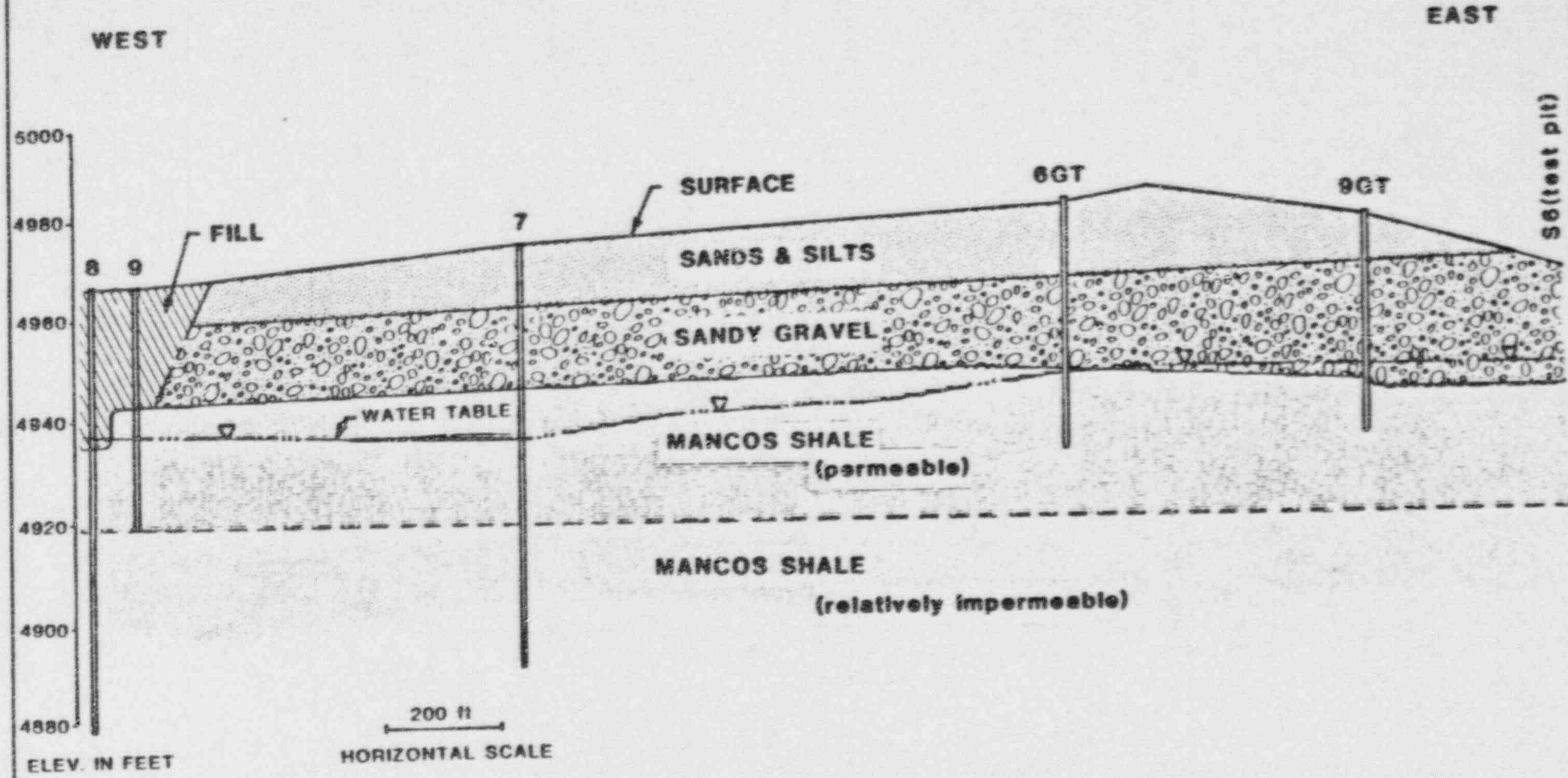


FIGURE 8.6
PROFILE C - C'
EXISTING STRATIGRAPHY

SHP-08-0021



NOTES
VERTICAL EXAGGERATION: 10 TO 1
SEE FIGURE 8.2 FOR CROSS-SECTION LOCATION

FIGURE 8.7
PROFILE D - D'
EXISTING STRATIGRAPHY

SHP-08-0022

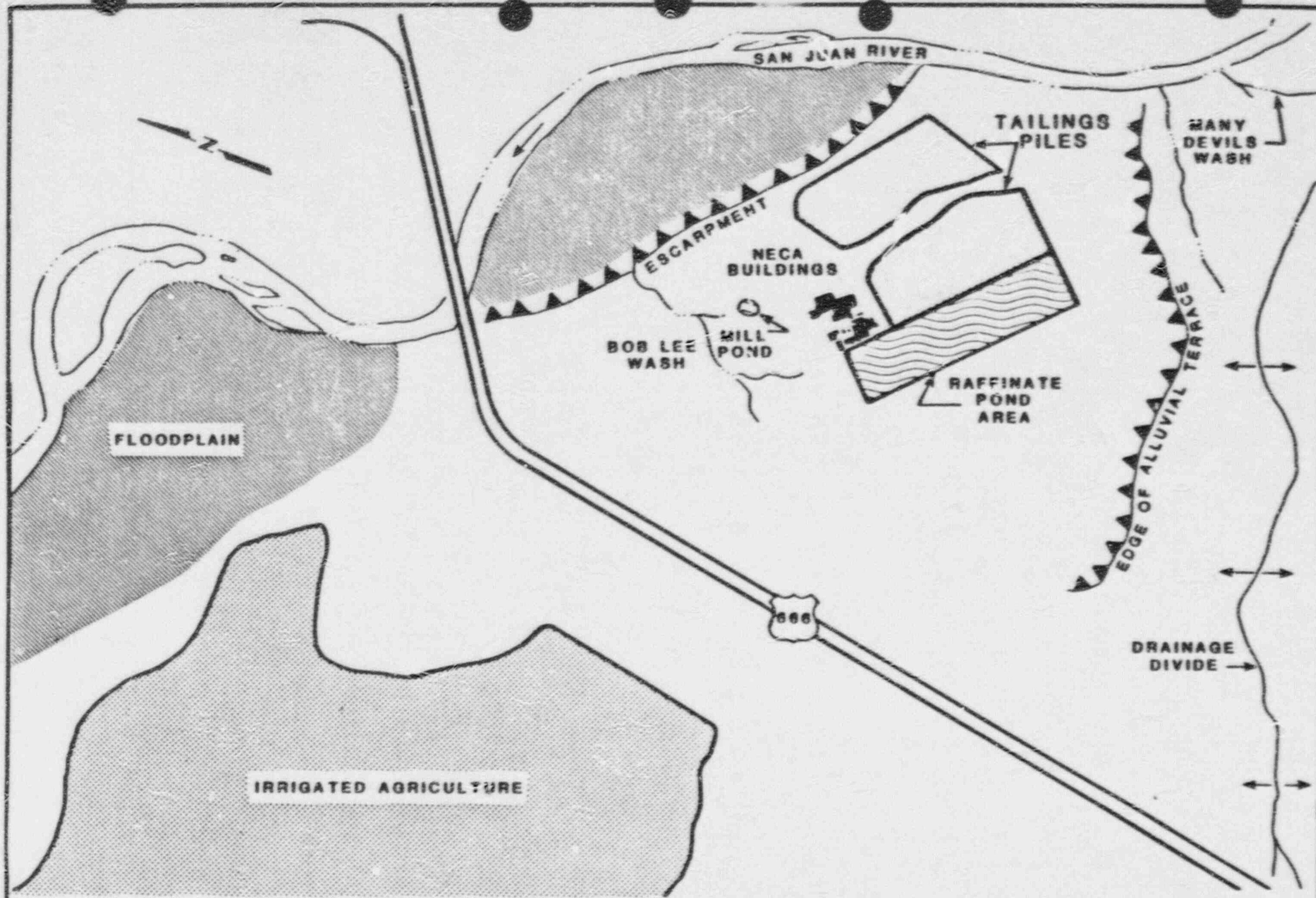


FIGURE 8.8
HYDROGEOLOGIC SETTING

SHP-08-0023

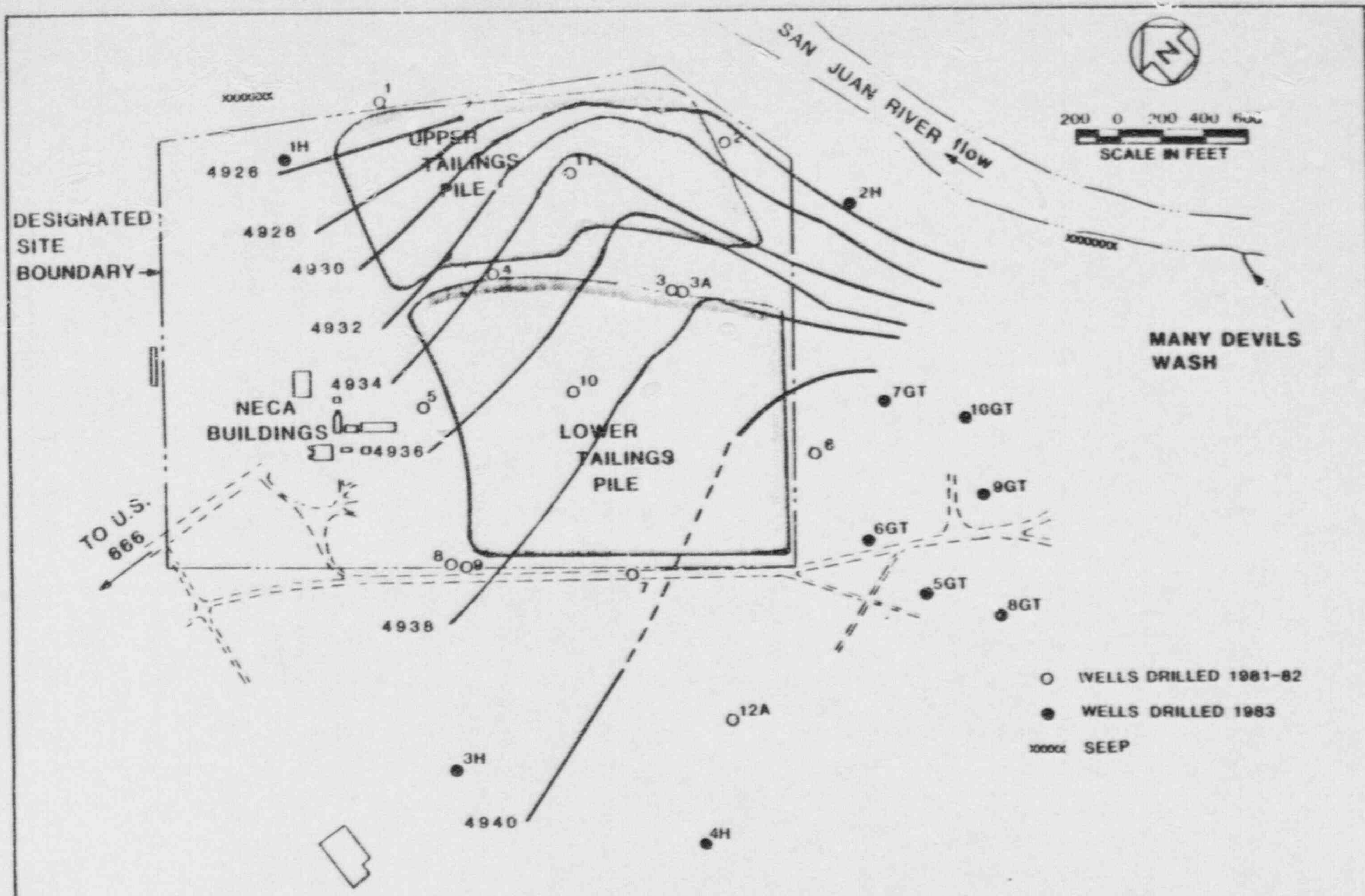


FIGURE 8.9

ALTERNATE POTENTIOMETRIC SURFACE SEPTEMBER 1983

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SHP-08-0024

Table 8.1 Well construction details - Shiprock, New Mexico

Well ID	Borehole diameter (inches)	Casing diameter (inches)	Casing depth (feet)	Perforated interval (feet)	Lithology Depth (feet)[a]	Lithology Formation	Ground elevation (feet MSL)	Water elevation (feet MSL)[b]
1H	6	2	0-25	10-20	0-60	Mancos	4943.33	4925.28
2H	6	2	0-38	23-33	0-18	Gravel	4962.90	4929.74
					18-60	Mancos		
3H	6	2	0-54.7	39.7-49.7	0-41	Alluvium	4977.31	4939.85
					41-60	Mancos		
4H	6	2	0-78	62.7-72.7	0-58	Alluvium	4995.29	4940.24
					58-80	Mancos		
5AGT	6	2	0-52.6	37.6-47.6	0-42	Alluvium	4984.92	4947.30
					42-55	Mancos		
6GT	6	2	0-45.3	30.3-40.3	0-37	Alluvium	4981.24	4948.07
					37-50	Mancos		
7GT	6	2	0-35	20.0-30.0	0-25	Alluvium	4971.43	4940.64
					25-35	Mancos		
8GT	6	2	0-39.4	29.4-39.4	0-41	Alluvium	4983.71	4947.37
					41-50	Mancos		
9GT	6	2	0-40.9	25.9-35.9	0-31	Alluvium	4975.18	4947.65
					31-42	Mancos		
10GT	6	2	0-34	19.0-29.0	0-24	Alluvium	4972.63	4954.10
					24-39	Mancos		
1/1	6.75	4	0-48.8	29-39	0-13.3	Alluvium	4957.5	4922.16
				43.8-45.8	13.8-62.7	Mancos		
				46.8-48.8				
1/2		0.75	0-13	11-13				Dry
2	6.75	4	0-30	15-25	0-4.5	Fill	4955.8	4931.88
				28-30	4.5-53.7	Mancos		

NOTE: Wells with the ID ending in H or GT were installed by the TAC, all others were installed by Dames & Moore.

[a]Depth shown in lithologic description is greater than casing depth because wells were installed in boreholes to a lesser depth than the total depth of the boreholes.

[b]Measured September, 1983.

SHP-08-0025

Table 8.1 Well construction details - Shiprock, New Mexico (Continued)

Well ID	Borehole diameter (inches)	Casing diameter (inches)	Casing depth (feet)	Perforated interval (feet)	Lithology Depth (feet)[a]	Lithology Formation	Ground elevation (feet MSL)	Water elevation (feet MSL)[b]
3	6.75	4	0-29.4	25.4-29.4	0-15	Fill	4970.6	4948.93
					15-27	Alluvium		
					27-47.6	Mancos		
3A/1	6.75	4	0-55	35-45	0-29	Fill, Tailings, Alluvium	4970.0	4937.54
				52-54				
					29-87.4	Mancos		
3A/2		1.5	0-29.5	25.5-29.5				4942.71
4	6.75	4	0-54	44-54	0-19	Fill, Tailings, Alluvium	4968.0	4934.74
					19-85.3	Mancos		
5	6.75	4	0-47	27-37	0-9.5	Fill	4956.9	4935.23
				45-47	9.5-96.7	Mancos		
6	6.75	4	0-48	29-39	0-24	Alluvium	4973.5	4941.42
				47-48	24-92.5	Mancos		
7	5.6	4	0-54	38-48	0-29	Alluvium	4974.8	4935.71
				51-53	29-85.1	Mancos		
8/1	6.75	4	0-64	36-46	0-31	Alluvium	4966.7	4937.60
				61-63	31-87.6	Mancos		
8/2		1.5	0-31	27-31				4937.77
9	6.75	4	0-40	27-40	0-23.5	Alluvium	4966.8	4938.80
					23.5-47.7	Mancos		
10/1	6.75	4	0-65	45-55	0-33	Tailings, Alluvium	4985.0	4937.04
				63-65				
					33-74.3	Mancos		
10/2		1.5	0-35	31-35				Dry

[a]Depth shown in lithologic description is greater than casing depth because wells were installed in boreholes to a lesser depth than the total depth of the boreholes.

[b]Measured September, 1983.

SHP-08-0026

Table 8.1 Well construction details, Shiprock, New Mexico (Concluded)

Well ID	Borehole diameter (inches)	Casing diameter (inches)	Casing depth (feet)	Perforated interval (feet)	Lithology: Depth (feet)[a]	Lithology: Formation	Ground elevation (feet MSL)	Water elevation (feet MSL)[b]
10A	6.75	2	0-40.3	35.3-40.3	0-39.8	Tailings, Alluvium	4985.0	Dry
					39.8-40.7	Mancos		
10B	6.75	4	0-35.25	31.25-35.25	0-36	Tailings, Alluvium	4986.0	Dry
11/1	6.75	4	0-70.6	49.1-59.1 67.6-69.6	0-45	Fill, Tailings, Alluvium	4986.4	4935.17
					45.0-71.3	Mancos		
11/2		1.5	0-44.4	40.4-44.4				4946.63
12A	6.75	4	0-84.3	54.3-59.3	0-44	Alluvium	4989.0	4941.11
				64.3-69.3	44-85	Mancos		
				79.3-84.3				

[a]Depth shown in lithologic description is greater than casing depth because wells were installed in boreholes to a lesser depth than the total depth of the boreholes.

[b]Measured September, 1983.

Table 8.2 Packer test results[a]

Boring number	Interval tested	Hydraulic conductivity (ft/yr)	Depth to water (ft)	Saturated thickness (ft)
1	20' - 60'10"	1104.2	35.3	15
	30' - 60'10"	559.9		
	30' - 60'10"	708.4		
	40' - 60'10"	34.7		
	50' - 60'10"	0		
2	15' - 53'8"	33.5	24.0	6
	20' - 53'8"	6.1		
	30' - 53'8"	0.0		
3a	50' - 86'6"	2.2	32.5	22
	50' - 86'6"	1.7		
	55' - 86'6"	0		
	55' - 86'6"	0		
4	38' - 85'4"	159.5	33.3	15
	38' - 85'4"	359.9		
	48' - 85'4"	0		
	58' - 85'4"	0		
5	27'6" - 96'8"	443.4	21.7	26
	27'7" - 96'8"	2.1		
	37'7" - 96'8"	45.1		
	47' - 96'8"	0		
	47' - 96'8"	0		
6	29'1" - 92'6"	786.5	32.1	7
	34'1" - 92'6"	12.8		
	34'1" - 92'6"	19.3		
	34'1" - 92'6"	29.4		
	39' - 92'6"	0		
	39' - 92'6"	0		
	39' - 92'6"	0		
7	45' - 63'	0	39.1	<6
	45' - 63'	0		
8	63' - 87'4"	0	29.1	<34
	63' - 87'4"	0		

Table 8.2 Packer test results[a] (Concluded)

Boring number	Interval tested	Hydraulic conductivity (ft/yr)	Depth to water (ft)	Saturated thickness (ft)
10	50' - 68'	689.2	48.0	17
	60' - 68'	0		
	60' - 68'	147.2		
	65' - 68'	0		
	65' - 68'	0		
11	54' - 70'	0	51.3	<3
	54' - 70'	0		
Geom. Mean				11.9

[a]Ref. DOE, 1982.

Table 8.4 Seasonal fluctuation of measured static water levels - Shiprock site

Well ID	5/25/82	9/23/83[d]	12/14/83
1/1	4922.3	4922.16	4922.36
1/2	dry	dry	dry
2	4931.7	4931.88	4932.09
3	4949.1	4948.93	4949.15
3A/1	4937.8	4937.54	4937.75
3AS/2	dry	4942.71	4942.14
4	4935.0	4934.74	4934.87
5	4935.15	4935.23	4935.09
6[a]	4934.25	4941.42	4934.33
7[a]	4935.8	4935.71	4924.52
8/1	4937.45	4937.60	4937.53
8/2	4937.4	4937.77	4937.53
9	4937.05	4938.80	4937.80[b]
10/1	4938.4	4937.04	4937.40
10/2	not measured	dry	not measured
10A	dry	dry	4947.18[c]
10B	dry	dry	dry
11/1	4935.8	4935.17	4935.76
11/2	4947.3	4946.63	4947.40
12A	4941.7	4941.11	4943.18
1H	non-existent	4925.28	4925.61
2H	non-existent	4929.74	4929.88
3H	non-existent	4939.85	4939.52
4H	non-existent	4940.24	4940.32
5GT	non-existent	4947.30	4946.99
6GT	non-existent	4948.07	4947.70
7GT	non-existent	4940.64	dry
8GT	non-existent	4947.37	4947.01
9GT	non-existent	4947.65	4947.35
10GT	non-existent	4954.10	4954.26

[a] Well usually recovers slowly after pumping/sampling.
[b] Approximate measurement.
[c] Well noted as intermittent location of perched "pockets" of water.
[d] Measured prior to sampling.

9.0 WATER BALANCE (INFILTRATION THROUGH THE COVER)

I. PROBLEM STATEMENT

Water infiltration into and through the contaminated materials is a potential source of ground-water contamination. The primary barrier against infiltration is the embankment cover.

II. ANALYSIS

Infiltration under existing conditions was analyzed using ground-water and soil permeability data in Geohydrology, Section 8.0, paragraph II, subparagraph C. The analysis showed that the existing infiltration rate is essentially zero.

The existing soil profile consists of a thin rock cover over tailings. The final soil profile will consist of a rock cover over seven feet of compacted silty sand. The permeability of the silty sand will be one to two orders of magnitude lower than the tailings, thus infiltration will be reduced.

Currently, the tailings support only sparse vegetation. The surface has been disturbed and the tailings form a poor growing medium. The embankment cover will, through time, support an increasing amount of vegetation, and infiltration will decrease as plant transpiration increases.

III. CONCLUSIONS

There is little or no water infiltrating through the tailings under existing conditions, and the infiltration will decrease as a result of the remedial action.

10.0 SLOPE STABILITY AND SEISMIC RISK EVALUATION

I. PROBLEM STATEMENT

The Shiprock site was evaluated for static and seismic slope stability. The possibility of liquefaction of the materials during earthquake ground motion was also evaluated. Procedures and material properties are summarized below. Details are included as Appendix D to the PSCR.

II. SLOPE STABILITY ANALYSIS

A. Material Properties

The proposed remedial action requires that the tailings be disposed of in an engineered pile. The pile will be composed of four material types: foundation materials, existing tailings, recompacted tailings, and cover materials.

The protective cover consists of a radon barrier layer and an armor riprap layer. Material properties for the cover were estimated from existing data in soil mechanics literature, and testing performed by Dames and Moore (1982). The dry unit weight of the radon barrier was estimated from the results of modified Proctor compaction tests (ASTM D1557). The materials will be placed in the embankment at a density of 95 percent of the maximum dry density as determined by the standard Proctor test (ASTM D698). Thus, the dry unit weight was reduced from the modified Proctor maximum of 125 pounds per cubic foot (pcf) to 114 pcf for the in-place dry density. In the absence of specific soil strength data, a conservative estimated value of 32 degrees was used for the cover material friction angle, based on representative values given by Terzaghi and Peck (1967). The estimated dry unit weight of the protective gravel riprap was 116 pcf with a friction angle of 35 degrees (Terzaghi and Peck, 1967). Both materials were assumed cohesionless.

Shear strength parameters for the recompacted tailings were determined by CSU (1982). Direct shear tests were performed on bulk test pit samples of sands, slimes, and a sand-slime mixture at various compacted densities (PSCR, 1984). Based on direct shear test data for these materials, a conservative effective strength friction angle of 32 degrees was selected for the recompacted tailings material. Long-term drained conditions would result in an expected cohesion value of zero.

In-situ tailings materials are extremely variable in composition and density. Therefore, the classification is divided into three types: sands, mixed sands and slimes, and slimes. Dry density of the slimes varied from 52 to 73 pounds per cubic foot with water contents of about 50 to over 80 percent, as reported by Dames and Moore (1982) and CSU (1982). Direct shear strength tests performed on remolded slime samples at saturated moisture contents were performed by CSU (1982). A drained friction angle of 15 degrees was determined for slimes at the equivalent in-situ density. Long-term drained conditions require that the value of cohesion be estimated at zero pcf.

Dry densities of the mixed sand and slimes were in the range of 85 to 95 pcf, with moisture contents of 10 to 30 percent. Direct shear strength data from CSU (1982) indicate that a drained friction angle of 25 degrees would be conservative. Tailings sands in the existing state had dry densities of 95 to 105 pcf with generally low moisture contents. The drained friction angle was conservatively estimated at 32 degrees, as taken from CSU (1982) direct shear data. The sands were assumed to be cohesionless. The tailings material properties are summarized in the PSCR (1984).

Foundation soils include silts, sands and gravels, and Mancos Shale at different stages of weathering. The silts are generally slightly plastic with dry densities of 90 pcf and greater. In the absence of specific shear strength data for the materials, a drained friction angle of 25 degrees was assumed based on a maximum plasticity index of 20 (Terzaghi and Peck, 1967). The material is expected to retain a minimum cohesive strength of 500 pounds per square foot during the life of the project.

The in-situ sands and gravels are dense to very dense as determined from the results of standard penetration testing. In the absence of specific soil strength data, the drained angle of internal friction was estimated to be 35 degrees (Terzaghi and Peck, 1967). The material is assumed cohesionless. Previous experience with the Mancos Shale indicates that cohesion values of 2000 psf and 4000 psf are conservative for the weathered and unweathered states, respectively.

The material properties as used in the analysis are presented in Table 10.1.

B. Earthquake Loading

An evaluation of the potential earthquake effects of the Shiprock site was performed. The study recommended a Maximum Credible Earthquake (MCE) of magnitude 5.75 on the Richter scale (TAC, 1983a). It was further recommended that a sustained peak ground acceleration of 0.11 to 0.13 g could be expected during the MCE (Weeks, 1984).

C. Embankment Geometry

Representative cross-sections of the existing conditions at the tailings disposal area were prepared by CSU (1982) and are presented in the PSCR (1984). These cross-sections were reviewed to determine the areas most susceptible to slope stability failures. A layer of unconsolidated slimes was found on the east side of the upper tailings pile. If these slimes were to remain in their present condition after placement of the cover materials, this would be the least stable condition for all of the embankment slopes. The interpretive cross-section, presented in Figure 10.1, indicates that the slimes vary in thickness from zero to 15 feet near the east edge.

Based on the Remedial Action Plan recommendations, an idealized cross-section of the stabilized pile was developed. The pile consists of eight feet of cover material placed on existing sand and slime tailings. A wedge of low density unconsolidated slimes was placed in the lower portion of the pile, immediately overlying the foundation silts. The thickness of the wedge is 10 feet at the embankment toe and diminishes to zero near the center of the embankment. A schematic section of the idealized slope is presented in Figure 10.2.

D. Method of Analysis

Slope stability calculations for both the static and seismic cases were made using the computer program REAME (Huang, 1983). The factor of safety against slope failure is calculated using the simplified Bishop method. Effective stress and strength parameters were used and no phreatic surface was considered.

A factor of safety of 2.5 was computed for the static case.

A seismic coefficient of 0.13 g was applied to the embankment to model seismic loading conditions. Amplification of the ground motion in the embankment was not considered necessary due to the low embankment height (50 to 60 feet) and large surface area of the pile.

A factor of safety for the seismic case is 1.5. The condition analyzed is expected to improve with time due to consolidation of the slimes under the weight of the overlying soils and an associated strength increase for this material. The values computed are made more conservative by the assumption that all of the tailings over the slimes remain in their existing condition when in fact the inevitable reworking of the upper three to five feet during construction will substantially improve their strength characteristics.

Additional wedge analyses were performed on the critical section of the slope. The minimum factor of safety of 1.7 was obtained for a failure through the slimes having a slip surface just below the cover. The safety factor increases to that obtained for a circular failure for wedges taken further into the slope.

Critical failure surfaces are presented in Figure 10.2. Critical failure surfaces passed through the interface between the slimes and the foundation silts and clays in both the static and seismic analyses.

Insufficient soil parameters are available for end-of-construction stability analyses. However, a parametric analysis indicates that values of friction angle equal to 0° and cohesion equal to 325 psf are required in the slimes in order to sustain a factor of safety equal to 1.3. Blow counts in the slimes indicate that approximately 1000 psf cohesion are available. Therefore, the embankment will be stable through the end of construction.

III. LIQUEFACTION ANALYSIS

The embankment and underlying natural soils were evaluated for liquefaction potential by the simplified method of Seed and Idriss (1982). Previous work by the TAC (1983a) has determined that the potential for cyclic mobility in the foundation materials is negligible due to the coarse grain sizes encountered in the terrace deposits. The potential for liquefaction of embankment components was investigated due to the presence of saturated slimes in the tailings piles.

An idealized cross-section of the embankment used in the liquefaction analysis is presented in Figure 10.3. The section is similar to that used in the slope stability analysis. Tailings slimes were considered saturated with the water surface just below the tailings sand. A standard penetration blow count of 10 was assigned to the slimes based on a review of boring logs by Dames and Moore (1982) and the TAC (1983b).

Seed and Idriss (1982) present techniques to evaluate the liquefaction potential of level ground under earthquake-induced ground motions. These methods were considered adequate as an approximation for the gradually sloping embankment and the large areas involved. Methods are presented for materials with particle size $D_{50} < 0.15$ mm (silty sands) and $D_{50} > 0.25$ (sands). The use of these methods in analyzing the slimes is conservative.

Analyses were performed in order to estimate the liquefaction potential at the embankment full height, or top of the slope, and one-half the full height, or at the midpoint on the slope. The factor of safety in the liquefaction analysis is defined as the horizontal shear stress required to produce liquefaction in the layer divided by the shear stress induced by the ground motion. The factor of safety was essentially the same for both slope conditions. The factor of safety against liquefaction of saturated slimes was 1.4 based on the analysis for pure sand, and 2.5 based on the analysis for silty sand. The actual factor of safety for saturated slimes should be greater than these values.

In addition to the conservatism of the analysis, the slimes exhibit some cohesion and there is no true ground-water table within the embankment. These factors would also contribute to stability of the embankment during a seismic event.

IV. CONCLUSIONS

A. The seismic setting of the area is expected to produce a Maximum Credible Earthquake no larger than magnitude 5.75. The resultant ground motion will have horizontal accelerations on the order of 0.11 to 0.13 g.

B. The embankment was evaluated for static and seismic slope stability with a seismic coefficient of 0.13. Factors of safety against deep-seated slope failure were 2.5 and 1.5 for the static and seismic cases, respectively. The most critical surface passed through unconsolidated, saturated slimes in both cases. The factor of safety of 1.7 was obtained for a shallow wedge static analysis and 1.1 for pseudo-static analysis of the same wedge.

C. The factor of safety against liquefaction of embankment materials was found to be in excess of 1.4 for the most critical case.

V. REFERENCES

CSU (Colorado State University), 1982. "Characterization of Inactive Uranium Mill Tailings Sites, Shiprock Site, Shiprock, New Mexico," Draft Report, Civil Engineering Department, Fort Collins, Colorado.

Dames and Moore, 1982. "Draft Feasibility Evaluation On-Site Stabilization of Uranium Mill Tailings, Shiprock, New Mexico," Job No. 10805-059-14, prepared by Dames and Moore, Los Angeles, California, for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

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Seed, H. B., and I. M. Idriss, 1982. Ground Motions and Soil Liquefaction During Earthquakes, Earthquake Engineering Research Institute, Berkeley, California.

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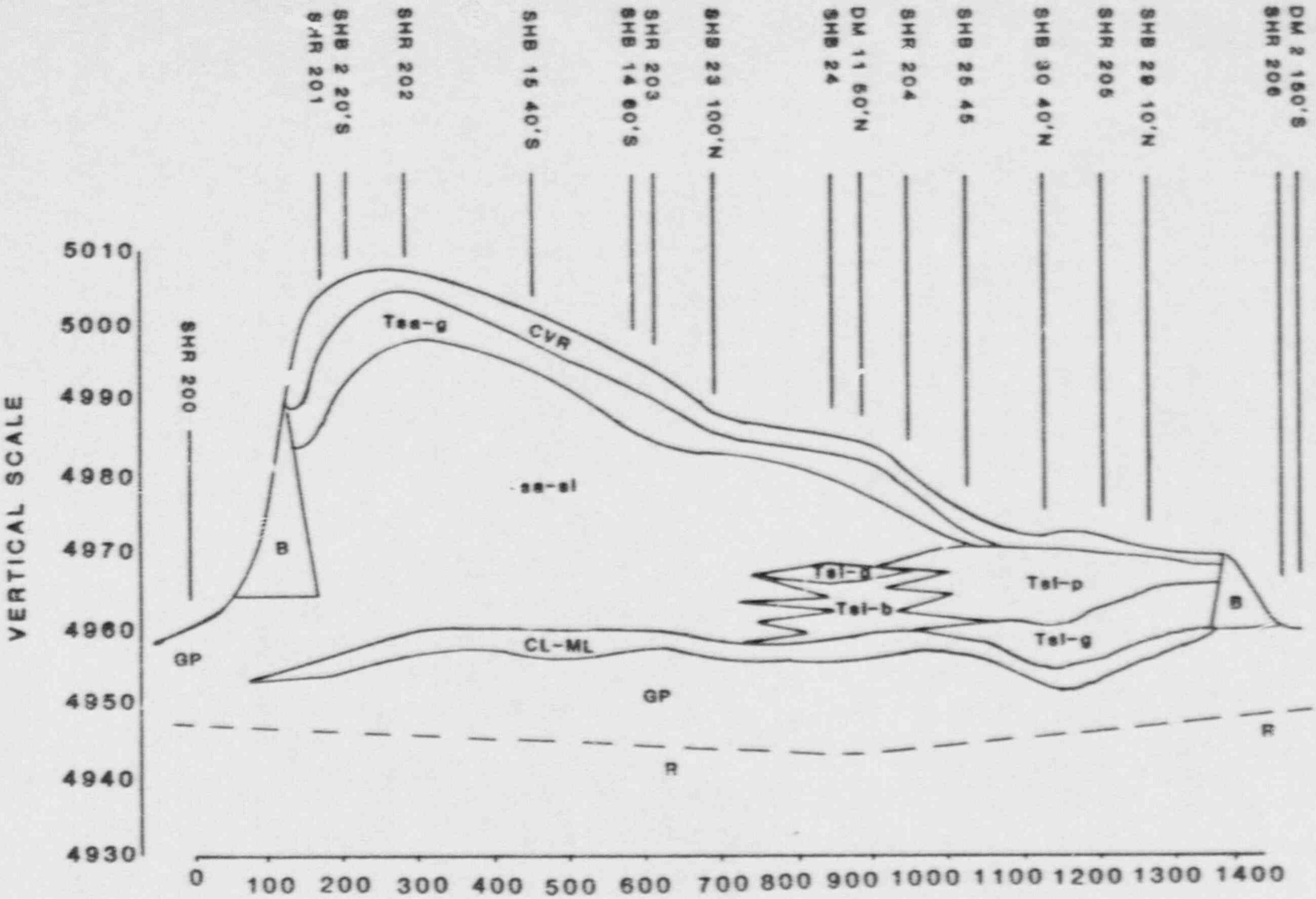

Ref: CSU, 1982

FIGURE 10.1
EXISTING CONDITIONS: SLOPE STABILITY

SOIL I.D. NO.	MATERIAL TYPE	COHESION (psf)	Φ (degrees)	γT (pcf)
1	WEATHERED SHALE	2000	130	20
2	SAND AND GRAVEL	0	35	120
3	SILT & CLAY	500	25	109
4	SLIMES	0	15	101
5	SAND & SLIMES	0	25	113
6	SILTY SAND	0	32	127
7	GRAVELLY SAND	0	35	120

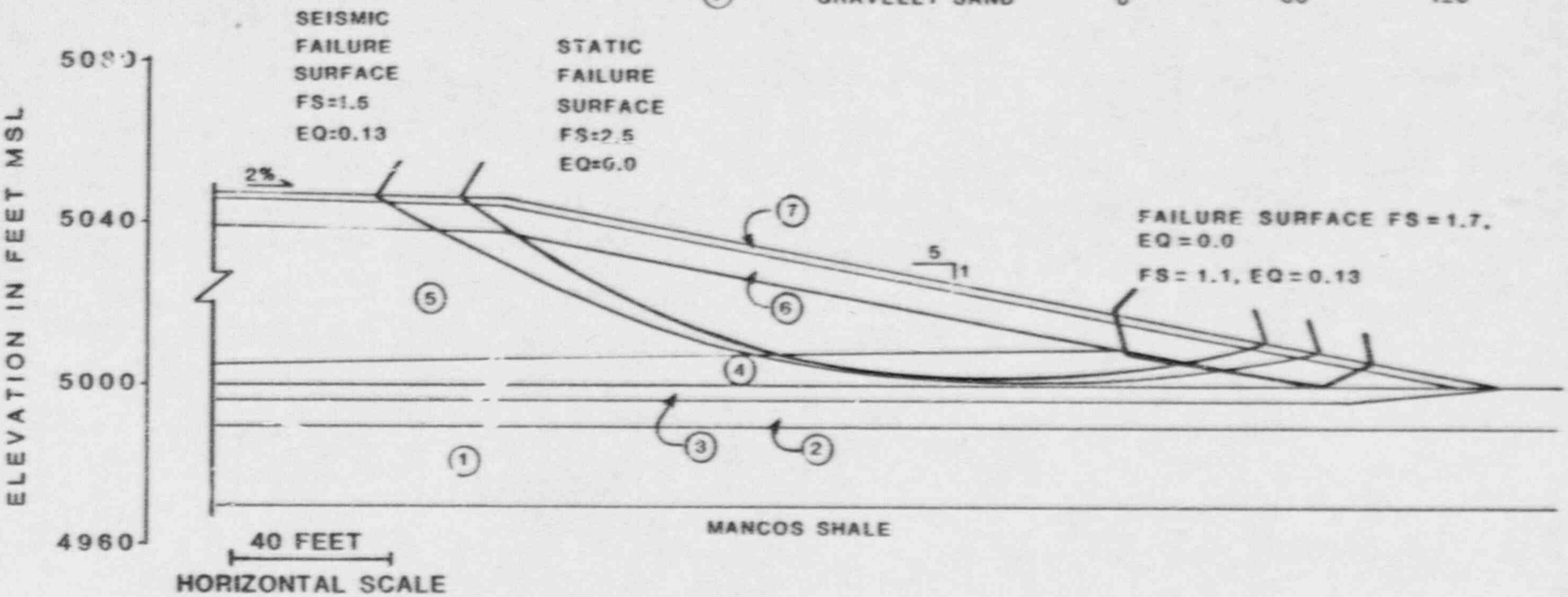

FIGURE 10.2
CROSS-SECTION AND CRITICAL SURFACES FOR SLOPE STABILITY

SHP-10-0007

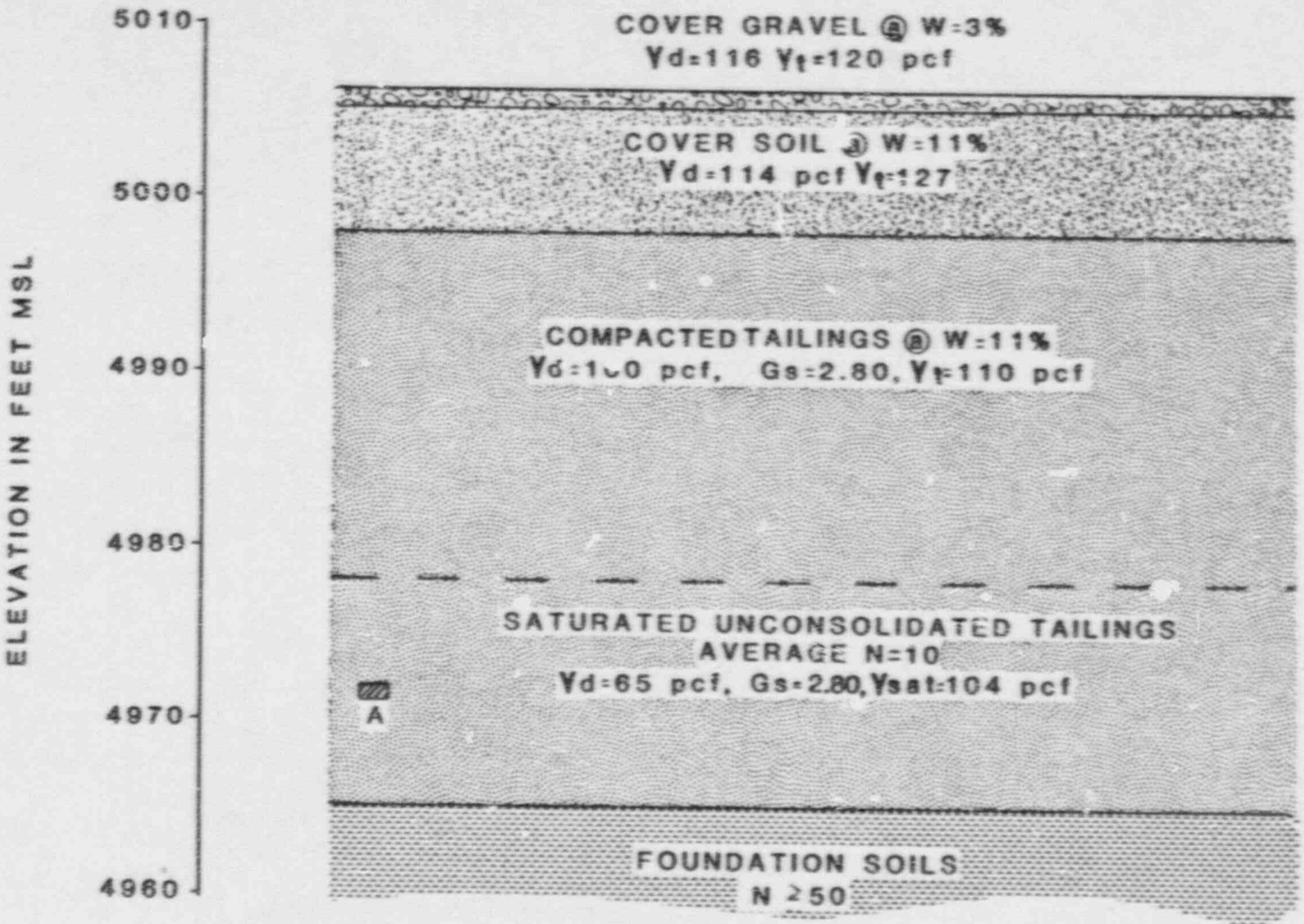

FIGURE 10.3

IDEALIZED TAILINGS PROFILE FOR LIQUEFACTION ANALYSIS

Table 10.1 Material properties for stability analysis

Material	Dry unit weight (pcf)	Moisture content (%)	Cohesion (psf)	Angle of internal friction (degrees)
Cover				
Gravelly sand	116	3	0	35
Silty sand	114	11	0	32
Rehandled tailings				
Mixed sands & slimes	103	10	0	35
In-situ tailings				
Sands	100	11	0	32
Mixed sands & slimes	90	25	0	25
Slimes	65	55	0	15
Foundation				
Silts	107	15	500	25
Sands and gravels	113	6	0	35
Mancos Shale				
- Highly weathered	120	9	2000	20
- Slightly weathered	151	4	4000	10

11.0 SITE GEOMORPHOLOGY

I. PROBLEM STATEMENT

The purpose of this calculation is to discuss and analyze the possible effects of river migration and slope recession on the proposed conceptual design. The following items will be addressed:

A. Encroachment toward the site by the San Juan River.
B. Slope recession due to mass wasting.
C. Site protection from slope attack and recession.

II. METHODS OF CALCULATION

A. A review of existing data and historical aerial photos, and a site visit were performed to identify active areas of slope recession and river attack that could impact upon the stability of the covered site (TAC, 1983).

B. Flooding information for the San Juan River was reviewed with regard to stage and discharge.

C. Predictions of slope recession due to mass wasting were made using values reported in various references pertinent to western arid slopes and site observations.

D. Predictions of slope recession due to attack by San Juan River flows are based on changes noted on the historical aerial photos, slope conditions noted in the field, and estimates of time that the escarpment will be under attack.

III. CONCLUSIONS

A. The slope forming the escarpment will experience gradual recession due to mass wasting and localized erosion. If this slope is undisturbed at the base by river attack, the final slope will have an angle of about 32° from the horizontal. It will probably take much longer than 1000 years for this to be completed.

B. The river will most likely attack the base of the escarpment adjacent to the pile at some time in the future even though such attack is not now occurring. The duration of attack in the next 1000 years is difficult to evaluate but for design purposes a range of 50 to 100 percent was used.

C. It is difficult to assign a definitive number to the magnitude of total slope recession expected in the next 1000 years due to mass wasting and river attack. However, to be conservative for design purposes, the toe of the reclaimed pile should be at least 270 feet back from the base of the escarpment. Further details on the derivation of the setback distance are contained in Appendix B, Geomorphic Stability.

D. The top edge of the escarpment is susceptible to localized erosion during runoff events. These areas will be protected with rock armoring and sloped to drain back toward the pile. Periodic inspection of the escarpment, specifically after major runoff events, will be required. These inspections will be incorporated into the long-term maintenance and surveillance plan.

E. The elevation of the pile with respect to the river channel is such that inundation from any predictable flood event will not occur. Calculations of flood effect are contained in the following section, Flood Analysis.

IV. REFERENCES

TAC (Technical Assistance Contractor), 1983. "Unpublished Site Erosion Evaluation Report, Shiprock Site, Shiprock, New Mexico," SHB Job. No. E82-1032A, prepared by Sergent, Hauskins, and Beckwith (SHB), Albuquerque, New Mexico, for the TAC (Jacobs-Weston Team), Albuquerque, New Mexico.

NOTE: The above reference is included as Appendix C to the PSCR.

12.0 FLOOD ANALYSIS

I. PROBLEM STATEMENT

The purpose of this calculation is to determine the effects of river flooding on the embankment. The Probable Maximum Flood (PMF) of the San Juan River at the Shiprock site was analyzed. The depth and velocity of the peak flow were calculated.

II. METHOD

A. The maximum height of the PMF was calculated through the following process:

1. The typical cross-section and average bed slope of the San Juan River at the site were found from the Shiprock Quadrangle map (USGS, 1983).

2. Flow rates for several flood elevations were then found using Manning's equation with a friction coefficient of 0.04. A curve of flow elevation was plotted.

3. The PMF at the Shiprock site was estimated using previous PMF estimates at Navajo Dam and Glen Canyon Dam. The peak flow from a failure of Navajo Dam was calculated. It is very unlikely that the peak flows from flooding in the San Juan River Basin and failure of Navajo Dam would coincide; however, to be conservative the peak flows were added.

4. The elevation of the resulting PMF was then found using the flow rating curve developed in Step 2.

B. The maximum average velocity of the PMF was calculated using the same procedure as above except that Manning's friction coefficient was assumed to be 0.03.

III. CONCLUSIONS

A. A conservative PMF estimate for the San Juan River is 844,000 cubic feet per second.

B. The depth of flow due to the PMF is estimated to be 26 feet, which is 44 feet below the base of the embankment.

C. The average velocity of the PMF was calculated to be 14 feet per second.

D. Erosion of the escarpment wall can be expected during passage of the PMF, but the embankment will be protected by the 300-foot setback.

IV. REFERENCES

USGS (U.S. Geological Survey), 1983. Shiprock Quadrangle, New Mexico - San Juan County, 7.5 minute series (Topographic), U.S. Geological Survey, Denver, Colorado.