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A SUMMARY OF THE ENGINEERING ASSESSMENT OF RADIOACTIVE SANDS AND RESIDUES

LOWMAN SITE, LOWMAN, IDAHO

SEPTEMBER 1981

PREPARED FOR

UNITED STATES DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE
URANIUM MILL TAILINGS
REMEDIAL ACTIONS PROJECT OFFICE
ALBUQUERQUE, NEW MEXICO

CONTRACT NO. DE-AC04-76GJ01658

BY

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Salt Lake City, Utah 84108

NOTICE

This engineering assessment has been performed under DOE Contract No. DE-AC04-76GJ01658 between the U.S. Department of Energy and Ford, Bacon & Davis Utah Inc.

Copies of this report may be obtained from the Uranium Mill Tailings Remedial Action Project Office, U.S. Department of Energy, Albuquerque Operations Office, Albuquerque, New Mexico 87115.

FOREWORD

This report is a summary of a parent report (issued under separate cover), entitled "Engineering Assessment of Radioactive Sands and Residues, Lowman Site, Lowman, Idaho". Both reports have been authorized by the U.S. Department of Energy (DOE), Albuquerque Operations Office, Uranium Mill Tailings Remedial Action Project Office, Albuquerque, New Mexico, under Contract No. DE-AC04-76GJ01658. These reports are revisions of an earlier report dated December 1977, entitled "Phase II - Title I Engineering Assessment of Inactive Uranium Mill Tailings, Lowman Site, Lowman, Idaho," which was authorized by DOE, Grand Junction, Colorado, under Contract No. E(05-1)-1658.

These reports have become necessary as a result of changes that have occurred since 1977 which pertain to the Lowman site and vicinity, as well as changes in remedial action criteria. The new data reflecting these changes are summarized in this report. Evaluation of the current conditions is essential to assessing the impacts associated with the options suggested for remedial actions for the radioactive sands and residues.

Ford, Bacon & Davis Utah Inc. (FB&DU) has received excellent cooperation and assistance in obtaining new data to prepare this report. Special recognition is due Richard H. Campbell and Mark Matthews of DOE, Robert Funderburg of the Idaho State Radiation Control Office, as well as several local, county, and state agencies and private individuals.

ABSTRACT

Ford, Bacon & Davis Utah Inc. has reevaluated the Lowman site in order to revise the December 1977 engineering assessment of the problems resulting from the existence of radioactive sands and residues at Lowman, Idaho. This engineering assessment has included the preparation of topographic maps, the performance of core drillings and radiometric measurements sufficient to determine areas and volumes of radioactive sands and residues and radiation exposures of individuals and nearby populations, the investigations of site hydrology and meteorology, and the evaluation and costing of alternative corrective actions.

Radon gas released from the 191,000 tons of radioactive sands, residues, and contaminated soils at the Lowman site constitutes the most significant environmental impact, although windblown radioactive sands and external gamma radiation also are factors. The three alternative actions presented in this engineering assessment range from millsite and off-site decontamination with the addition of 3 m of stabilization cover material (Option I), to removal of the radioactive sands to remote disposal sites and decontamination of the former site (Options II and III). Cost estimates for the three options range from about $2,500,000 for stabilization in-place, to about $6,000,000 for disposal at a distance of about 15 mi.

Reprocessing the radioactive sands for uranium recovery is not practicable.

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CHAPTER 1

A SUMMARY OF THE ENGINEERING ASSESSMENT OF RADIOACTIVE SANDS AND RESIDUES

1.1 INTRODUCTION

The U.S. Energy Research and Development Administration (ERDA) contracted in 1975 with Ford, Bacon & Davis Utah Inc. (FB&DU) of Salt Lake City, Utah, to provide architect-engineering services and final reports based on the assessment of the problems resulting from the existence of large quantities of radioactive uranium mill tailings at inactive millsites in eight western states and in Pennsylvania. In 1980, the U.S. Department of Energy (DOE) contracted with FB&DU to produce revised reports of the sites designated in the Uranium Mill Tailings Remedial Action (UMTRA) program in order to reflect the current conditions, new criteria and options, and to estimate current remedial action costs.

A preliminary survey (Phase I) was carried out in 1974 by the U.S. Atomic Energy Commission (AEC) in cooperation with the U.S. Environmental Protection Agency (EPA) and the affected states. In a summary report,(1) ERDA identified 17 sites in Arizona, Colorado, Idaho, New Mexico, Utah, and Wyoming for which practical remedial measures were to be evaluated. Subsequently, ERDA added five additional sites (Riverton and Converse County, Wyoming; Lakeview, Oregon; Falls City and Ray Point, Texas). More recently, DOE has added a site in Canonsburg, Pennsylvania, one near Baggs, Wyoming, and two sites in North Dakota (Belfield and Bowman) and deleted Ray Point, for a total of 25 sites. DOE continues to investigate the status of the site near Baggs, Wyoming. Most of the mills at these sites produced by far the greatest part of their output of uranium under contracts with the AEC during the period 1947 through 1970. After operations ceased, some companies made no attempt to stabilize the tailings, while others did so with varying degrees of success. Recently, concern has increased about the possible adverse effects to the general public from long-term exposure to low-level sources of radiation from the tailings piles and sites.

Prior to 1975, the studies of radiation levels on and in the vicinities of these sites were limited in scope. The data available were insufficient to permit assessment of risk to people with any degree of confidence. In addition, information on practicable measures to reduce radiation exposures and estimates of their projected costs was limited. The purposes of these recent studies performed by FB&DU have been to update the information necessary to provide a basis for decision making for appropriate remedial actions for each of the 25 sites.

Evaluations of the following factors have been included in this engineering assessment in order to assess the significance of the radiological conditions that exist today at the Lowman site:

(a) Exhalation of radon gas from the radioactive sands and residues

(b) On-site and off-site direct radiation

(c) Land contamination from windblown sands and residues

(d) Hydrology and contamination by water pathways

(e) Potential health impact

(f) Potential for extraction of additional minerals from the sands and residues

Investigation of these and other factors originally led to the evaluation of two potential practicable remedial action alternatives. Since that time, these alternatives have been judged unacceptable because of new criteria that have been proposed. In the work performed in the preparation of this report, the remedial action alternatives are revised as follows:

(a) Option I - Stabilization of radioactive sands and residues on site with a 3-m cover

(b) Option II - Disposal at an unspecified site located 15 mi from the present site

(c) Option III - Disposal at an unspecified site located 30 mi from the present site

1.1.1 Background

On March 12, 1974, the Subcommittee on Raw Materials of the Joint Committee on Atomic Energy (JCAE), Congress of the United States, held hearings on S. 2566 and H.R. 11378, identical bills submitted by Senator Frank E. Moss and Representative Wayne Owens of Utah. The bills provided for a cooperative arrangement between the AEC and the State of Utah in the area of the Vitro tailings site in Salt Lake City.* The bills also

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*The proceedings of these hearings and the Summary Report on the Phase I Study were published by the JCAE as Appendix 3 to ERDA Authorizing Legislation for Fiscal Year 1976. Hearings before the Subcommittee on Legislation, JCAE, on Fusion Power, Biomedical and Environmental Research; Operational Safety; Waste Management and Transportation, Feb 18 and 27, 1975, Part 2. The Phase I report on the Lowman site appears as Appendix I to Reference 4.

provided for the assessment of an appropriate remedial action to limit the exposure of individuals to radiation from uranium mill tailings.

Dr. William D. Rowe, testifying on behalf of the EPA, pointed out that there are other sites with similar problems. He recommended the problem be approached as a generic one, structured to address the most critical problem first.

Dr. James L. Liverman, testifying for the AEC, proposed that a comprehensive study should be made of all such piles, rather than treating the potential problem on a piecemeal basis. He proposed that the study be a cooperative two-phase undertaking by the states concerned and the appropriate federal agencies, such as the AEC and EPA. Phase I would involve site visits to determine such aspects as their condition, ownership, proximity to populated areas, prospects for increased population near the site, and need for corrective action. A preliminary report then would be prepared which would serve as a basis for determining if a detailed engineering assessment (Phase II) were necessary for each millsite. The Phase II study, if necessary, would include evaluation of the problems, examination of alternative solutions, preparation of cost estimates and of detailed plans and specifications for alternative remedial action measures. This part of the study would include physical measurements to determine exposure or potential exposure to the public.

The Phase I assessment began in May 1974, with teams consisting of representatives of the AEC, the EPA, and the states involved visiting 21 of the inactive sites. The Phase I report was presented to the JCAE in October 1974. Table 1-1, adapted from Reference 1, summarizes the conditions in 1980. Based on the findings presented in the Phase I report, the decision was made to proceed with Phase II.

On May 5, 1975, ERDA, the successor to AEC, announced that Ford, Bacon & Davis Utah Inc. of Salt Lake City, Utah, had been selected to provide the architect-engineering (A-E) services for Phase II. ERDA's Grand Junction, Colorado, Office (GJO) was authorized to negotiate and administer the terms of a contract with FB&DU. The contract was effective on June 23, 1975. The Salt Lake City Vitro site was assigned as the initial task, and work began immediately. Work at Lowman was performed from September 20 through September 23, 1976, and the original Phase II - Title I engineering assessment was published in December 1977.(2)

On November 8, 1978, the Uranium Mill Tailings Radiation Control Act of 1978 (PL 95-604) became effective. This legislation provides for state participation with the Federal Government in the remedial action for inactive tailings piles. Pursuant to requirements of PL 95-604, the EPA has the responsibility to promulgate remedial action standards for the cleanup of areas contaminated with residual radioactive material and for disposal of tailings. The U.S. Nuclear Regulatory Commission (NRC) has the responsibility for enforcing these standards.

In 1979, DOE established the UMTRA Program Office in Albuquerque, New Mexico. Work on the program has since been directed by personnel in that office. The supplementary field work by FB&DU in support of this report was performed during the week of June 2, 1980.

1.1.2 Scope of Phase II Engineering Assessment

Phase II A-E Services are divided into two stages: Title I and Title II.

Title I services include the engineering assessment of existing conditions and the identification, evaluation, and costing of alternative remedial actions for each site. Following the selection and funding of a specific remedial action plan, Title II services will be performed. These services will include the preparation of detailed plans and specifications for implementation of the selected remedial action.

This report is a continuation of the assessment made for Title I requirements and has been prepared by FB&DU. In connection with the field studies made in 1976, the Oak Ridge National Laboratory (ORNL) at Oak Ridge, Tennessee, under separate agreement with DOE, provided measurements of the radioactivity concentrations in the soil and water samples and gamma surveys. The EPA staff provided the results of radiation surveys they previously had made at the Lowman site.

The specific scope requirements of the Title I assessment may include but are not limited to the following:

(a) Preparation of an engineering assessment report for each site, and preparation of a comprehensive report suitable for submission to the Congress on reasonable remedial action alternatives and their estimated cost.

(b) Determination of property ownership in order to obtain release of Federal Government and A-E liability for performance of engineering assessment work at both inactive millsites and privately owned structures.

(c) Preparation of topographic maps of millsites and other sites to which tailings and other radioactive materials might be moved.

(d) Performance of core drillings and radiometric measurements ample to determine volumes of tailings and other radium-contaminated materials.

(e) Performance of radiometric surveys, as required, to determine areas and structures requiring cleanup or decontamination.

(f) Determination of the adequacy and the environmental suitability of sites at which mill tailings containing radium could be disposed; and once such sites are identified, perform evaluations and estimate the costs involved.

(g) Performance of engineering assessments of structures where uranium mill tailings have been used in off-site construction to arrive at recommendations and estimated costs of performing remedial action.

(h) Evaluation of various methods, techniques, and materials for stabilizing uranium mill tailings to prevent wind and water erosion, to inhibit or eliminate radon exhalation, and to minimize maintenance and control costs.

(i) Evaluation of availability of suitable fill and stabilization cover materials that could be used.

(j) Evaluation of radiation exposures of individuals and nearby populations resulting from the inactive uranium millsite, with specific attention to:

  (1) Gamma radiation

  (2) Radon

  (3) Radon daughter concentrations

  (4) Radium and other naturally occurring radioisotopes in the tailings

(k) Review of existing information about site hydrology and meteorology.

(l) Evaluation of recovering residual values, such as uranium and vanadium in the tailings and other residues on the sites.

(m) Performance of demographic and land use studies. Investigation of community and area planning, and industrial and growth projections.

(n) Evaluation of the alternative corrective actions for each site in order to arrive at recommendations, estimated costs, and socioeconomic impact based on population and land use projections.

(o) Preparation of preliminary plans, specifications, and cost estimates for alternative corrective actions for each site.

Not all of these items received attention at the Lowman site.

1.2 SITE DESCRIPTION

1.2.1 Location and Topography

The Lowman millsite is located in Boise County approximately 75 mi northeast of Boise, Idaho. The site is in a pine-covered mountain valley in the Boise National Forest. It rests on a west-facing terrace of the Sawtooth Mountain Range. The elevation of the site is generally 4,000 ft above sea level. Drainage from the site is into Clear Creek just above the junction of Clear Creek and the South Fork Payette River. The site and its relationship to the surrounding area are shown in the aerial photograph in Figure 2-1.*

1.2.2 Ownership and History of Milling Operations and Processing

The original owner and only operator was the Porter Brothers Corporation of Boise, Idaho. The site now is owned by Velsicol Chemical Corporation, formerly known as the Michigan Chemical Corporation. Figure 2-3 shows the current ownership and legal description of the site.

The plant operated from 1955 until 1960. During that time approximately 200,000 tons of dredge product obtained from Bear Valley, 20 mi north of Lowman, were processed. The process used was a mechanical rather than a chemical process. Columbite-euxenite and monazite concentrates and other by-products such as magnetite, ilmenite, zircon, and garnet were extracted from the ore.

1.2.3 Present Condition of the Site

Some concrete foundations, a few small sheds, and some debris are all that remain of the mill structures. Just over 90,000 tons of sands remain on the site in several piles. The sands and residues are scattered throughout the 37-acre site in 10 locations covering about 5 acres. A descriptive map of the site is included as Figure 2-4.

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*Figures and tables referenced in this summary are extracted from Chapters 2 through 9 of the parent report and are in the addendum.

All of the sands are radioactive in varying degrees. None of these materials have been stabilized. Some of the more radioactive sands have been eroded by water down a steep slope on the west side of the site and into an old settling pond adjacent to Clear Creek.

The site is about 80% covered with native grasses and trees, but there is no vegetation on the piles of sand. The barbed-wire fencing around the site is in a state of substantial disrepair. Since the field survey work, a posted gate with a lock has been installed to control vehicle access to the site.

1.2.4 Characteristics of Contaminated Materials and Soils

The radioactive sands are angular, dense, coarse-grained, and of several colors. The black sands are primarily magnetite; the red sands are garnet. The grey and white sands, also residues of the mechanical separation process, were deposited along the upper edge of the slope above Clear Creek. Table 2-1 is a listing of the amounts of these materials on the site.

The soil beneath the radioactive sands and residues is mountain loam, nearly black in color, with gravelly aggregates resulting from glacial deposits in some locations.

1.2.5 Geology, Hydrology, and Meteorology

The Lowman millsite is located on a glacial terrace, which has been incised by Clear Creek to the west of the site and is bordered by a ridge to the east. A lower river-laid terrace, on which a settling pond area was constructed, is adjacent to the higher millsite terrace. The glacial terrace material is composed of deep sandy and loamy soils, gravels, sands, boulders, and cobbles. The lower alluvial terrace is river-run material, primarily of granitic origin. Igneous granite bedrock (granodiorite) of the Idaho batholith underlies the site. This granite is fractured and weathered. Bedrock is exposed in the streambed and forms the escarpment to the east of the site. Figure 2-5 is a simplified stratigraphic column of the area.

The flowing surface waters near the site consist of Clear Creek, the South Fork Payette River, and the intermittent flow in ditches on the site. Clear Creek is a swiftly flowing stream that intersects the South Fork Payette River approximately 0.5 mi south of the site. It is possible that the lower terrace which borders the creek could be eroded by flood waters of Clear Creek, with resulting undercutting and erosion of the piles. However, there is no evidence that such flooding has occurred.

Contamination of the surface waters could occur by physical transport of the sands as a result of overland runoff and by seepage through the piles into the waters. Placement of the piles parallel to the slopes, which tends to trap water behind the piles, has encouraged seepage into the surface waters. The degree of physical transport from the site has been aggravated by the steep banks of the sparsely vegetated piles, where some slopes have gullies up to 10 ft deep. Rill erosion is occurring on the cut behind and adjacent to the mill foundations. The ridge east of the piles limits the catchment area near the site; however, a substantial trench was constructed to convey process water from the eastern slope to the mill during operations. This ditch continues to channel runoff, and this concentration of flow aggravates erosion.

Shallow unconfined aquifers characterize the hydrology of the area. Clear Creek and the South Fork Payette River are gaining streams fed by flows from unconfined ground waters. The terrace materials tend to filter sediments from the waters and act as buffers to regulate overland and subsurface flow. The interface between the unconsolidated surficial materials and bedrock acts as the surface for lateral ground water flow. Seeps and springs are common in the area, particularly at the exposure of this interface. One such spring lies at the southern margin of the piles relatively near the source of domestic water for a mobile home. Eight wells within 2 mi of the site are on record at the Idaho State Department of Water Resources. Three wells in the area are Federal Government wells, but they have not been monitored. There is no problem associated with confined ground waters at the site because there are no confined ground waters associated with the igneous bedrock of the Idaho batholith.

Average annual precipitation at the site ranges between 20 and 25 in., much of which comes as snowpack. High-intensity rainstorms are infrequent, but such a storm at the site could result in serious erosion of the more susceptible areas of the piles. The strongest winds blow up and down the valley in a north-south direction, but the local land relief and the forest canopy tend to serve as windbreaks and protect the sands from wind erosion.

1.3 RADIOACTIVITY AND POLLUTANT IMPACTS ON THE ENVIRONMENT

About 85% of the total radioactivity originally in uranium ore remained in the sands after removal of the uranium. The principal environmental radiological impact and associated health effects arise from the ^{230}Th, ^{226}Ra, ^{222}Rn, and ^{222}Rn daughters contained in the sands. Although these radionuclides occur in nature, their concentrations in the sands are several orders of magnitude greater than their average concentrations in the earth's crust. Since these sands were processed by physical methods and were not chemically treated, the solubility of the ^{226}Ra has not been increased by processing and hence is not significantly more mobile.

1.3.1 Radiation Exposure Pathways, Contamination Mechanisms, and Background Levels

The major potential environmental routes of exposure to man are:

(a) Inhalation of ^{222}Rn and its daughter products, resulting from the continuous radioactive decay of ^{226}Ra in the sands and residues. Radon is a gas which diffuses from the piles. The principal exposure results from inhalation of ^{222}Rn daughters. This exposure affects the lungs. For this assessment, no criteria have been established for radon concentrations in air. However, the pathway for radon and radon daughters accounts for the major portion of the exposure to the population.

(b) External whole-body gamma exposure directly from radionuclides in the piles.

(c) Inhalation and ingestion of windblown sands. The primary health effect relates to the alpha emitters ^{230}Th and ^{226}Ra, each of which causes exposure to the bones and lungs.

(d) Ingestion of ground and surface water contaminated with radioactive elements (primarily ^{226}Ra) and other toxic materials.

(e) Contamination of food through uptake and concentration of radioactive elements by plants and animals is another pathway that can occur; however, this pathway was not considered in this study.

1.3.1.1 Radon Gas Diffusion and Transport

Measurements of radon flux from the sands made in 1976 using the charcoal canister technique(3) ranged from 50 to 150 pCi/m^2-s on the residue piles. Radon flux depends principally on radium content of the sands; however, it also varies considerably because of moisture, soil characteristics, and climatological conditions.

1.3.1.2 Direct Gamma Radiation

The range of natural background values in the Lowman area was between 10 and 12 μR/hr, averaging 11 μR/hr as measured with an energy-compensated Geiger Mueller detector.(4) Gamma rates were measured as high as 2,450 μR/hr above the surface of the ore piles and 1,220 μR/hr above the surface of the residue piles, as shown in Figure 3-9.

1.3.1.3 Windblown Contaminants

Background gamma radiation rates were reached within 0.2 mi to the north and 0.1 mi in the other directions from the site. The results of the EPA gamma radiation survey around the site are shown in Figure 3-11. The background line closely follows the area where the radioactive sands are located. An iso-exposure line indicating the portion of the land surrounding the site that is contaminated in excess of 5 pCi/g of radium above background concentration is shown in Figure 3-12.

A surface soil sample taken 0.1 mi north of the site contained 4 times background levels of ^{226}Ra (1.1 pCi/g). On-site soil samples had radium concentrations from background to 15 times average radium background concentration. However, one sample near Clear Creek and near the base of the grey sand pile contained 200 pCi/g of radium. This sample probably contained sand eroded from the pile by surface runoff.

1.3.1.4 Ground and Surface Water Contamination

Two surface water samples from Clear Creek upstream and downstream from the Lowman site were analyzed for ^{226}Ra. The upstream sample contained 0.16 pCi/l of radium; only a trace of radium was found in the downstream sample. The radium content of water from a spring south of the site was 0.12 pCi/l. These results indicate no contamination of surface water from radium leached from the sands.

1.3.1.5 Soil Contamination

The leaching of radium into the soil beneath the radioactive sands extends from 2 to 3 ft below the pile-soil interface before reaching twice the average background level of radium concentration in local soil samples (1.1 pCi/g). A few isolated locations were found where deeper contamination exists.

1.3.2 Remedial Action Criteria

Although the following discussion refers to uranium mill tailings, it also applies to the radioactive sands and residues on the Lowman site.

For the purpose of conducting the original engineering assessment,(2) provisional criteria provided by the EPA were used. The criteria were in two categories, and applied either to structures with tailings present or to land areas to be decontaminated. For structures, the indoor radiation level below which no remedial action was indicated was considered to be an external gamma radiation level of less than 0.05 mR/hr above background and a radon daughter concentration of less than 0.01 WL above background. Land could be released for unrestricted use if the external gamma radiation levels were less than 10 μR/hr above background. When cleanup was necessary, residual radium content of the soil after remedial action should not exceed twice background in the area.

Since enactment of the Uranium Mill Tailings Radiation Control Act of 1978 (PL 95-604), which was effective November 8, 1978, the EPA has published interim (45 FR 27366) and proposed (46 FR 27370) standards for structures and open lands. These standards establish the indoor radon daughter concentration, including background, below which no remedial action is indicated at 0.015 WL. The indoor gamma radiation limit is 0.02 mR/hr above background.

For open land, remedial action must provide reasonable assurance that the average concentration of ^{226}Ra attributable to residual radioactive material from any designated processing site in any 5-cm thickness of soils or other materials within 1 ft of the surface, or in any 15-cm thickness below 1 ft, shall not exceed 5 pCi/g.

Environmental standards have been proposed by the EPA (46 FR 2556) for the disposal of residual radioactive materials from inactive uranium processing sites. These standards require that disposal of residual radioactive materials be conducted in a way which provides a reasonable assurance that for at least 1,000 yr following disposal:

(a) The average annual release of ^{222}Rn from the disposal site to the atmosphere by residual radioactive materials will not exceed 2 pCi/m^2-s.

(b) Substances released from residual radioactive materials after disposal will not cause:

(1) the concentrations of those substances in any underground source of drinking water to exceed the level specified below,* or

(2) an increase in the concentrations of those substances in any underground source of drinking water where the concentrations of those substances prior to remedial action exceed the levels specified below for causes other than residual radioactive materials.*

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*These requirements apply to the dissolved portion of any substance listed above at any distance greater than 1.0 km from a disposal site that is part of an inactive processing site, or greater than 0.1 km if the disposal site is a depository site.

Substance	mg/l
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Molybdenum	0.05
Nitrogen (in nitrate)	10.0
Selenium	0.01
Silver	0.05
	pCi/l
Combined ^{226}Ra and ^{228}Ra	5.0
Gross alpha particle activity (including ^{226}Ra but excluding radon and uranium)	15.0
Uranium	10.0

(c) Substances released from the disposal site after disposal will not cause the concentration of any harmful dissolved substance in any surface waters to increase above the level that would otherwise prevail.

Since the passage of PL 95-604, the NRC has published final regulations for uranium mill tailings licensing in the Federal Register (45 FR 65521). They include the requirement that the stabilization method must include an earth cover of at least a 3-m thickness and sufficient to reduce the radon emanation rate from the contaminated materials to less than 2 pCi/m^2-s above background. In addition, seepage of materials into ground water should be reduced by design to the maximum extent reasonably achievable.

While these standards may undergo further revisions, the interim and proposed standards as indicated above form the basis for determining required remedial actions and their associated costs.

1.3.3 Potential Health Impact

Radon gas exhalation from the radioactive sands and the subsequent inhalation of radon daughters account for most of the total dose to the population from the Lowman site under present conditions. The gamma radiation exposure from the piles is virtually zero since there are very few people who live or work within 0.2 mi of the radioactive sands, where gamma radiation is above background.

Gamma radiation can be reduced effectively by shielding with any dense material. However, experience has shown that it is very difficult to control the movement of radon gas through porous materials. Once released from the radium-bearing minerals in the tailings, the gaseous radon diffuses by the path of least resistance to the surface. The radon has a half-life of about 4 days, and its daughter products are solids. Therefore, part of the radon decays en route to the surface and leaves daughter products within the residue piles. If the diffusion time can be made long enough, then, theoretically, virtually all of the radon and its daughter products will have decayed before escaping to the atmosphere. Calculations using the theoretical techniques of Kraner, Schroeder, and Evans(5) earlier indicated that 13 ft of earth cover would be required to reduce the radon diffusion from the Lowman radioactive sands by 95%. Later experimental work(6) has demonstrated that 2 to 3 ft of compacted clay may be sufficient to reduce radon flux to less than 2 pCi/m^2-s, assuming the continued integrity of the clay cover.

The health significance to man of long-term exposure to low-level radiation is a subject that has been studied extensively. Since the end results of long-term exposure to low-level radiation may be diseases such as lung cancer or leukemia, which are also attributable to many other causes, the determination of specific cause in any given case becomes very difficult. Therefore, the usual approach to evaluation of the health impact of low-level radiation exposures is to make projections from observed effects of high exposures on the premise that the effects are linear. A considerable amount of information has been accumulated on the high incidence of lung cancer in uranium miners and others exposed to radon and its daughters in mine air. This provides a basis for calculating the probable health effects of low-level exposure to large populations. (The term "health effect" refers to an incidence of disease; for radon daughter exposure, a health effect is a case of lung cancer.) This is the basis of the health effects calculated in this report. It should be recognized, however, that there is a large degree of uncertainty in such projections. Among the complicating factors is the combined effect of radon daughters with other carcinogens. As an example, the incidence of lung cancer among uranium miners who smoke is far higher than can be explained on the basis of either smoking or the radiation alone.

The risk estimators used in this report are given in the report of the National Academy of Sciences Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR-III report).(7) This report presents risk estimators for lung cancer derived from epidemiological studies of both uranium miners and fluorspar miners. The average of the age-dependent absolute risk estimator for these two groups as applied to the population at large is 150 cancers per year per 10^6 person-WLM of continuous exposure, assuming a lifetime plateau to age 75. The term WLM means working level months, or an exposure to a concentration of one working level of radon daughter products in air for 170 hr, which is a work-month. A working level (WL) is a unit of measure of radon daughter products which recognizes that the several daughter elements are frequently not in equilibrium with each other or with the parent radon. Because of the many factors that contribute to natural biological variability and of the many differences between exposure conditions in mines and residences, this estimator (150 cancer cases per year per 10^6 person-WLM of continuous exposure) is considered to have an uncertainty factor of about 3. Another means of expressing risk is the relative risk estimator, which yields risk as a percentage increase in health effects per 10^6 person-WLM of continuous exposure. However, this method has been shown to be invalid(8) and is not considered in this assessment.

For the purpose of this engineering assessment, it was assumed that about 50% equilibrium exists inside structures between radon and its daughter elements resulting in the following conversion factors:

$$1 \text{ pCi/l of } {}^{222}\text{Rn} = 0.005 \text{ WL}$$

For continuous exposure:

$$0.005 \text{ WL} = 0.25 \text{ WLM/yr}$$

On the basis of predictions of radon concentrations in excess of the background value under present conditions, it was calculated that the average lung cancer risk attributable to radon released from the radioactive sands in the area within 3 mi of the Lowman site is 6.7×10^{-7} per person per year, or less than 1% of the average lung cancer risk due to all causes for Idaho residents (1.0×10^{-4}).(9)

The 25-yr health effects were calculated for three population projections using the present population of 90 people in the 0- to 3-mi area. The results for pile-induced radon and background radon for the area were as follows:

25-Year Cumulative Health Effects within 3 Miles of Edge of Radioactive Sands and Residues

Projected Population Growth	Pile-Induced RDC	Background RDC
0.8% constant growth rate	0.0017	0.12
5% declining growth rate*	0.0023	0.16
10% declining growth rate*	0.0037	0.26

Pile-induced radon daughter health effects are approximately 1.5% of the background radon daughter health effects for the 0- to 3-mi area. The exposure and consequent risk will continue as long as the radiation source remains in its present location and condition.

1.3.4 Nonradioactive Pollutants

Four water samples were taken from the vicinity of the Lowman site and analyzed for heavy metal content. Two samples were from Clear Creek upstream and downstream from the site, and two samples were from a well and a spring downgradient from the site. None of the samples indicated leaching of nonradioactive heavy metals from the site.

1.4 SOCIOECONOMIC AND LAND USE IMPACTS

The area near the site either is forest land or is used for recreation. Much of the land is administered by the U.S. Forest Service. There are no population concentrations near the site, although the community of Lowman has a general store, a service station, a lodge, and a motel. Some of the private tracts near the site have been subdivided into lots for summer homes. One such tract is located across the river from the site. Projected land uses are similar to present land uses, with increased development of lots for year-round uses, as well as for vacation purposes.

Single one-acre lots sell for approximately $13,000 near the site area. The presence of the sands and residues has not affected land uses or values of nearby land, although the use of the site has been restricted by the sands and the aesthetic quality of the site has been diminished by the sparsely vegetated slopes and abandoned property on the site.

1.5 RECOVERY OF RESIDUAL VALUES

Only a few samples of radioactive sands were obtained during this study. Consequently, calculations based on these samples would not be statistically representative.

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*Declines linearly from its initial value to zero in 25 yr and remains constant at zero thereafter.

There are, however, five factors that can be employed to evaluate whether reprocessing the Lowman radioactive sands and residues to extract uranium and other mineral values would be practicable:

(a) The amount of sands and residues present

(b) Concentrations of residual values

(c) Projected recovery

(d) Current market price of recovered values

(e) Proximity to processing mills

The Lowman ore was processed using physical separation methods, and the concentrates shipped elsewhere for further processing.

Based on the aforementioned considerations, reprocessing of the Lowman radioactive sands for uranium is not practicable.

1.6 MILL TAILINGS STABILIZATION

The methods and criteria for uranium mill tailings stabilization were briefly reviewed and found to apply to the radioactive sands at the Lowman site. The following summary of mill tailings stabilization is therefore applicable to the stabilization of radioactive sands.

Investigations of methods of stabilizing uranium mill tailings piles from wind and water erosion have indicated a variety of deficiencies among the methods. Chemical stabilization (treatment of the tailings surface) has been successful only for temporary applications and is thus viewed as inadequate for currently proposed disposal criteria. Volumetric chemical stabilization (solidifying the bulk of the tailings) techniques appear to be costly and of questionable permanence. Physical stabilization (emplacement of covers over the tailings) methods using soil, clay, or gravel have been demonstrated on a laboratory scale to be effective in stabilizing tailings. Artificial cover materials are attractive but have the disadvantage of being subject to degradation by natural and artificial forces. Vegetative stabilization (establishment of plant growth) methods are effective in limiting erosion. However, where annual precipitation is less than about 10 in., soil moisture content may be inadequate to ensure viability of the plant life.

Migration of contaminants into ground water systems must be limited under the NRC and EPA criteria. Control of water percolating through the tailings can be accomplished by stabilizing chemically, by physically compacting the cover material, and by contouring the drainage area and tailings cover surface. Isolation of the tailings from underlying ground water systems can be accomplished by lining a proposed disposal site with natural or artificial impermeable membranes.

Several materials have been identified which sufficiently retard radon migration so that the radon flux is substantially reduced, on a laboratory scale. Unfortunately, no large-scale application has been undertaken which would demonstrate that these materials satisfy all of the technical criteria in the EPA-proposed standards and the NRC regulations for licensing of uranium mills. However, extensive investigations of these questions continue in the Technology Development program of the Uranium Mill Tailings Remedial Actions Project Office in Albuquerque, New Mexico.

In view of findings from stabilization research, it appears that physical stabilization of tailings with 3 m of well-engineered cover material may be sufficient to appropriately stabilize tailings at their disposal site to meet NRC regulations.

1.7 OFF-SITE REMEDIAL ACTION

A mobile scanning unit, operated by the AEC under interagency agreement with the EPA, performed a gamma radiation survey of the Lowman, Idaho, area prior to 1973. A subsequent field survey identified eight off-site areas where use of the radioactive sands was suspected or confirmed. The cost of remedial action for these locations has been estimated at $250,000. The windblown contamination survey identified about 11 acres of off-site land contaminated in excess of 5 pCi/g above background levels. Cleanup of this land is estimated at $200,000. Therefore, the total remedial action estimated cost for off-site structures is $450,000, exclusive of engineering and contingency allowances.

1.8 DISPOSAL SITE SELECTION

In this report, two of the alternative remedial action options include moving the Lowman radioactive sands to a disposal site. Since the present site can probably meet the existing criteria for stabilization of the sands, no specific disposal sites have been identified. However, to provide an understanding of the magnitude of costs involved with off-site disposal of the sands, unspecified sites at distances 15 and 30 mi from the present site were evaluated. Since site-specific characteristics could influence the cost of these options quite substantially, care must be exercised in the use of these cost estimates. Option II corresponds with disposal at the 15-mi site and Option III with disposal at the 30-mi site. Since the responsibility for disposal site selection lies with the Federal Government, with input from the State, the disposal sites evaluated in this report must be considered only as tentative.

In each of these options, surface material would be removed, as appropriate, from the disposal area and stockpiled. A retaining dike and diversion ditches would be constructed if necessary. The radioactive sands would be emplaced, contoured, and covered with 3 m of soil. The surface would be covered with 0.3 m of riprap or vegetation would be established for erosion control, and the entire site would be fenced.

1.9 REMEDIAL ACTIONS AND COST-BENEFIT ANALYSES

1.9.1 Remedial Action Options

The remedial action options examined include stabilization of the residue piles in their present locations, and removal of all radioactive materials to an area where these materials could be isolated from the public. The options for which cost estimates were made include stabilization on the present site with 3 m of cover material and the removal of the radioactive sands to one of two unspecified locations. The options are summarized in Table 1-2.

The basis for comparison, from which the cost effectiveness of remedial alternatives can be judged, is the present condition of the site with no remedial action.

Option I represents remedial action activities to stabilize the piles more completely in their present locations with the addition of 3 m of cover. Erosion of the sands and residues would be controlled more completely and radon exhalation would be reduced to not more than 2 pCi/m^2-s above background. The site would have limited future use.

1.9.2 Cost-Benefit Analyses

As summarized in Table 9-1, the total costs for the three remedial action options vary from about $2,500,000 to about $6,000,000. Each of these options would have associated health and monetary benefits. The options are identified by number in Paragraph 1.1.

The number of cancer cases avoided per million dollars expended for each option is given in Figure 9-3. The curves in this figure indicate an increase in benefit-cost ratio with time due to the greater reduction in population exposure over longer periods of time as a result of remedial action. The potential cancer cases avoided for each option and the cost per potential cancer case avoided are given in Table 9-2.

TABLE 1-1

SUMMARY OF CONDITIONS NOTED AT TIME OF 1980 SITE VISITS

	Condition of Tailings[a]	Condition of Structures On Site[b]	Mill Housing[c]	Adequate Fencing, Posting, Security	Property Close to River or Stream	Houses or Industry within 0.5 Mi	Evidence of Wind or Water Erosion	Possible Water Contam-ination	Tailings Removed for Private Use	Other Hazards On Site
ARIZONA										
Monument Valley	U	R	N	No	No	Yes	Yes	No	Yes	No
Tuba City	U	PR-UO	E-P	No	No	Yes	Yes	No	No	Yes
COLORADO										
Durango	P	PR-UO	N	Yes	Yes	Yes	Yes	No	Yes	Yes
Grand Junction	S	PR-O	N	Yes	Yes	Yes	Yes	Yes	Yes	No
Gunnison	S	B-O	N	No	Yes	Yes	No	Yes	No	No
Maybell	S	R	N	Yes	No	No	Yes	No	No	No
Naturita	RMS	PR-O	N	Yes	Yes	Yes	Yes	Yes	No	No
New Rifle	P	M-O	N	Yes	Yes	Yes	Yes	Yes	No	No
Old Rifle	S	PR-UO	N	Yes	Yes	Yes	No	Yes	Yes	No
Slick Rock (NC)	S	R	N	Yes	Yes	Yes	Yes	Yes	No	No
Slick Rock (UCC)	S	R	E-P	Yes	Yes	Yes	No	Yes	No	No
IDAHO										
Lowman	U	R	N	No	Yes	Yes	Yes	Yes	Yes	No
NEW MEXICO										
Ambrosia Lake	U	PR-O	N	No	No	No	Yes	No	No	No
Shiprock	S	PR-O	N	Yes	Yes	Yes	No	Yes	Yes	No
NORTH DAKOTA										
Belfield	R	PR-O	N	No	No	Yes	No	No	No	No
Bowman	R	R	N	No	No	No	No	No	No	No
OREGON										
Lakeview	S	B-O	N	Yes	No	Yes	Yes	No	No	No

TABLE 1-1 (Cont)

	Condition of Tailings[a]	Condition of Structures On Site[b]	Mill Housing[c]	Adequate Fencing, Posting, Security	Property Close to River or Stream	Houses or Industry within 0.5 Mi	Evidence of Wind or Water Erosion	Possible Water Contamination	Tailings Removed for Private Use	Other Hazards On Site
PENNSYLVANIA										
Canonsburg	P	B-O	N	Yes	Yes	Yes	No	Yes	Yes	Yes
TEXAS										
Falls City	P	B-O	N	Yes	No	No	Yes	No	No	No
UTAH										
Green River	S	B-Y	N	Yes	Yes	Yes	Yes	Yes	No	No
Mexican Hat	U	PR-UO	E-O	No	No	Yes	Yes	Yes	No	No
Salt Lake City	U	R	N	No	Yes	Yes	Yes	Yes	Yes	Yes
WYOMING										
Converse County	U	R	N	Yes	No	No	No	No	No	No
Riverton	S	PR-O	N	No	No	Yes	No	No	No	No

[a]S - Stabilized but requires improvement

P - Partially stabilized

U - Unstabilized

RMS - Reprocessed, moved and stabilized - contamination remaining

R - Removed - contamination remaining

[b]M - Mill intact

B - Building(s) intact

R - Mill and/or buildings removed

PR - Mill and/or buildings partially removed

O - Occupied or used

UO - Unoccupied or unused

[c]N - None

E - Existing

O - Occupied

P - Partially occupied

TABLE 1-2

SUMMARY OF REMEDIAL ACTION OPTIONS AND EFFECTS

Option Number	Site Specific Cost ($000)	Description of Remedial Action	Benefits	Adverse Effects
I	2,500	The radioactive sands would be stabilized in place with 3 m of local earth cover. Natural vegetation would be established or a riprap cover provided. On- and off-site contaminated materials would be cleaned up as necessary.	A-E,H-J	Z
II	6,000	The radioactive sands, contaminated soil, and rubble would be moved by truck to an unspecified site located about 15 mi from the radioactive sands site. The radioactive sands site would be decontaminated and released for unlimited use.	A,C-G, I-K	--
III	5,700	Same as Option II, except radioactive sands moved to an unspecified site located about 30 mi from the radioactive sands site.	A,C-G, I-K	--

Notes

1. All options include on- and off-site remedial action.

2. For Options II and III, costs include removal of 3 ft of contaminated earth beneath the radioactive sands.

TABLE 1-2 (Cont)

Definition of Benefits

A. Off-site structures decontaminated
B. Access to the radioactive sands site controlled by fencing and posting
C. Off-site windblown radioactive sands cleaned up
D. Wind and water erosion controlled
E. Gamma radiation reduced
F. The source of gamma radiation and radon gas removed from the area
G. No building restrictions on or near site
H. The prime use of the final disposal location unchanged
I. Disposal site maintenance required only on a limited basis; minimal possibility of contaminating air or water supplies
J. A reduction in rate of radon exhalation to at least 2 pCi/m^2-s
K. Maintenance and fencing at the radioactive sands site eliminated

Definition of Adverse Effects

Z. Limited use of the radioactive sands site

CHAPTER 1 REFERENCES

1. "Summary Report, Phase I Study of Inactive Mill Sites and Tailings Piles"; AEC; Grand Junction, Colorado; Oct 1974.

2. "Phase II - Title I Engineering Assessment of Inactive Uranium Mill Tailings, Lowman Site, Lowman, Idaho"; GJT-17; Ford, Bacon & Davis Utah Inc.; Dec 1977.

3. R.J. Countess; "^{222}Rn Flux Measurement with a Charcoal Canister"; Health Physics; Vol 31, p. 455; 1976.

4. F.F. Haywood, et al.; "Radiological Survey of the Radioactive Sands and Residues at Lowman, Idaho"; ORNL-5456; Oak Ridge National Laboratory; Oak Ridge, Tennessee; Aug 1980.

5. H.W. Kraner, G.L. Schroeder, and R.D. Evans; "Measurements of the Effects of Atmospheric Variables on Radon-222 Flux and Soil-Gas Concentrations"; The Natural Radiation Environment; J.A.S. Adams and W.M. Lowder, eds; University of Chicago Press; 1964.

6. Argonne National Laboratory and Ford, Bacon & Davis Utah Inc.; "Characterization of Uranium Tailings Cover Materials for Radon Flux Reduction"; NUREG/CR-1081 (FBDU-218-2); Mar 1980.

7. "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation"; Report of Advisory Committee on Biological Effects of Ionizing Radiation; NAS, National Research Council; 1980.

8. B.L. Cohen; "The BEIR Report Relative Risk and Absolute Risk Models for Estimating Effects of Low Level Radiation"; Health Physics; Vol 37, p. 509; 1979.

9. Vital Statistics of the U.S.; Vol II; Mortality; National Center for Health Statistics; HEW; 1968.

ADDENDUM

FIGURES AND TABLES

(The figures and tables contained on the following pages have been extracted from Chapters 2 through 9 of the parent report.)

LIST OF FIGURES

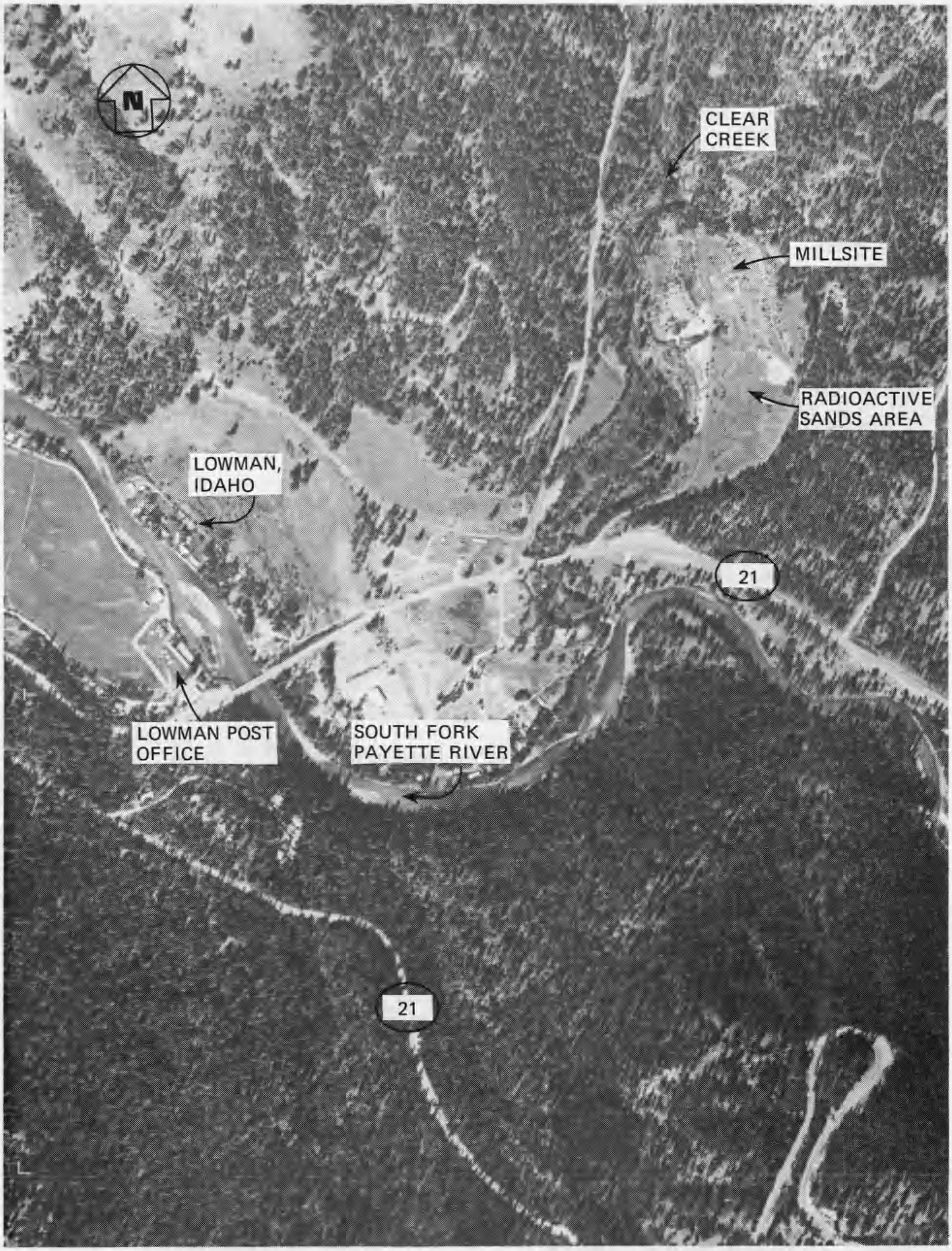

FIGURE 2-1. AERIAL PHOTOGRAPH OF SITE

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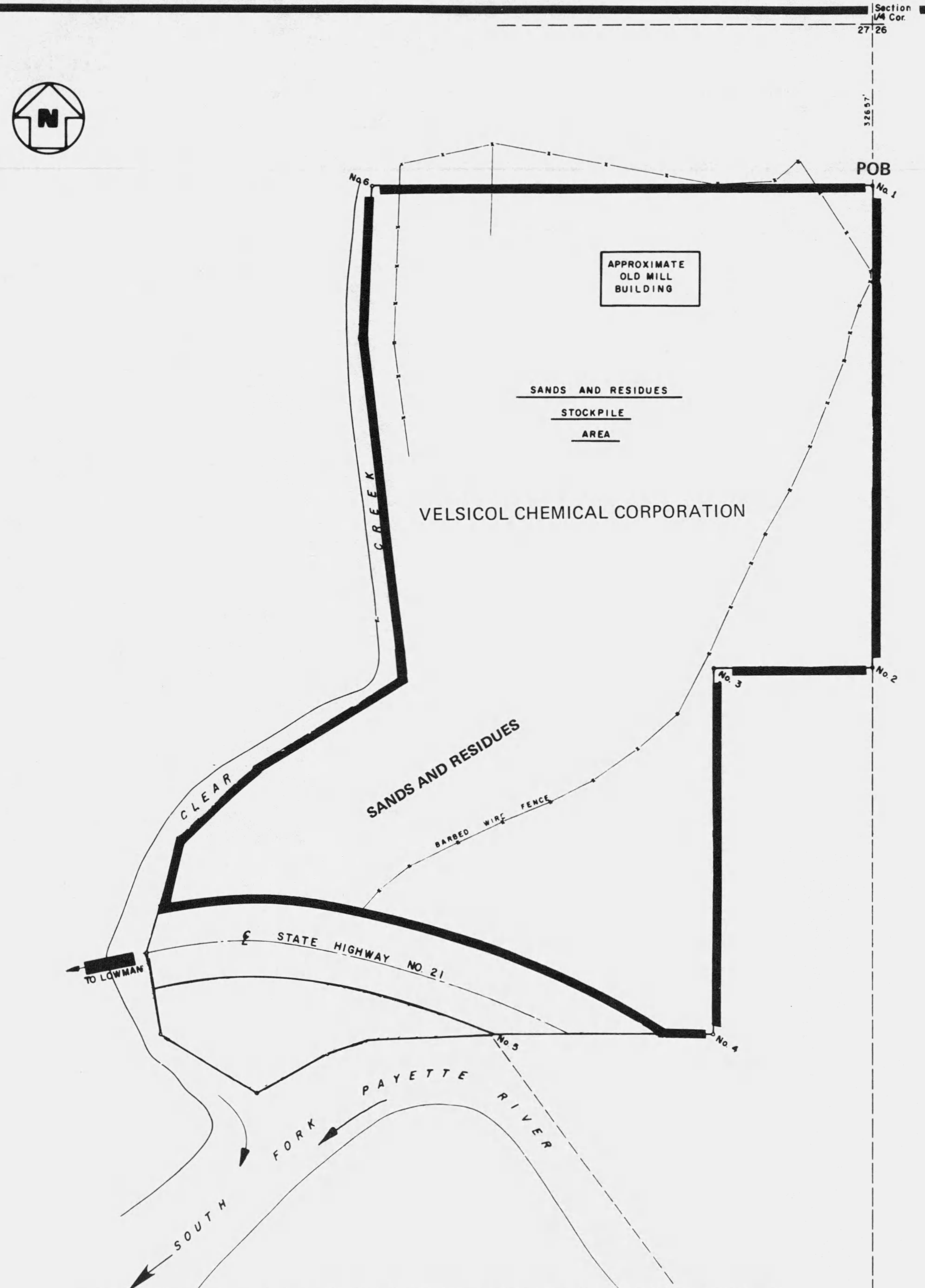

FIGURE 2-3. LAND OWNERSHIP AND SITE DESIGNATION MAP

LOWMAN, IDAHO SITE

BEGINNING AT A POINT WHICH IS S 0°01'W, 326.7 FT FROM THE N.E. 1/4 CORNER OF SECTION 27, T9N, R7E, SAID POINT BEING THE NO. 1 POINT ON THE HOMESTEAD ENTRY SURVEY NO. 490 (H.E.S.), AND RUNNING THENCE S 0°01'W, 993.3 FT TO H.E.S. 490 CORNER NO. 2, THENCE WEST 330 FT TO H.E.S. 490 CORNER NO. 3, THENCE SOUTH 755.04 FT TO H.E.S. 490 CORNER NO. 4 THENCE WEST 112 FT TO THE NORTH R/W LINE OF IDAHO STATE HIGHWAY NO. 21, THENCE NORTHWESTERLY ALONG SAID R/W LINE TO THE EAST MEANDER LINE OF CLEAR CREEK, THENCE NORTHERLY ALONG SAID MEANDER 1708 FT (MORE OR LESS) TO H.E.S. 490 CORNER NO. 6, THENCE EAST 1045.44 FT TO THE POINT OF BEGINNING.

CONTAINS 36 ACRES (MORE OR LESS)

NOTE:

ADAPTED FROM REFERENCE 1

NO SCALE

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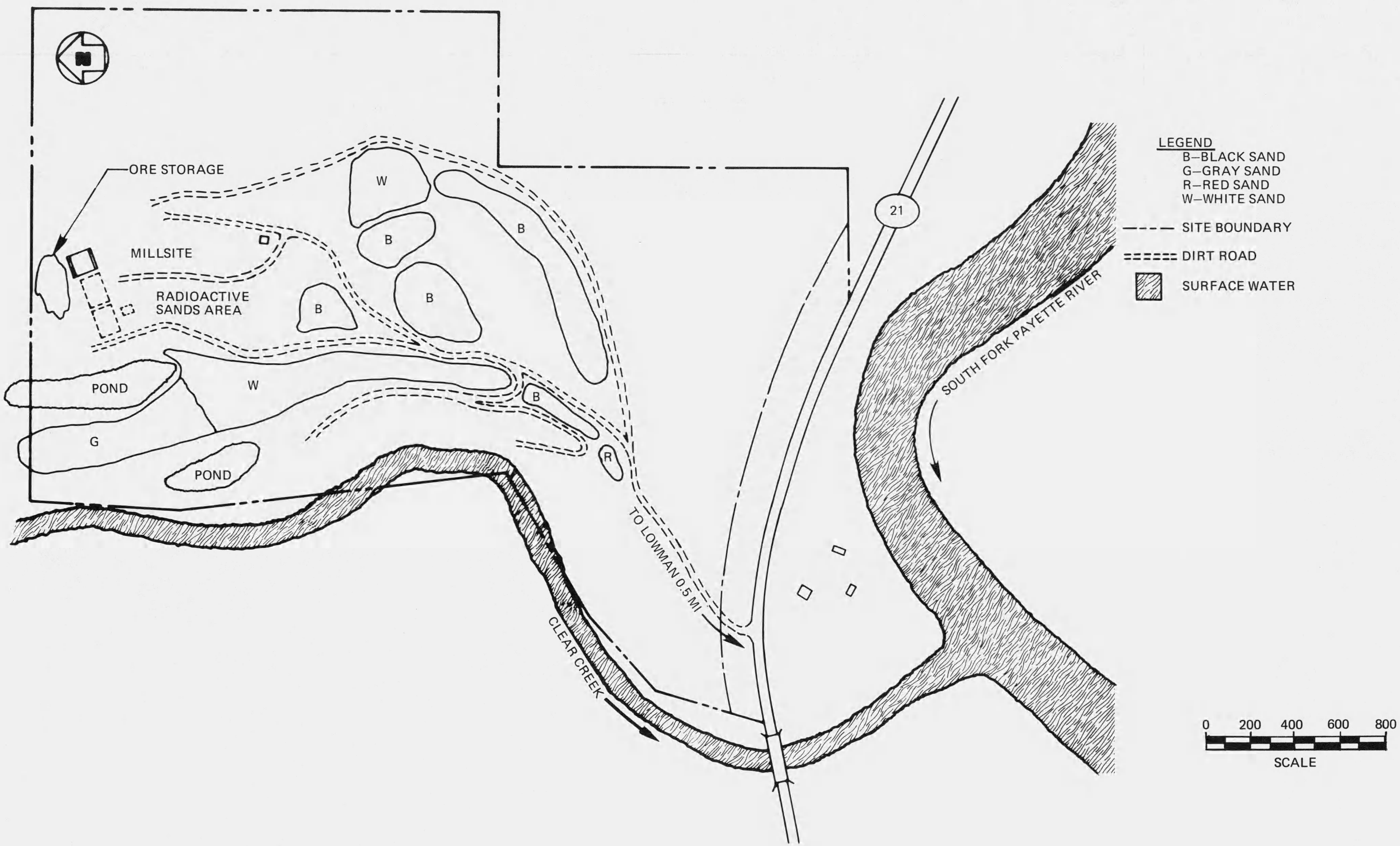

FIGURE 2-4. DESCRIPTIVE MAP

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ERA	SYSTEM	SERIES	FORMATION	CHARACTER
CENOZOIC		HOLOCENE AND LATE PLEISTOCENE	ALLUVIAL DEPOSITS	GRANITIC PEBBLES AND SAND AQUIFER
		PLEISTOCENE	GLACIAL TERRACE–OUTWASH	POORLY SORTED, BOULDERS, COBBLES, GRAVEL AND SAND AQUIFER
MESOZOIC	CRETACEOUS | LATE JURASSIC		IDAHO BATHOLITH	GRANITIC BATHOLITH, PRIMARILY GRANODIORITE & QUARTZ MONZONITE ONLY UPPERMOST FRACTURED AND WEATHERED ZONE IS AN AQUIFER

FIGURE 2-5. SIMPLIFIED STRATIGRAPHIC COLUMN

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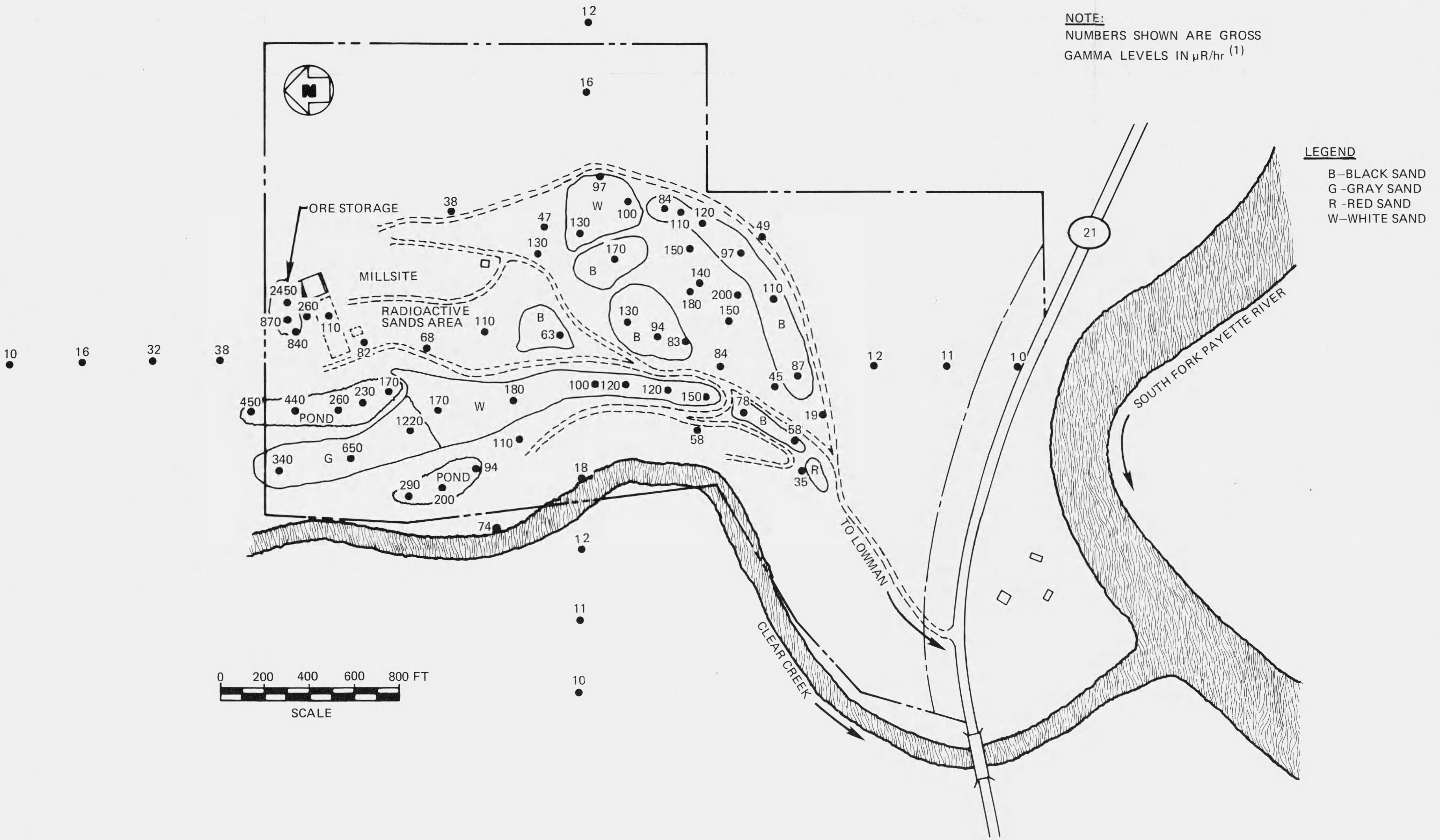

FIGURE 3-9. GAMMA LEVELS AT SITE 3 FT ABOVE GROUND

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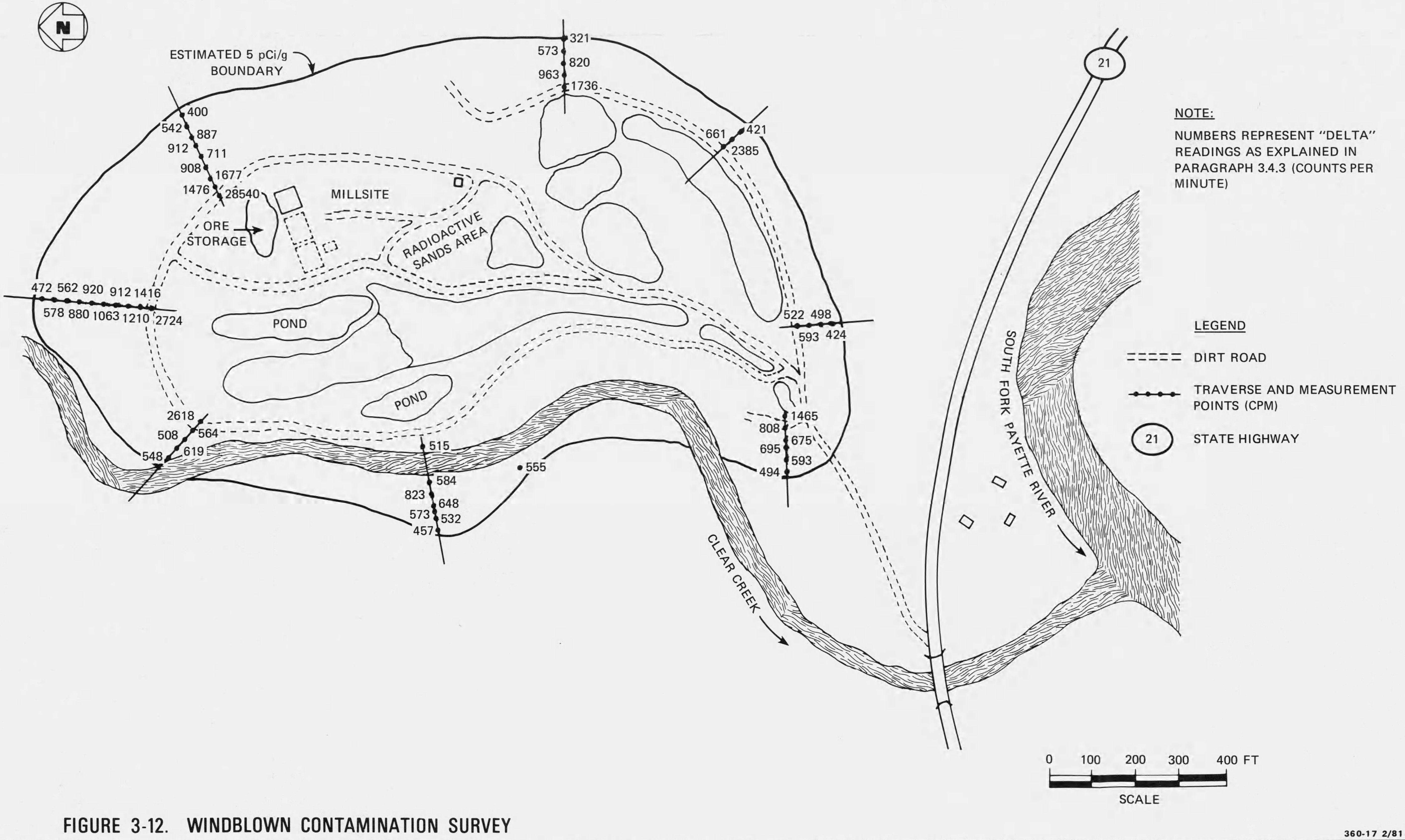

FIGURE 3-12. WINDBLOWN CONTAMINATION SURVEY

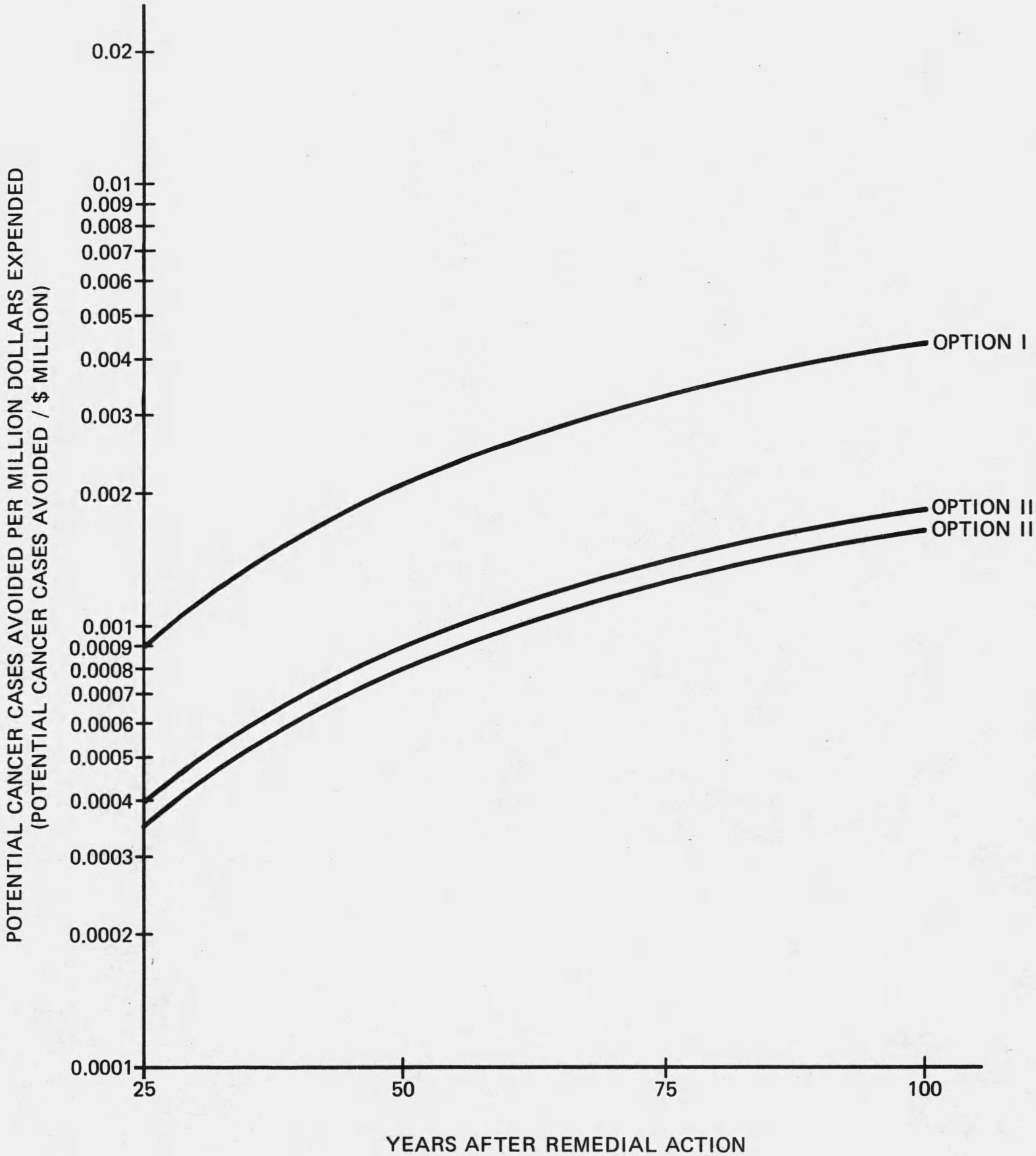

FIGURE 9-3. POTENTIAL CANCER CASES AVOIDED PER MILLION DOLLARS EXPENDED

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LIST OF TABLES

TABLE 2-1

CONTAMINATED MATERIALS AT THE LOWMAN SITE

Material	Volume (yd^3)	Weight (tons)	% U_3O_8
White Sand	--	50,000	0.01
Black Sand	--	23,000	0.02
Grey Sand	--	10,000	0.18
Original Source Ore	--	5,000	0.22
Contaminated Soil in Mill and Ore Storage Area	9,700[a]	13,000[e]	--
Contaminated Subsoil Beneath Sands	48,400[b]	65,000[e]	--
On-Site Windblown	9,700[c]	13,000[e]	--
Off-Site Windblown	8,900[d]	12,000[e]	--
Total		191,000	

[a]Based on 3 acres contaminated to an average depth of 2 ft.

[b]Based on 10 acres contaminated to an average depth of 3 ft below interface.

[c]Based on 12 acres contaminated to an average depth of 6 in.

[d]Based on 11 acres contaminated to an average depth of 6 in.

[e]Weight based on a density of 100 lb/ft^3.

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TABLE 9-1

SUMMARY OF STABILIZATION AND DISPOSAL COSTS[a]

		Options		
		I	II	III
1.	Radioactive Sands Site	1.0	0.5	0.5
2.	Off-Site Other than Windblown	0.3	0.3	0.3
3.	Off-Site Windblown	0.2	0.2	0.2
4.	Transportation			
	a. Capital Costs	--	0.1	0.1
	b. Haul Costs	--	2.2	2.0
5.	Disposal Site	--	0.8	0.8
6.	Total Cleanup[b] (sum of lines 1 through 5)	1.5	4.1	3.8
7.	Engineering Design and Construction Management (30% of the difference between lines 6 and 4b)	0.4	0.6	0.6
8.	Total[b] (sum of lines 6 and 7)	1.9	4.6	4.4
9.	Contingency (30% of line 8)	0.6	1.4	1.3
10.	GRAND TOTAL[b] (sum of lines 8 and 9)	2.5	6.0	5.7

[a]Costs are presented in millions of year 1980 dollars.

[b]Totals may differ from the sum of component costs because of round-off.

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TABLE 9-2

POTENTIAL CANCER CASES AVOIDED
AND COST PER POTENTIAL CASE AVOIDED

A. Number of Potential Cancer Cases Avoided

Options:	I	II	III
Option Cost (million $)	2.5	6.0	5.9
Years After Remedial Action			
25	<0.0023	0.0023	0.0023
50	<0.0053	0.0053	0.0053
75	<0.0082	0.0082	0.0082
100	<0.011	0.011	0.011

B. Cost Per Potential Cancer Case Avoided (Million $)

Options:	I	II	III
Option Cost (million $)	2.5	6.0	5.9
Years After Remedial Action			
25	>1,100	2,600	2,500
50	> 470	1,100	1,100
75	> 310	730	700
100	> 230	550	520

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