LA-6848-MS, Vol. I

Informal Report

Special Distribution

Issued: June 1977

History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A, B, C, D, E, F, G, and T)

A Source Document

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UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
CONTRACT W-7405-ENG. 36

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HISTORY AND ENVIRONMENTAL SETTING

OF LASL NEAR-SURFACE LAND DISPOSAL FACILITIES

FOR RADIOACTIVE WASTES (AREAS A, B, C, D, E, F, G, AND T)

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ABSTRACT

The Los Alamos Scientific Laboratory (LASL) has been disposing of radioactive wastes since 1944. The LASL Materials Disposal Areas examined in this report, Areas A, B, C, D, E, F, G, and T, are solid radioactive disposal areas with the exception of Area T which is a part of the liquid radioactive waste disposal operation. Areas A, G, and T are currently active. Environmental studies of and monitoring for radioactive contamination have been done at LASL since 1944.

I. INTRODUCTION

This report evolved into a source document as the result of an extensive review of solid radioactive waste management operation at the Los Alamos Scientific Laboratory (LASL) which is operated by the University of California for the ERDA/AEC.* It contains extensive quotes and other material sequestered here for easy access. This compilation represents the effort to date. It is our intent to supplement this report as further information is developed.

The desire to determine the environmental impact of solid waste disposal has led to the reexamination of the concept of land burial as a means of permanent disposal. An evaluation of site monitoring practices, both past and present, is in progress or planned for all major ERDA sites by the United States Geological Survey (USGS) under contract to ERDA and in cooperation with ERDA contractors. The evaluation at the Los Alamos Scientific Laboratory began in September 1973, and included Materials Disposal Areas A, B, C, D, E, F, G, and T (see Fig. 1). T. E. (Tim) Kelly of the USGS Water Resources Division, Albuquerque, and Margaret Anne Rogers, LASL/H-8, the investigators.

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*The U. S. Atomic Energy Commission (AEC) was absorbed by the Energy Research and Development Administration (ERDA) in January 1975.

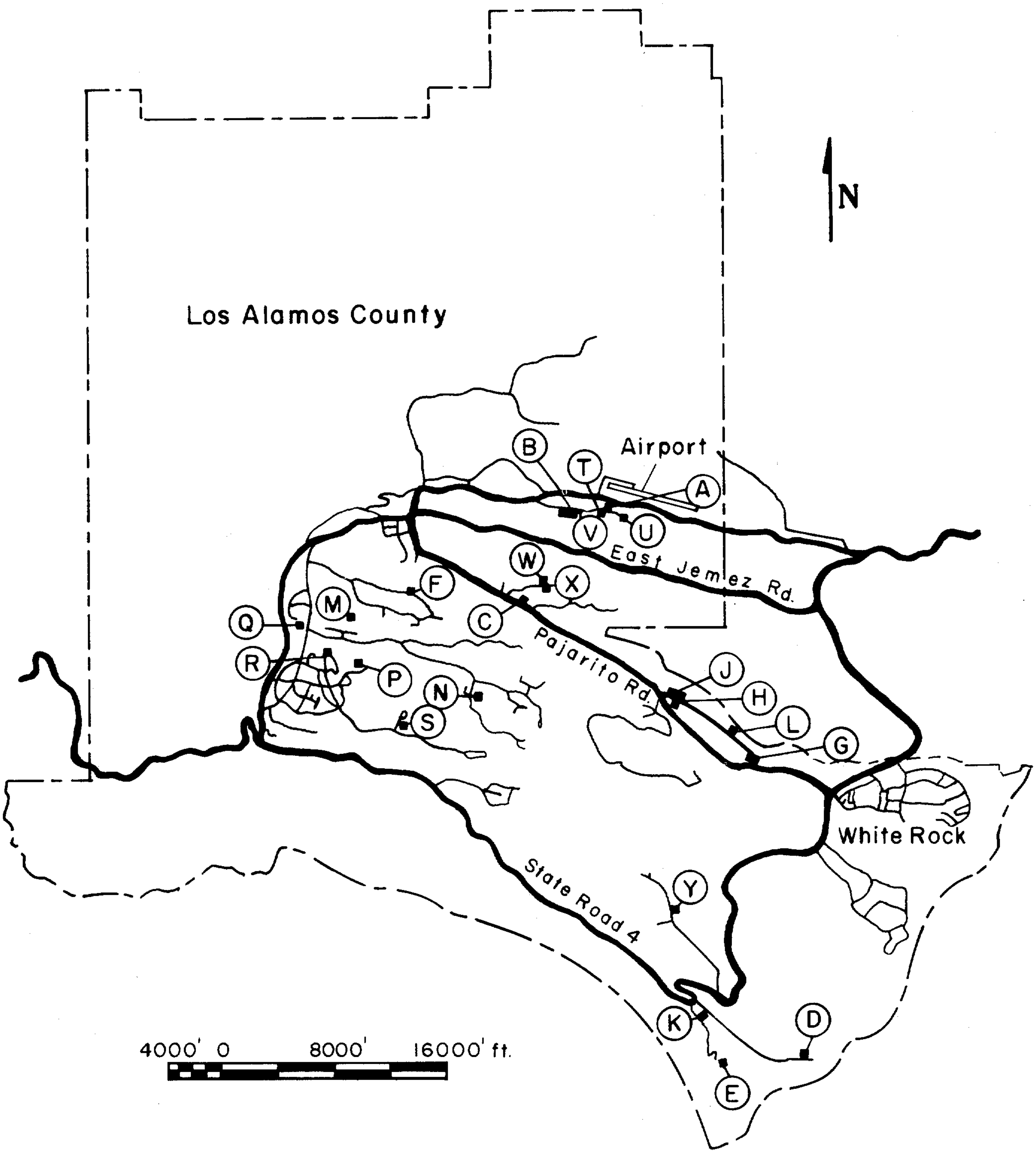

Fig. 1.
Map of Materials Disposal Areas.

As the data were being collected for the evaluation, it became apparent that LASL had a need for a report which would parallel the USGS Report to the ERDA but which would include much more detail.

This report has been compiled to provide a readily available source of accurate, in-depth information for reference by LASL personnel. It is as comprehensive as time and information sources allowed.

In compiling the information presented in this report, opinions and conclusions as to the accuracy of any particular source material have been avoided. All sources on a given subject are presented, despite apparent contradictions. The reader must therefore draw his own conclusions as to which sources may have the greater validity. By presenting all sources, bias is hopefully minimized.

General information on Areas A, B, C, D, E, F, G, and T can be found in the Summary; comprehensive information is given under individual area discussions. Appendixes A, B, and C are lists of known photographs, photographic slides, and engineering drawings, respectively, of Areas A, B, C, D, E, F, G, and T.

Metric units followed by English conversion in parentheses are used throughout this document except in quoted material, which has been left in its original form.

A. History of Los Alamos

From 1918 until late 1942, Los Alamos was the site of a boy's ranch school.[1] Because of its isolated location and existing facilities, the school was acquired by the Army, November 25, 1942, for use by the Manhattan Engineer District. As a patriotic gesture[1] the University of California accepted the contract to operate the new laboratory January 1, 1943. After the war, Los Alamos continued as a site of government sponsored scientific research operated by the University under the auspices of the USAEC through 1974 and continues under the auspices of ERDA.

B. Location

Los Alamos and the Los Alamos Scientific Laboratory are located on the Pajarito Plateau, which flanks the eastern side of the volcanic Jemez Mountains in north-central New Mexico. The plateau is 16-24 km (10-15 mi) wide and more than 48 km (30 mi) long. It is bounded on the west by the Sierra de los Valles, on the east by the Rio Grande, on the northeast by the Puye Escarpment, and on the southwest by Canada de Cochiti (Figs. 2a and 2b).

The plateau slopes eastward from an elevation of 2377 m (7800 ft) abutting the Sierra de los Valles to an elevation of 1890 m (6200 ft) adjacent to the Rio Grande. It is cut 61-122 m (200-400 ft) deep by numerous southeast trending intermittent streams. The dissected eastern margin of the plateau rises 91-305 m (300-1000 ft) above the Rio Grande.

Los Alamos is 38.6 km (23 mi) northwest of Santa Fe and 92.8 km (58 mi) north-northeast of Albuquerque.

C. Radioactive Wastes Generated by the LASL

LASL radioactive wastes are categorized as routine or nonroutine. Most of the waste is routine, consisting of Laboratory trash (mostly combustible), equipment, chemicals, oil, animal tissue, chemical treatment sludge, cement paste, hot-cell waste, and classified materials. Nonroutine waste, generated during facility renovation and decommissioning projects, consists of building debris, large equipment items, and soil or rock removed during site cleanup.

The wastes may be contaminated by transuranic radionuclides (^{239}Pu, ^{238}Pu, or ^{241}Am), uranium (enriched, depleted, normal or ^{233}U), fission products, induced activities, or tritium. Wastes contaminated by fission products, induced activities, and tritium are small in volume, 1-3% of the whole, but high in total curies disposed of by LASL.

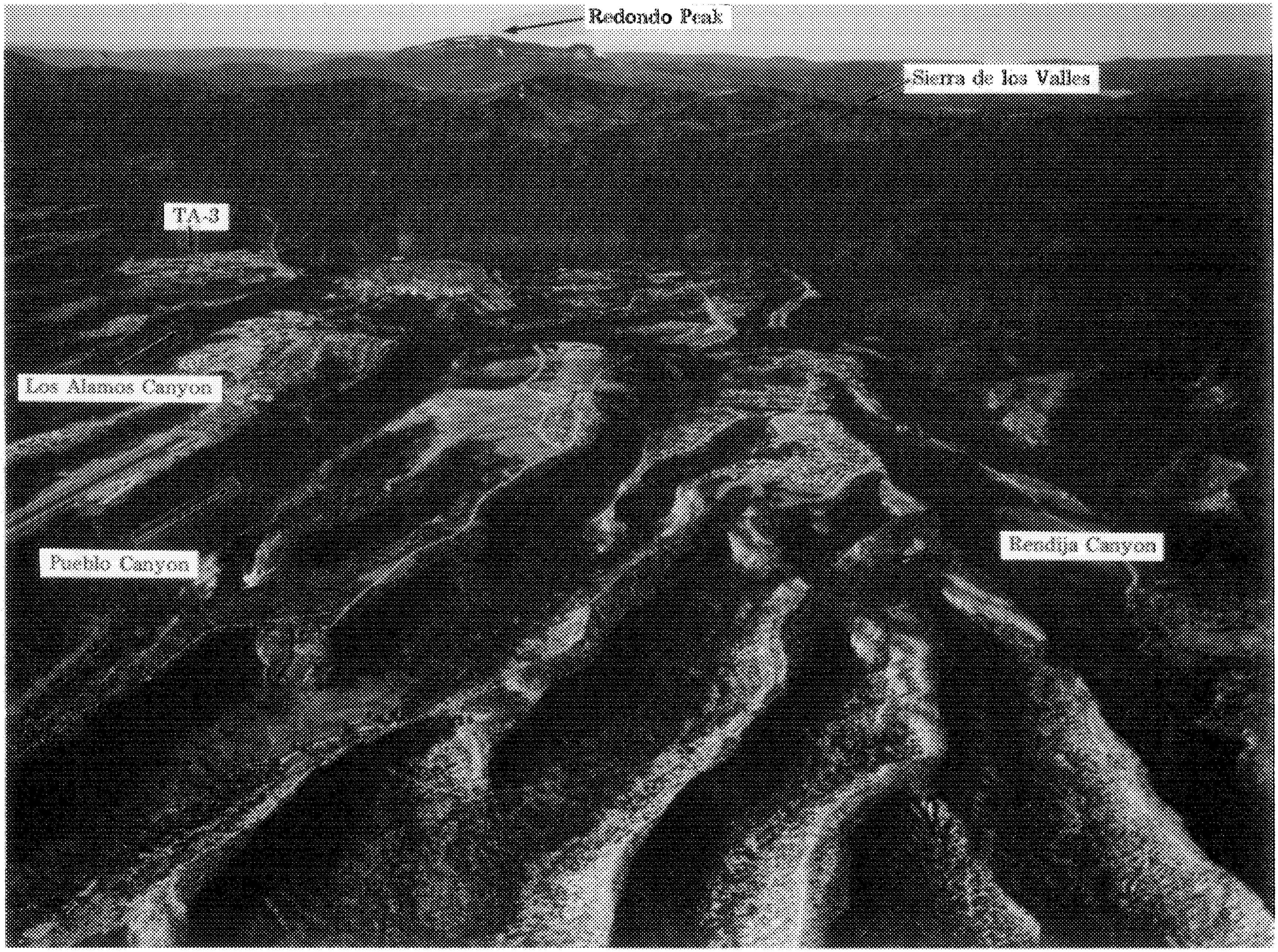
Redondo Peak
Sierra de los Valles
TA-3
Los Alamos Canyon
Pueblo Canyon
Rendija Canyon

Fig. 2a.

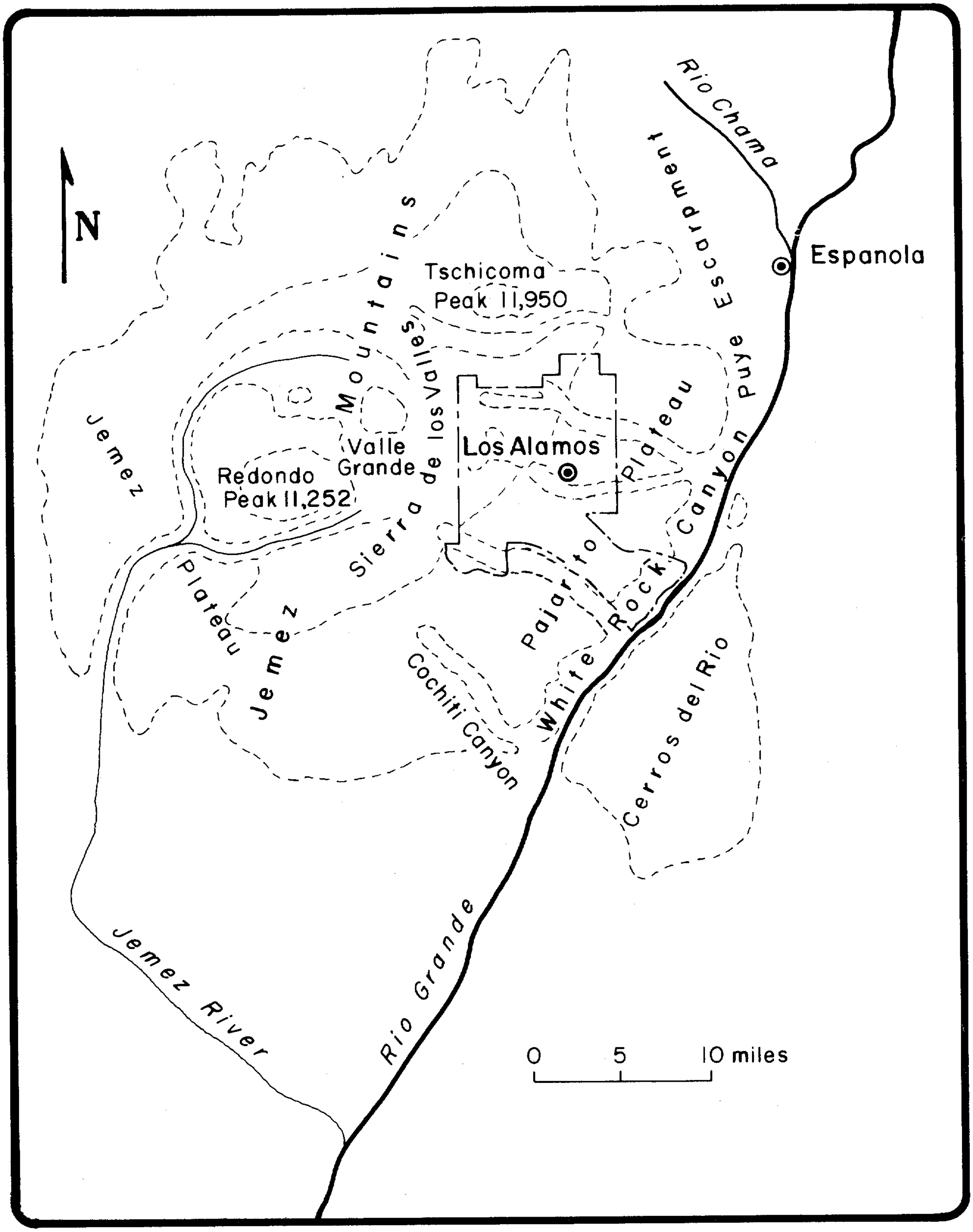

Fig. 2b.
Map showing general geography of Jemez Mountains.

Over the past 20 years waste volume has averaged 5073 m^3 (6631 yd^3) per fiscal year (see Fig. 3). During the past 10 years the volume has varied from 7792 m^3 (10 185 yd^3) in 1964 to 4250 m^3 (5556 yd^3) in 1972. For the period 1965-1975 approximately 3542 m^3 (4630 yd^3) to 4250 m^3 (5556 yd^3) of the waste volume per fiscal year is due to routine waste.

Appendix D contains correspondence pertaining to LASL radioactive solid waste management policy.

II. SUMMARY AND CONCLUSIONS

A. General

The Los Alamos Scientific Laboratory has been disposing of solid radioactive wastes since 1944. Throughout the history of the Laboratory, the principal means of disposal has been pits. In the late fifties shafts began to be used as well as pits. Geometrically, pits are rectangular prisms and shafts are cylinders.

The LASL Materials Disposal Areas examined in this report, A, B, C, D, E, F, G, and T, are solid radioactive waste disposal areas, with the exception of Area T which has always been part of the liquid waste disposal operation at LASL. All the areas except Areas A, T, and G are currently inactive. Areas A, B, C, D, E, F, and T were used in the forties; Areas C, E, G, and T were used in the fifties; and Areas A, C, G, and T were used in the sixties and seventies.

In the late fifties waste disposal documentation improved greatly; therefore, knowledge of Areas C, G, and T is much better than of Areas A, B, D, E, and F. Knowledge of Area G far exceeds that for any other area.

Disposal-area fires seem to be a thing of the past since the following policies were simultaneously put into effect: (1) uncontaminated hazardous chemicals are not buried with contaminated solid waste, and (2) flammable solid waste is covered immediately after it is placed in a pit.

Radioactive contamination studies and monitoring have been done at LASL since 1944. Through the years the USGS has performed a large part of this work. Available information indicates that the USGS did the majority of the specific migration studies and a significant amount of the monitoring in the fifties and sixties.

B. By Site

Area A, located at TA-21, has been used intermittently since 1945. It was the second common burial ground for radioactive waste at the Laboratory. The oldest Area A disposals were made in two pits situated in the eastern part of the area. The "Generals's Tanks"* which are in the western part were filled shortly after the pits. The central (and largest) pit was dug in 1969 and continues in active use today, July 1976. Records on disposal have not been located for the pits. Some records on the liquid waste placed in the General's Tanks are available. The only known study related to environmental monitoring conducted in the area is a geologic inspection of the 1969 pit.

Area B, located south of DP Road, is the first common burial ground for radioactive waste at the Laboratory. Only the outline of Area B is shown on engineering drawings. Location of the series of pits which were in use from 1944 until 1948 has not been established. Waste disposal records from 1944 through January 5, 1947, have not been located. Records are available from January 6, 1947, through the closing of Area B. The site was studied by the USGS before establishment of the boat and trailer storage yard within the area.

Area C, north of Pajarito Road near TA-50, became inactive April 8, 1974. Its history of use covers 26 years. There are seven pits within the area, one of which was reserved exclusively for the disposal of non-radioactive hazardous chemical wastes and 108 shafts, none of which are greater than 1 m (3 ft) in

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*Two storage tanks designated TA-21-107 and TA-21-108.

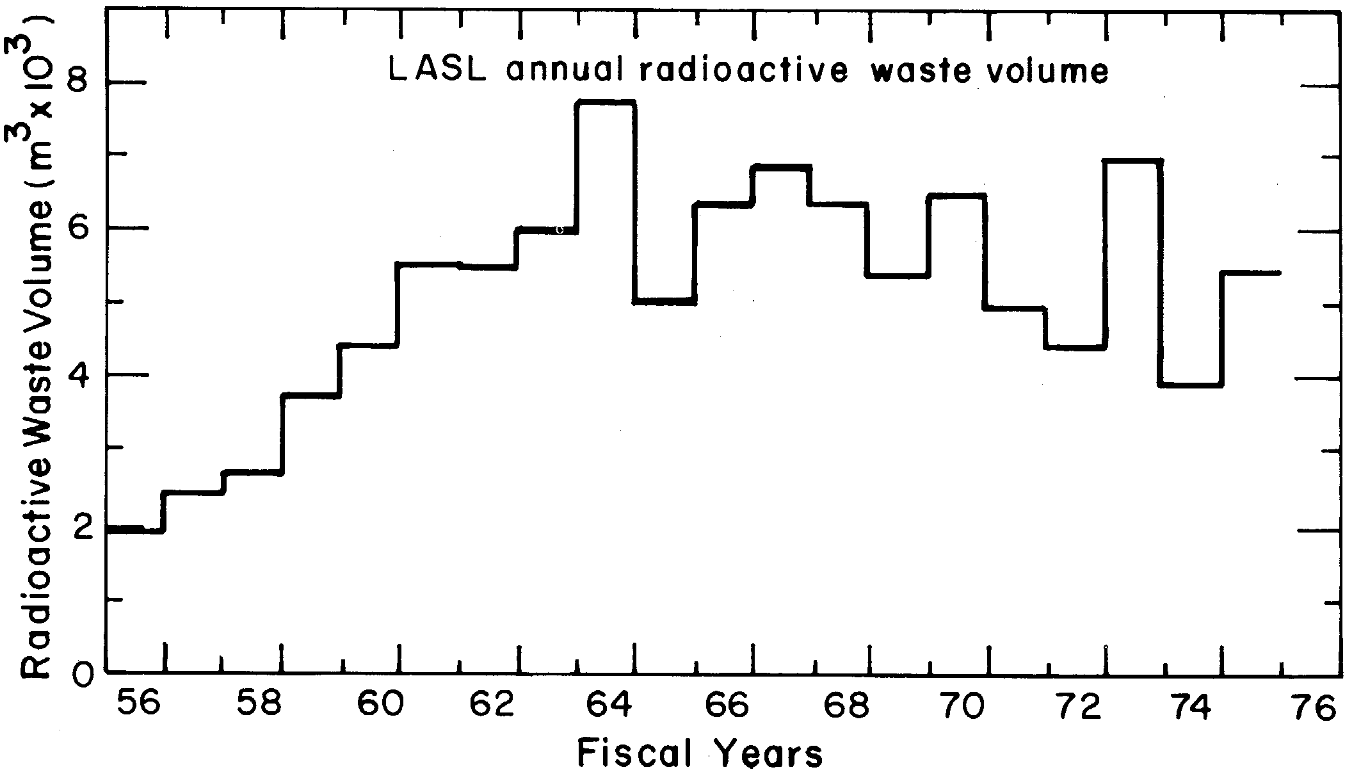


Fig. 3.
Record of waste volume over last 20 yr.

diameter and 7.6 m (25 ft) deep. Area C is the first burial ground for which detailed records were kept. Few studies related to environmental monitoring have been conducted in Area C.

Area D is two underground chambers used in 1948 at "Hot Point," TA-33. Chamber 2 was contaminated by polonium and it is assumed Chamber 1 was likewise. (The available records do not support the idea of other radioactive contaminants.) A minimum of 22 years has passed since any experimentation. With a half-life of 138 days for polonium, it is unlikely any radioactive contamination remains. Studies are limited to surveys made shortly after the chambers were used.

Area E, located at "New Hot Point," TA-33, includes an underground chamber destroyed in 1950 and six pits. The area was in use through 1962. Records on the underground chamber and the pits have not been found. No environmental monitoring studies have been conducted in the area.

Area F, TM Site, TA-6, may not be a radioactive waste disposal area. The first pit was dug in 1946. The exact size, location, and number of pits is not known. No records of disposal have been found. There is no indication any environmental monitoring studies have been done in Area F.

Area G, TA-54, is the largest disposal area at LASL. It has been in operation since early 1957. The site was originally picked because of its isolated location and because it offered ample space for disposal activities over a period of years. Although it is not as isolated as it once was, it still has enough space for disposal needs in the foreseeable future. Area G has 16 pits, 2 trenches, and 81 shafts. Detailed disposal records have been kept throughout the history of Area G. Most of the pits and some of the shafts received a geologic inspection before being put in use. Environmental monitoring activities are increasing in Area G.

Area T, west of Area A at TA-21, has been in use since 1945. It reflects the thinking and practices in liquid radioactive waste disposal from the time the Laboratory began. Four absorption beds were constructed in 1945. They received untreated and treated wastes from 1945-1967. Since mid-1968, treated wastes have been mixed with cement and pumped down shafts augered between the south absorption beds and the north absorption beds. The shafts are 2.4 m (8 ft) in diameter and as deep as 19.8 m (65 ft). Though small in physical size, Area T has received more intensive study from an environmental monitoring viewpoint than any other waste disposal area at the Laboratory.

C. Recommendations

1. Site Improvement

- Specific boundaries should be designated for Areas T, D, and F.
- Areas A, D, F, and T are not adequately fenced and should be. If Area D is to be considered just the two underground chambers, there is no need to fence it.
- Identification signs and radioactive contamination warning signs should be posted for all areas.
- Individual pits and shafts within each area should be clearly identified. In some cases this involves replacing existing signs and in others erecting new markers. Areas affected are A, C, E, F, G, and T.
- Areas which should receive restoration treatment are A, E, F, G, and T.

2. Studies and Monitoring

- The "History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A, B, C, D, E, F, G, and T)" should be a continuing project for the next several years and thereafter periodically updated. With the exception of Area G, it is quite possible that there are existent records which have merely not been located. An extensive effort should be made to locate all records as soon as possible, lest the passage of time render the task impossible. One way to gain insight on some of the areas is through interviews with LASL personnel, LASL retirees, and previous LASL employees.

- Detailed geologic mapping for each area should be done to establish fracture patterns and stratigraphy in order to have a basis for monitoring. The mapping project should extend from Area to Area, with special emphasis as necessary at any particular Area, and should not result in eight individual maps which cannot be easily related to each other.
- Vegetative mapping in the Areas should be done. In the case of Areas B, C, D, and F, mapping can provide insight for revegetation of other areas.
- A comprehensive ion-exchange study should be done. "Soil Absorption of Radioactive Wastes at Los Alamos"[2] is based on too few samples to generalize on the ion-exchange capacity of the soil, fracture fillings, and tuff in the Los Alamos area. Because of the variability in the physical and chemical properties of the tuff, which in turn creates variability in the soils and fracture fillings, more work should be done on ion exchange.
- A program should be designed for site-specific monitoring of disposal areas. The present monitoring network is intended to monitor disposal areas only in a general way.

III. GEOLOGY

A. Stratigraphy

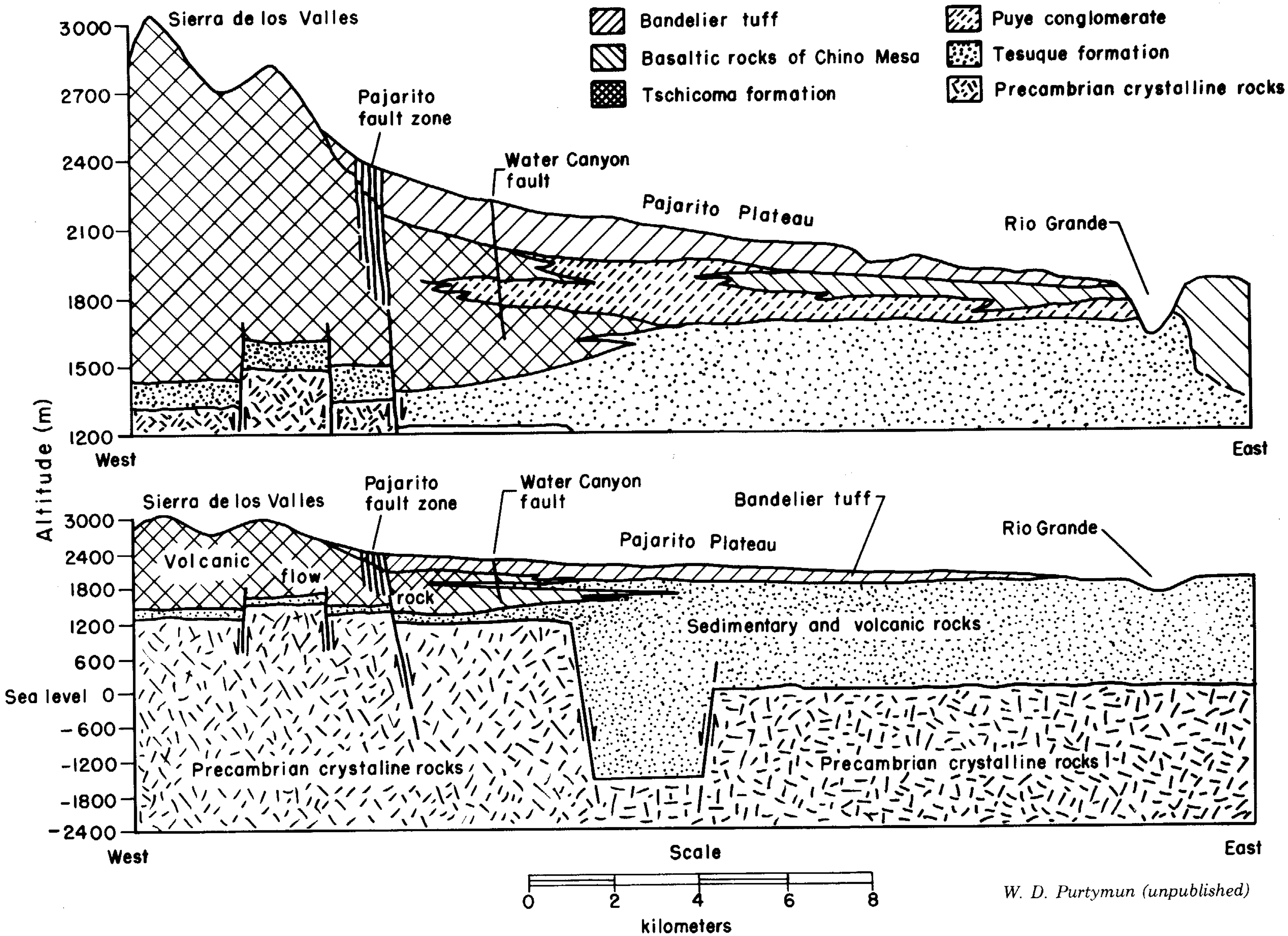
Introduction. For the purposes of this report the Los Alamos area is defined roughly as the area bounded by the Rio Grande on the east, the Rito de los Frijoles on the south, the crest of the Sierra de los Valles on the west, and Guaje Canyon on the north.

The volcanic and sedimentary rock cropping out in this area range in age from Tertiary to Quaternary. Stratigraphic nomenclature varies. There is general agreement on the unit definitions for the volcanic rocks whose origin is the Valles or Toledo Calderas; however, there appears to be considerable disagreement on unit definition and usage for the sedimentary rocks and basalt flows which form the basin fill for the Rio Grande Rift.

The oldest sedimentary sequence cropping out in the Los Alamos area has been referred to as the Santa Fe Formation, a restricted usage, or as part of the Santa Fe Group, a usage which includes all basin-fill rocks regardless of origin. Spiegel and Baldwin (1963),[3] Griggs(1964),[4] and Galusha and Blick (1971)[5] favor use of the Santa Fe Group designation; Bailey, Smith and Ross (1969)[6] favor use of the older term, Santa Fe Formation. These four reports define stratigraphic nomenclature for the Los Alamos area since all use rock sequences in or adjacent to the area to define their unit usage. Other authors such as Baltz, Abrahams, and Purtymun (1962),[7] have adopted the unit usage of one of these four reports (see Fig. 4).

The same named unit does not necessarily refer to the same rock and/or include the same subunits. Spiegel and Baldwin, Griggs, and Galusha and Blick agree the term Santa Fe should have group status, but the three reports do not use the same subunits. The term Puye seems to be applied to the same sequence of rocks by three of the reports, although it receives different treatment by each. Spiegel and Baldwin recognize the Puye Gravel as used by Smith (1938, p. 937).[270] Griggs (1964, p. 28)[4] gave the Puye formal status as a formation with a specified type locality, *"the belt of exposures along Guaje Canyon between Guaje Mountain and the Puye Escarpment."* He also changed the name from Puye Gravel to Puye Conglomerate because *"the formation is sufficiently consolidated to stand in vertical cliffs"* and separated it into two members of alluvial origin — the Totavi Lentil and the fanglomerate member. Bailey, Smith and Ross (1969, p. 12)[6] propose to call the Puye the Puye Formation because *"most of the constituent materials of the formation are of ultimate pyroclastic origin, and many of the component beds, especially those close to the source areas in the Jemez Mountains, are pumiceous tuffs and lithic lapilli tuffs that show only slight alluvial reworking."*[6]

This report does not propose to solve the stratigraphic nomenclature problems which have been briefly outlined in the preceding paragraphs. A comparison of unit usage by Galusha and Blick; Bailey, Smith and Ross; Griggs; and Spiegel and Baldwin is shown in Fig. 5. Descriptions of all stratigraphic units in use in the Los Alamos area follow:



W. D. Purtymun (unpublished)

Fig. 4.

Geologic cross section showing generalized stratigraphic and structural relationship of rocks in the Los Alamos Area.

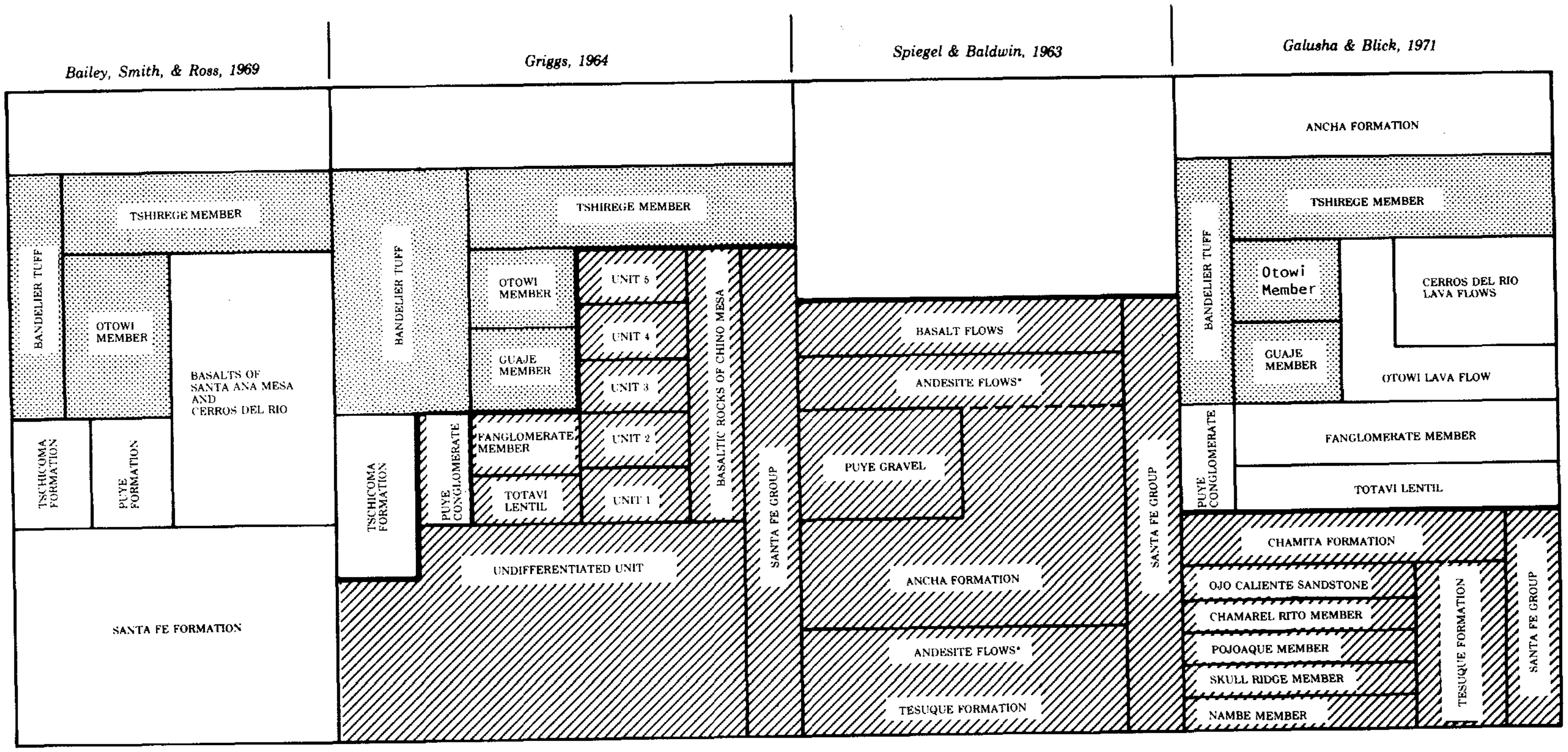


Fig. 5.
Nomenclature of the tertiary-quarternary rocks in the Los Alamos area.

*Same unit. It is stratigraphically lower than the Ancha Formation, which correlates with the top of the Santa Fe Formation (Bailey, Smith & Ross, 1969, p.2) and possibly the top of the Undifferentiated Unit (Griggs, 1964, p.2). However, the Andesite Flows have been correlated with Unit 3 of the Basaltic Rocks of Chino Mesa (Spiegel & Baldwin, 1963, p.53). Obviously, it cannot comply with both correlations.

Santa Fe Group

Spiegel and Baldwin proposed the term Santa Fe be raised to group status. They considered the Santa Fe Group to include sedimentary and volcanic rocks which ranged in age from middle(?) Miocene to Pleistocene (?) and were related to the Rio Grande Rift. They placed all rocks above the latitic and limburgitic flows and breccias exposed in the Cienega area in the Santa Fe Group. This definition includes the terrace deposits and alluvium of present valleys.

Tesuque Formation. The Tesuque Formation (Spiegel and Baldwin, 1963, p. 39)[3] is middle (?) Miocene to early Pliocene in age. It consists of several hundred meters of pinkish-tan, soft arkosic, silty sandstone and minor conglomerate with two minor volcanic units. Most of the sediments were derived from siltstone Precambrian rocks. Named for the town of Tesuque, its arbitrary type section is along the north boundary of T. 17 N., extending 14 1/2 km (9 mi) westward from Tesuque Creek (NE 1/4 sec. 5, T. 17 N., R. 10 E.) to a point three-fourths of a mile east of the Buckman Road (NE 1/4 NW 1/4 sec. 2, T. 17 N., R. 8 E.).

The Tesuque Formation (Galusha and Blick, 1971, p. 44)[5] is restricted to beds of dominantly granitic origin with a total thickness of more than 1130 m (3700 ft) in the Espanola Valley. It is divided from bottom to top as follows: (1) the Nambe Member, (2) the Skull Ridge Member, (3) the Pojoaque Member, (4) the Chama-el rito Member, and (5) the Ojo Caliente Sandstone. Only the Pojoaque Member crops out in the Los Alamos area.

The Tesuque Formation crops out in the eastern part of the Los Alamos area along the Rio Grande.

Andesite Flows. Basaltic andesite makes up part of the high mesas of Cerros del Rio. These flows are considered older (Spiegel and Baldwin, 1963, p. 50)[3] than the flows several hundred feet below which form the main level of the lava mesa. The andesite flows intertongue with the Ancha Formation along Ancha Canyon.

Ancha Formation. The Ancha Formation (Spiegel and Baldwin, 1963, p. 45)[3] rests with angular unconformity on the Tesuque Formation. A late Pliocene or Pleistocene age is inferred for the Ancha from physiographic relations. It consists of up to 91 m (300 ft) of arkosic gravel, sand, and silt. The formation is named for Canada Ancha.

The Ancha Formation (Galusha and Blick, 1971, p. 78)[5] rests with angular unconformity on the Pojoaque Member of the Tesuque Formation. It is considered Pleistocene, approximately equivalent to or slightly post-Bandelier Tuff in age.

In the Los Alamos area, (defined as west of the Rio Grande), the Ancha has never been mapped.

Chamita Formation. The contact between the Ojo Caliente Sandstone (Galusha and Blick, 1971, p. 67)[5] and the Chamita Formation (Galusha and Blick, 1971, p. 71)[5] is an unconformity. The medial Pleistocene Chamita Formation is predominantly fluviatile in origin and consists of as much as 213 m (700 ft) of pinkish, brownish, gray, or white tuffaceous and quartzitic sands, gravels, and conglomerates. It is named for the village of Chamita and has its type section south of Black Mesa between the Chama River and the Rio Grande, specifically the NW 1/4 sec. 10 and the W 1/2 sec. 3, T. 21 N., R. 8 E. The Chamita Formation crops out in the northeastern part of the Los Alamos area in Los Alamos Canyon and along the Rio Grande.

Puye Conglomerate. Mid-Pliocene (?)[5] in age, the Puye Conglomerate (Griggs, 1964, p. 28)[4] consists of well-rounded pebbles, cobbles, and small boulders of quartzite, quartz, and granite with some volcanic debris in a matrix of arkosic sand. The type locality is Guaje Canyon between Guaje Mountain and the Puye Escarpment. The Puye Conglomerate is divided into two members, the Totavi Lentil and the Fanglomerate. Outcrops of the Puye Conglomerate are found in the northeastern part of the Los Alamos area and along the Rio Grande.

Totavi Lentil

The Totavi Lentil (Griggs, 1964, p. 29)[4] is the lower member of the Puye Conglomerate. The type locality is a quarry north of State Highway 4 and about 402 m (a quarter mile) west of the community of Totavi from which it derives its name. As much as 23 m (75 ft) thick, the Totavi is a channel deposit of poorly consolidated conglomerate composed of Precambrian rocks.

Fanglomerate Member

The upper member of the Puye Conglomerate is a fanglomerate composed of latitic debris derived from the Tschicoma Formation. The fanglomerate member (Griggs, 1964, p. 31)[4] ranges in thickness up to 183 m (600 ft.) It thins southward and wedges out southwest of Otowi Bridge.

Basaltic Rocks of Chino Mesa. Those flows which form the steep walls of White Rock Canyon and cap the high mesas to the east are the basaltic rocks of Chino Mesa (Griggs, 1964, p. 37).[4] The sequence of flows, erupted from centers in the Cerros del Rio, is greater than 396 m (1300 ft) thick at Chino Mesa. Their age is late Pliocene to middle or late Pleistocene.

The basaltic rocks of Chino Mesa have been divided into five units. Unit 1 rests unconformably on the undifferentiated unit (Griggs, 1964, p. 20)[4] and interfingers with the Totavi Lentil. Unit 2 conformably overlies unit 1, interfingers with the upper tongue of the undifferentiated unit, rests on the Totavi Lentil, and abuts the fanglomerate member. Unit 3 is disconformable on unit 2, rests on the fanglomerate member, and interfingers with the old alluvium unit (Griggs, 1964, p. 41). Unit 4 rests unconformably on the undifferentiated unit, the Puye Conglomerate, and unit 2. In some places unit 4 abuts unit 2 and unit 3. Unit 5 consists of cinder cones and local flows which unconformably overlie all older rocks with which they are in contact.

Polvadera Group. Polvadera Group is the name proposed by Smith, Bailey, and Ross (1969, p. 10)[6] for the sequence of basaltic, andesitic, dacitic, and rhyolitic rocks 1524 m (5000 ft) thick, which form part of the central and most of the northern Jemez Mountains. The group is divided into three formations: the Lobato Basalt, the Tschicoma Formation, and El Rechuelos Rhyolite. The Tschicoma Formation is the only one which crops out in the Los Alamos area.

Tschicoma Formation. The Tschicoma Formation (Griggs, 1964, p. 42)[4] of the Polvadera Group consists of andesites, dacites, rhyodacites, and quartz latites. Radiometric dates of 6.7 to 3.7 million years [G. B. Dalrymple, written communication, 1967 (Bailey, Smith and Ross, 1969, p. 11)][6] on the rocks indicate an age of middle to late Pliocene. The Tschicoma Formation crops out along the western margin of the area in the Sierra de los Valles. It is greater than 793 m (2600 ft) thick in the Los Alamos area.

Puye Formation. Penecontemporaneous with the Tschicoma Formation is the Puye Formation (Bailey, Smith, and Ross, 1969, p. 12).[6] It is described as essentially a broad alluvial and pyroclastic fan flanking the east side of the northern Jemez Mountains. It interbeds with the Tschicoma Formation and the basalts of Chino Mesa (Cerros del Rio) and unconformably overlies the Santa Fe Formation. The formation is not assigned to any group.

Tewa Group. The name Tewa Group was given by Griggs (1964, p. 45)[4] to the rhyolitic tuff and the rhyolite and quartz latite domes which constitute the latest eruptive rocks of the Jemez Mountains. The group consists of the Bandelier Tuff, Cerro Toledo Rhyolite, Cerro Rubio Quartz Latite, and the Valles Rhyolite. In the Los Alamos area the Bandelier Tuff is the only formation which crops out.

Bandelier Tuff. In the Los Alamos area the Bandelier Tuff can be subdivided into three members (Griggs, 1964, p. 46).[4] These members are, from bottom to top: (1) The Guaje Member, a bedded pumice-fall deposit, (2) The Otowi Member, a massive pumiceous tuff breccia of ash-flow origin, and (3) the Tshirege Member, a succession of cliff-forming welded ash flows. Away from the Los Alamos area, this subdivision is not used. The Otowi Member is defined (Bailey, Smith, and Ross, 1969, p. 13)[6] to include a basal pumice fall, the Guaje pumice bed (Guaje Member of Griggs), and the overlying ash-flow units (Otowi Member of Griggs). The Tshirege Member is defined (Bailey, Smith, and Ross, 1964, p. 13) to include a basal pumice fall, the Tsankawi pumice bed, and the overlying ash-flow units (Tshirege Member of Griggs). Due to the lack of detailed stratigraphic mapping, it is unclear whether in the Los Alamos area the Bandelier will continue to be subdivided into three units or the more general usage outside the immediate area of two units will be adopted.

The Los Alamos area is also unique in that the Tshirege Member has been subdivided into seven numbered units, unit 1a; unit 1b; unit 2; unit 3; unit 4; unit 5; and unit 6, by Weir and Purtymun (1962)[9] and into five numbered units, unit 1a; unit 1b; unit 2a; unit 2b; and unit 3 by Baltz, Abrahams and Purtymun (1963)[7] Weir and Purtymun give the type section for their units as the south wall of Water Canyon — NW 1/4 NE 1/4 sec. 3 (projected) T. 18 N., R. 6 E. Units 1a and 1b of Baltz, Abrahams, and Purtymun (1963, p. 29) correlate with unit 1b of Weir and Purtymun. Unit 2 (Weir and Purtymun, 1962, p. 121) seems to correlate with units 2a and 2b (Baltz, Abrahams, and Purtymun, 1963, p. 26-27); and unit 3 (Weir and Purtymun, 1962, p. 124) seems to correlate with unit 3 (Baltz, Abrahams, and Purtymun, 1963, p. 28). It is not clear with which unit the Tsankawi Pumice Bed of Bailey, Smith, and Ross (1969, p. 14)[6] correlates.

The Bandelier Tuff is Pleistocene in age. The basal unit of the Tshirege Member, the Tsankawi Pumice Bed, has been dated radiometrically as 1.1 million years old (Doell and others, 1968).[10]

In the Los Alamos area the Bandelier Tuff, 79-320 m (260-1050 ft thick)[4] crops out on the Pajarito Plateau. See Table I for a chemical analysis of the tuff.

TABLE I

CHEMICAL ANALYSIS* OF LOS ALAMOS TUFF[11]

	%
SiO_2	76.3
Al_2O_2	13.1
Fe_2O_3	1.9
FeO	0.25
MgO	0.32
CaO	0.51
Na_2O	3.9
K_2O	4.6
H_2O	1.3 (chemically bound)
TiO_2	0.26
P_2O_5	0.06
MnO	0.06
CO_2	>0.05

*Rapid Rock Method

Recent Alluvium. Recent alluvium is found in the canyons cutting the Pajarito Plateau. For those canyons which head in the Sierra de los Valles the alluvium consists mainly of detritus derived from the Tschicoma Formation. For those canyons which head on the Pajarito Plateau the alluvium consists of detritus derived from the Bandelier Tuff.

B. Structure

The Los Alamos area is on the Pajarito Plateau which flanks the eastern side of the volcanic Jemez Mountains. Volcanism began approximately 12 million years ago in late Miocene or early Pliocene time. Finally, in mid-Pleistocene time (about 1 million years ago) volcanism was climaxed by two gigantic pyroclastic outbursts, which produced the Bandelier Tuff (Smith and Bailey, 1966).[6] Each outburst deposited nearly 209 km^3 (50 mi^3) of rhyolite ash and pumice, mainly as ash flows, and was followed by caldera collapse. The first outburst (first cycle) produced the Toledo Caldera, of which only a semicircular portion is now preserved. The second outburst (second cycle) some 300 000 yrs later produced the Valles Caldera. Its collapse truncated the southwestern part of the Toledo Caldera and destroyed much of the evidence of the Toledo Caldera's postcollapse history. The Valles Caldera had a relatively long and complex postcollapse history, which included upheaval of the center of the caldera floor and three stages of rhyolite volcanism (Smith and Bailey, 1968, p. 617).[12]

The Jemez Mountains are located along the western border of the Rio Grande Rift, a linear structure and topographic depression formed by faulting beginning about 20 million years ago in Middle Miocene time (Budding and Purtymun, 1976).[13] The Jemez volcanic rocks are faulted progressively downward to the east by numerous north-trending faults (Smith, Bailey, and Ross, 1961).[14] The major fault in the Los Alamos area, the Pajarito Fault, separates the Pajarito Plateau from the Sierra de los Valles.

The Pajarito Fault displaces the Bandelier Tuff; therefore, faulting took place after deposition of the Bandelier. Using the radiometric date of 1.1 million years (Doell and others, 1968)[10] on the Tsankawi Pumice Bed of the Tshirege Member, faulting occurred less than 1.1 million years ago.

Earth tremors have been felt in the Los Alamos area recently. At 4:30 a.m. on February 17, 1971, an earth tremor of magnitude 1.8 (Richter Scale) occurred (written communication from Allan R. Sanford, New Mexico Institute Mining and Technology). The earth tremor was of such a low order of magnitude that while it was felt on Barranca Mesa, it could not be felt on South Mesa, an approximate distance of 3.4 km (2.1 mi). There seems to be no geologic or cultural evidence to suggest intensive earthquakes have occurred for hundreds, possibly thousands, of years in this region.

> *"A number of pinnacles 10 to 50 feet high, eroded from soft formations and capped with boulders 2 to 5 times the diameter of the supporting pinnacle, lie in Rendija Canyon, just north of Los Alamos. These formations are unstable and it is reasonable to think that they would topple under the influence of any sizeable ground tremors. We note that a 60 foot pinnacle would require 75,000 to 120,000 years to develop with the erosion rate normal in the major canyons in the area.*
>
> *Remains of Indian dwellings constructed with free standing walls with little lateral support indicate the absence of strong tremors for at least 500 years. Nearby pueblos that have been occupied continuously since the late sixteenth century, buildings in Santa Fe constructed by the Spanish in the early seventeenth century, and a lack of references to earthquakes in surviving records add support to this contention."*[15]

Tectonic fractures in the Los Alamos area are related to development of the Rio Grande Rift and the Jemez volcanic complex. Cooling fractures are also present in the area.

No area or regional studies of joint pattern have been done. See individual disposal sites for scattered data.

Identification of faults in the Los Alamos area is the result of other specific geological studies. No study as yet has had as its principal goal the drawing of a structural map at either a local or regional level. Four named faults in the area are: the Pajarito Fault, the Los Alamos Fault, the Guaje Mountain Fault, and the Water Canyon Fault (see Fig. 6). All four faults are north trending faults with vertical or near vertical displacements. The Pajarito Fault is downthrown to the east with a maximum surface displacement of 121.9 m (400 ft).[13] The Los Alamos Fault is downthrown to the west with a maximum surface displacement of 6 m (20 ft).[13] The Guaje Mountain Fault is downthrown to the west with a maximum surface displacement of 16 m (52 ft).[13] The Water Canyon Fault is downthrown to the east with a maximum surface displacement of 9.1 m (30 ft).[13]

C. Hydrology

Climatology and Meteorology

Los Alamos has a semiarid continental mountain climate. The average annual precipitation is slightly greater than 450 mm (18 in.). Seventy-five percent of this precipitation falls from May to October. Shower activity peaks in August when 3 mm (1/10 in.) or more of rain can be expected on one day out of four. Winter precipitation consists of snow. An average winter has 1000 mm (50 in.) of snow with as much as 150 mm (6 in.) or more often falling in 24 h.

The mean humidity value is 41%. The lowest humidity values average 30% in late spring, and the highest humidity values near 50% during July and August.

Prevailing winds are out of the south. They are 10 mph or less almost 80% of the time.

The maximum temperature reaches 32°C (90°F) on an average of 2 days per year with 35°C (95°F) the highest recorded. July is the hottest month. Freezes have been recorded in all months except July and August. An average winter includes only 18 days when mercury fails to rise above freezing. Below-zero readings can be expected only once a year (see Table II).

Main Aquifer

The water table is within the main aquifer. Beneath the plateau it is at an approximate depth of 400 m (1200 ft) along the western margin, and at an approximate depth of 200 m (600 ft) along the eastern margin[15] (see Fig. 7). The aquifer is recharged through the intermountain basins formed by the Valles Caldera,[8] and to a limited extent along the eastern margin of the Sierra de los Valles. Water moves eastward from the recharge area toward the Rio Grande at a rate of approximately 30 cm (1 ft) per day;[15] the actual rate at any point being dependent on the permeability of the aquifer and the elevation gradient on the water table. A portion of the water is discharged through seeps and springs along the Rio Grande.

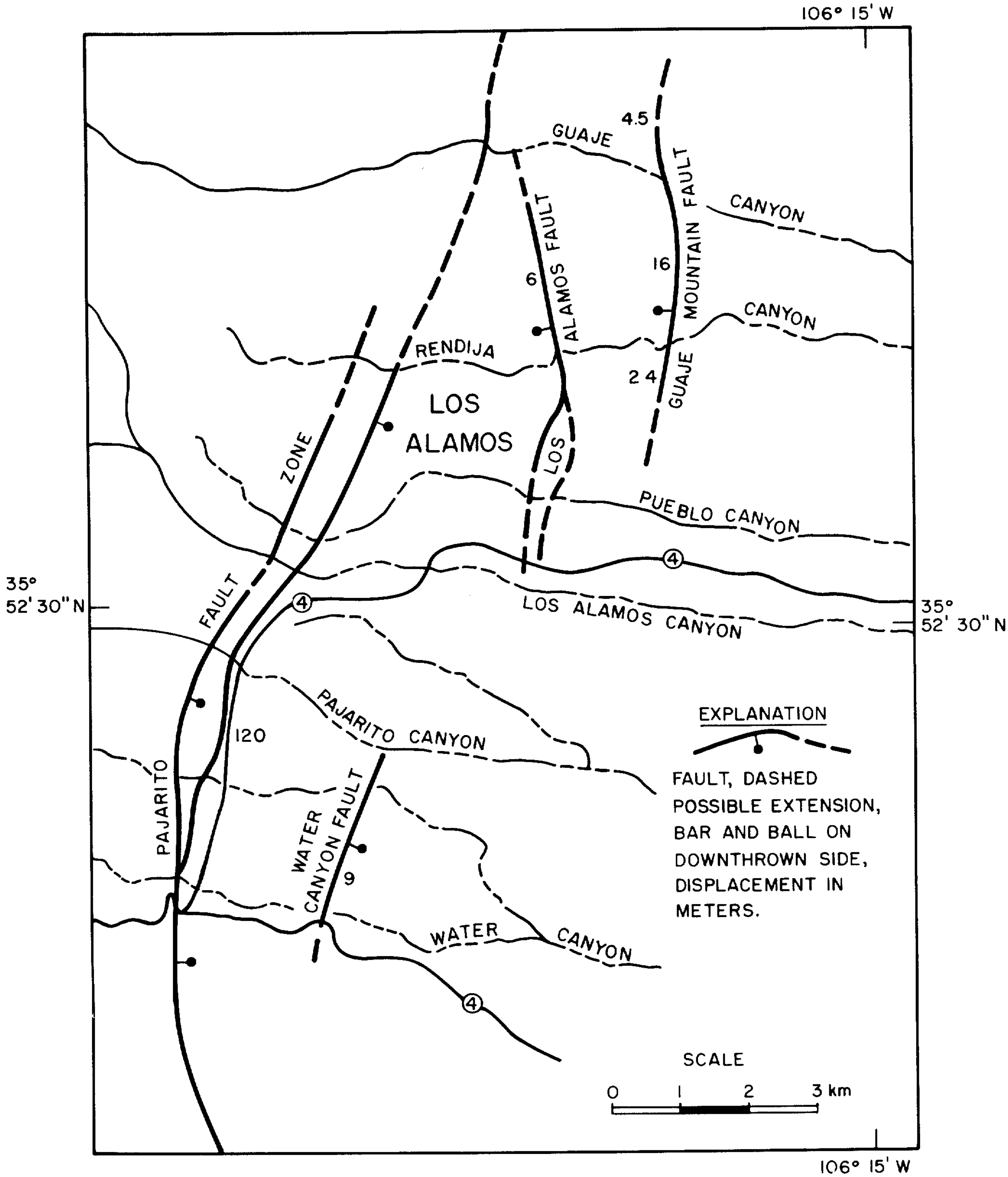
Beneath the plateau the zone of saturation lies within the Tesuque Formation of the Santa Fe Group. This formation consists of beds of siltstone and sandstone with lenses of clay and conglomerate. It crops out along the Rio Grande where the upper part of the formation is above the zone of saturation. Some of the lower Tschicoma volcanic flow rocks are within the zone of saturation beneath the western part of the plateau.

The Puye Formation, a conglomerate of volcanic debris from the Tschicoma Formation interbedded with basalt, is above the zone of saturation along the Rio Grande. Beneath the plateau the lower part is in the zone of saturation.

Throughout the plateau the Bandelier Tuff which forms the plateau surface is above the zone of saturation (see Fig. 8).

Perched Water

Perched water occurs in the interbedded basalts of the Puye Formation near the eastern edge of the plateau in Pueblo, Los Alamos, and Sandia Canyons. The perched water in the basalts is probably replenished from water moving from the small bodies of perched water contained in recent alluvium in



Budding and Purtymun, 1976[13]

Fig. 6.
Faults in the Los Alamos area.

TABLE II

CLIMATOLOGICAL SUMMARY 1910-1974[a]

	TEMPERATURE (°C)							PRECIPITATION TOTAL (mm)										MEAN NO. OF DAYS[b]		
	MEANS			EXTREMES				RAIN[c]					SNOW/FROZEN PRECIPITATION							
Mo	Max	Min	Mo Mean	High	Yr	Low	Yr	Mean	Daily Max	Yr	Mo Max	Yr	Mean	Daily Max	Yr	Mo Max	Yr	Precip. ≥2.5mm	Max Temp ≥2.67°C	Min Temp ≤9.4°C
Jan	3.9	-7.9	-2.0	17.8	1963	-27.8	1963	21.21	62.23	1916	171.45	1916	246.1	381.0	1913	989.2	1949	2	0	8
Feb	6.1	-5.8	0.1	18.9	1936	-25.6	1951	17.38	26.67	1915	61.89	1948	204.8	330.2	1915	604.2	1948	2	0	6
Mar	9.4	-3.4	3.1	21.7	1971	-19.4	1948	25.38	57.15	1916	104.4	1973	261.3	457.2	1916	938.8	1973	3	0	3
Apr	14.6	1.0	7.8	26.7	1950	-15.0	1925	24.69	36.83	1969	117.86	1916	103.9	304.8	1958	853.4	1958	3	0	0
May	19.9	6.0	12.9	31.7	1935	- 4.4	1938	32.16	45.72	1929	113.54	1929	19.7	228.6	1917	431.8	1917	3	1	0
Jun	25.3	10.9	18.1	33.9	1954	- 2.2	1919	34.64	34.80	1931	141.49	1913	0.0	0.0	--	0.0	--	3	14	0
Jul	26.9	12.9	19.9	35.0	1935	2.8	1924	86.06	70.61	1968	202.69	1919	0.0	0.0	--	0.0	--	8	19	0
Aug	25.4	12.3	18.9	33.3	1937	4.4	1947	94.53	57.40	1951	283.97	1952	0.0	0.0	--	0.0	--	8	12	0
Sep	22.4	8.9	15.7	34.4	1934	- 5.0	1936	50.02	56.13	1929	147.07	1941	4.9	152.4	1913	152.4	1913	5	5	0
Oct	16.7	3.2	9.9	27.8	1930	- 8.9	1970	41.31	88.39	1919	171.96	1957	36.9	228.6	1972	228.6	1959 1972	3	0	0
Nov	9.4	-3.1	3.2	20.6	1937	-20.0	1957	17.77	37.08	1931	83.82	1957	126.4	335.6	1931	876.3	1957	2	0	2
Dec	4.9	-6.8	-1.0	16.7	1933	-23.3	1924	23.01	34.29	1965	72.39	1965	266.8	457.2	1915	1049.0	1967	3	0	6
Year	15.4	2.3	8.9	35.0	1935	-27.8	1963	468.16	88.39	1919	283.97	1952	1270.8	457.2	1915	1049.0	1967	45	51	25

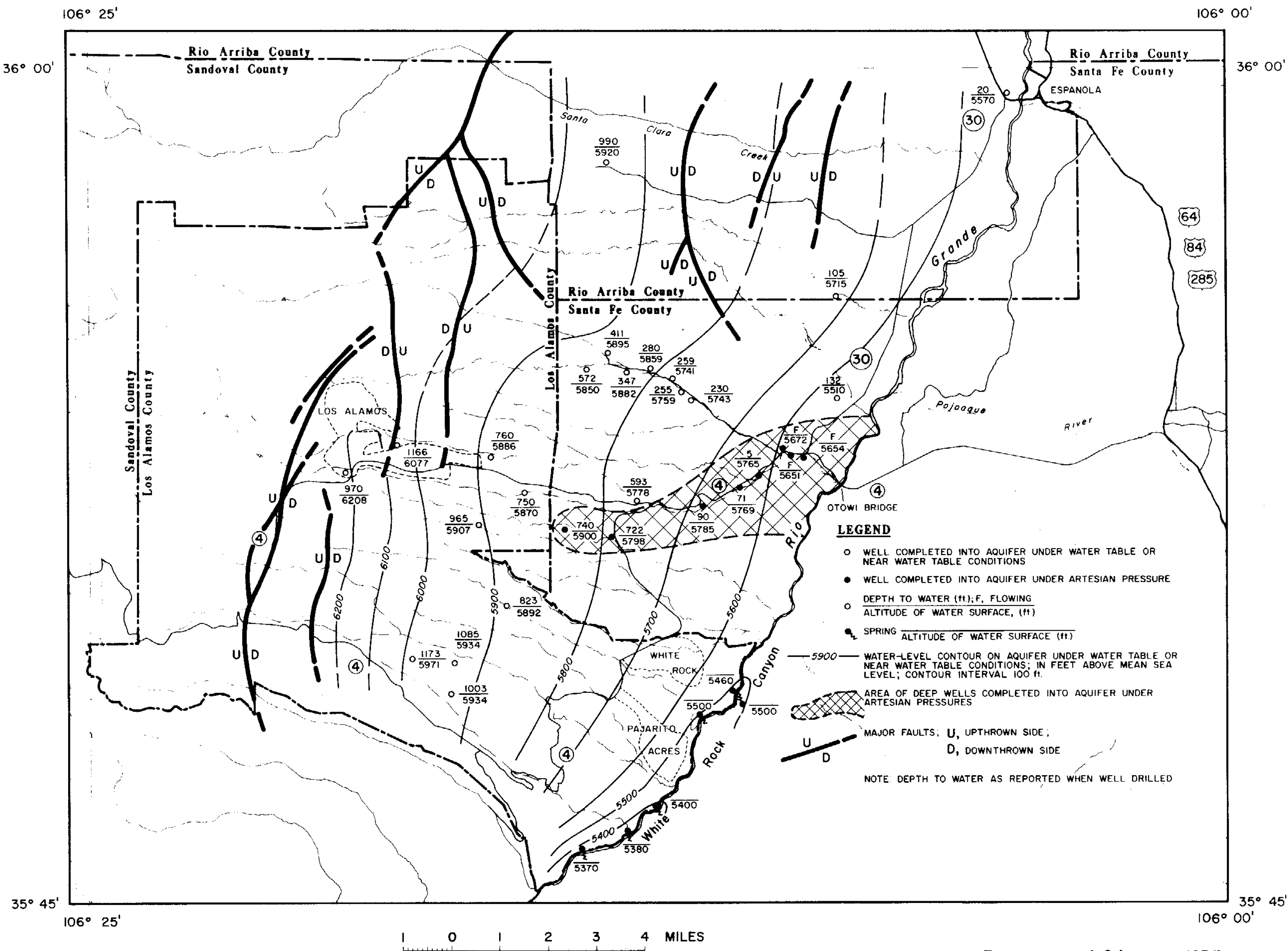
CLIMATOLOGICAL SUMMARY 1975[a]

	TEMPERATURE (°C)					PRECIPITATION TOTAL (mm)				NO. OF DAYS[b]		
	MEANS (Daily Values)			EXTREMES		RAIN[c]		SNOW/FROZEN PRECIPITATION		NO. OF DAYS		
Mo	Max	Min	Mo Mean	High	Low	Total	Daily Max	Total	Daily Max	≥2.5mm	≥26.7°C	≤9.4°C
Jan	3.7	-9.5	-2.9	16.1	-23.3	32.8	17.5	399.0	165.0	3	0	14
Feb	4.3	-7.5	-1.6	11.7	-20.0	46.7	24.4	584.0	267.0	3	0	9
Mar	8.4	-2.7	2.9	15.6	-11.1	32.5	8.1	305.0	76.0	5	0	4
Apr	11.8	-1.1	5.4	21.1	- 7.8	82.0	50.8	843.0	508.0	3	0	0
May	18.7	4.3	11.5	24.4	- 3.3	4.1	1.5	0.0	0.0	0	0	0
Jun	25.0	10.0	17.5	31.0	0.0	8.9	5.8	0.0	0.0	1	14	0
Jul	25.6	12.0	18.8	28.9	9.4	98.6	29.2	0.0	0.0	11	13	0
Aug	26.0	12.0	19.0	29.0	9.0	41.4	11.2	0.0	0.0	4	17	0
Sep	19.9	7.8	13.9	28.0	1.0	115.6	29.0	0.0	0.0	7	2	0
Oct	16.8	2.3	9.6	23.3	- 7.8	5.6	2.5	0.0	0.0	1	0	0
Nov	9.1	-3.8	2.7	18.9	-14.4	15.0	7.6	38.1	25.4	2	0	5
Dec	5.4	-6.7	-0.7	12.2	-13.9	7.6	4.3	76.2	63.5	2	0	8
Year	14.6	1.4	8.0	31.0	-23.3	490.8	50.8	2245.3	508.0	42	46	40

[a] Los Alamos, New Mexico; Latitude 35° 32' North, Longitude 106° 19' West; Elevation 2260 m

[b] 26.7°C = 80°F; -9.4°C = 15°F

[c] Includes liquid water equivalent of frozen precipitation



Purtymun and Johanson, 1974[8]

Fig. 7.
Contour map of Los Alamos aquifer.

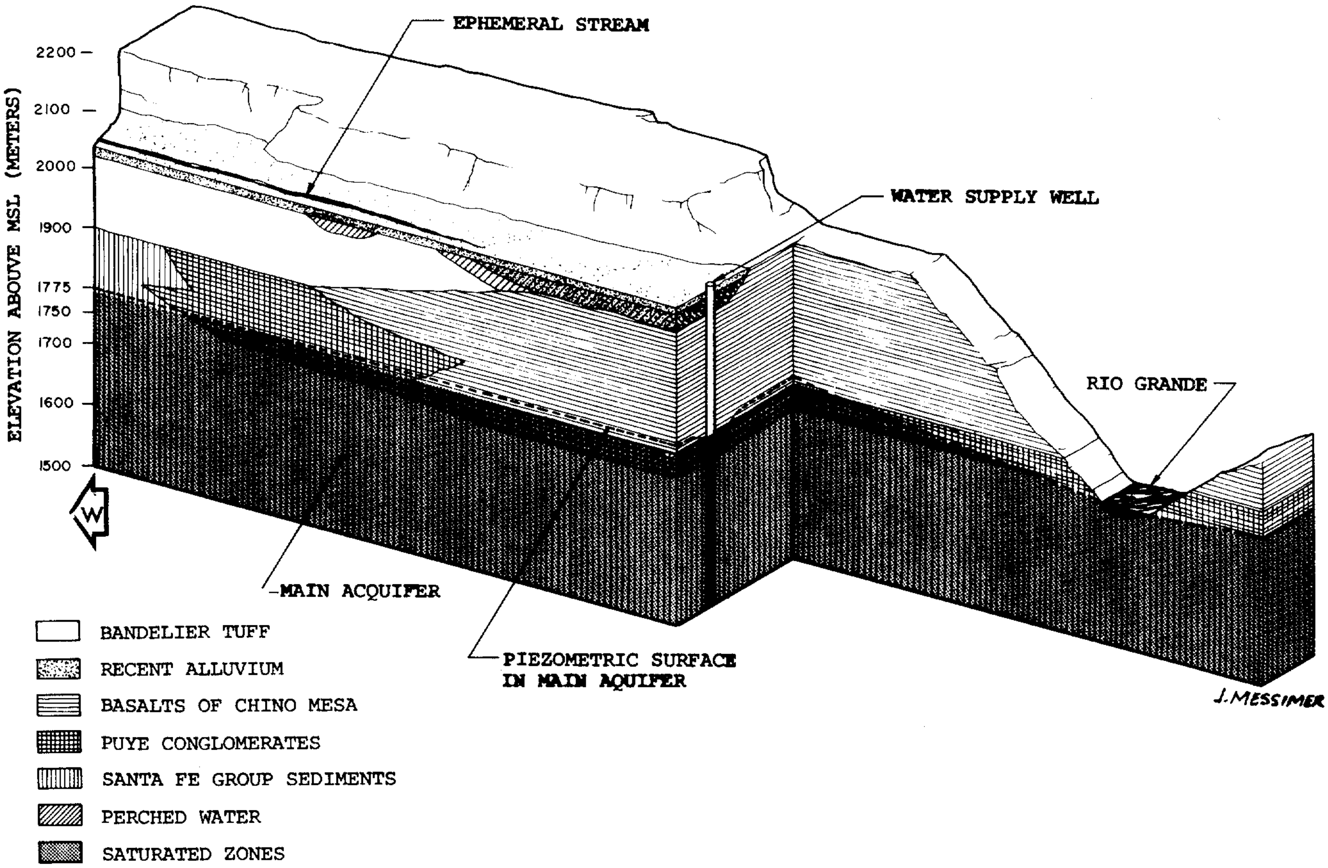


Fig. 8.
Conceptual hydrological cross section of the Los Alamos area.

Pueblo, Los Alamos, and Sandia Canyons. Perched water is also found in small bodies in the recent alluvium of Pajarito and Mortandad Canyons. It probably occurs seasonally in upper parts of other canyons which receive seasonal runoff from the mountains and plateau.

The absence of perched water in the tuff or volcanic sediments above the main aquifer is believed[16] to indicate that infiltration of water from alluvium in stream channels into the underlying tuff is small due to the low permeability of the tuff.

Surface Water

The only perennial streams in the area are the Rio Grande, which flows along the eastern edge of the plateau, and the Rito de los Frijoles which defines the southern boundary of the area. The upper reaches of Los Alamos and Guaje Canyons have natural perennial flow. This flow is depleted by evaporation and infiltration before it crosses the western third of the plateau. In the upper and middle reaches of Pueblo and Sandia Canyons the perennial flow is due to the release of treated sewage effluent. DP Canyon and the mid-reach of Mortandad Canyon have intermittent flow due to the release of treated industrial effluents.

Surface runoff from most canyons to the Rio Grande occurs generally during periods of great precipitation (summer thunder showers). Some small canyons with small drainage areas never receive enough precipitation for storm runoff to reach the Rio Grande.

IV. STUDIES AND MONITORING

Concern, expressed as action, about radioactive contamination of the Los Alamos environs by Laboratory activities dates back to early 1944, "Report on Contamination of Creek Water — II."[16] March 2, 1944, water analyses made by the USGS of water taken from (1) the west end of building "D" (Room 103), (2) room U-18 of "U" building, and (3) water mains at Don Gaspar Avenue and Water Street, Santa Fe, New Mexico, were received by the Laboratory.[17]

In 1945[18] and 1946[18] interest in the chemical and sanitary sewer lines and Los Alamos and Pueblo Canyons seems to have become more intense.[19,20,21,22] From the "Preliminary Survey of Sewer System,"[19] June 11, 1946:

"It is evident that most every sewer line originating in the Tech Area or at DP site is contaminated. They are poorly planned, and even more poorly used and maintained. In several instances the septic tanks are too small and in almost every instance the septic tanks are not operating properly because of improper bacterial action.

It is very desirable that water and earth samples be taken at each sewer location to determine the degree of hazard. Further, it is desirable that some type of check be made by qualified technicians to determine why the sanitary sewers are contaminated or why the acid sewer should show evidence of refuse from sanitary installations."[19]

February 20, 1947, "Survey of Los Alamos and Pueblo Canyon for Radioactive Contamination and Radioassay Tests Run on Sewer-Water Samples and Water and Soil Samples Taken from Los Alamos and Pueblo Canyons,"[23] (LAMS-516) was published.

"Chemical sewers and sanitary sewer lines draining the Tech Area, D.P. Site, CMR-12 Laundry, and surrounding residential areas flow into Pueblo and Los Alamos Canyon streams. The water flow formed in these two canyons winds southeastward to the Rio Grande River after joining beside the old Lowdermilk camp site east of the junction of Route 4 and the road to Post 1. In order to determine the extent and sources of radioactive contamination in these localities it is necessary to collect and radioassay fluid samples from each of the sewers, soil samples from the ground surrounding the sewer exits, and water and soil samples from selected spots in or near each of the two canyon streams. Some preliminary radioassay work was carried out in July, 1945 and previously reported, but because of the importance of the work and the possibility of increasing amounts of radioactive materials accumulating in the area the analyses and surveys were repeated using more exacting methods.

Four groups of radioassay determinations were run. The first group of assays was made on water samples from all sanitary and chemical sewer outlets. Samples were collected and assayed in July, 1946 and in September, 1946. The second group of assays (October and November, 1946) was made on soil samples taken from the ground surrounding all sewer outlets that were found contaminated when surveyed with a portable alpha survey instrument. In some cases, however, soil samples were collected from the ground surrounding exits where the presence of radioactive contaminants, by instrument survey, was not indicated but was suspected. This was done to insure a complete and accurate survey of the entire area and to insure a positive check of spots where any possible contamination might be present even though it might not be detectable by direct instrumentation. Pictures *were taken of most of these samples sources. The third group of assays (September, 1946) was made on samples of water taken from stagnant pools in both Pueblo and Los Alamos Canyons. These samples were collected from pools as far down as the Rio Grande River. The fourth group of assays (October and November, 1946) was made on soil samples taken from points in the stream beds in Pueblo and Los Alamos Canyons. As in the case of the soil samples taken from near the sewer exits, pictures were taken of the sources of the soil samples in the canyons where alpha contamination was found to be appreciable by survey with a portable alpha survey meter."*[23]

Similar monitoring continued at least through 1949.[24,25,26,27,28]

At the meeting of the AEC Waste Processing Committee at Los Alamos in October 1950, the USGS presented a paper "Geologic Background of Waste and Water-Supply Problems at Los Alamos,"[29]

"The U. S. Geological Survey in cooperation with the U. S. Atomic Energy Commission and the University of California, Los Alamos Scientific Laboratory, began a program in 1949 to monitor the chemical and radiochemical concentrations in surface and ground water in the Los Alamos area. Water samples for chemical and radiochemical analyses were collected downgradient from waste disposal points, industrial-waste treatment plants, and disposal pits."[36]

"The purpose of collecting these data is to determine if, or to what extent, low-level radioactive effluents from the operation of the Los Alamos Scientific Laboratory contaminate surface and ground-water systems downgradient from Los Alamos."[39]

There were at least eleven reports in this series describing monitoring of surface and ground water in the Los Alamos area. The first report, "Geologic and Hydrologic Environment of Radioactive Waste Disposal Sites at Los Alamos, New Mexico,"[30] was released in February 1963.

"A systematic sampling program was started about 1959, and a period of intensive sample collection lasted from July 1957 through July 1959, after which the program was reduced and sampling was done on a less intensive and a more selective basis."[30]

Other reports in the series presented basic data on the chemical and radiochemical analyses of water and on the hydrology of the Los Alamos area:

"The Hydrology and the Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, 1949-55."[31]

"The Hydrology and the Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, January, 1956 through June, 1967."[32]

"The Hydrology and the Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July, 1957 through June, 1961."[33]

"The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July 1961 through June 1962."[34]

"The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July, 1962 through June, 1963."[36]

"The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July, 1963 through June, 1964."[37]

"The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July 1964, through June, 1965."[38]

"The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July, 1965 through June, 1966.[39]

"The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July, 1966 through June, 1967."[39]

"Chemical and Radiochemical Analyses of Water in the Los Alamos Area, New Mexico, Made by the U.S. Geological Survey, 1960 through 1968."[40]

"The chemical and radiochemical quality-of-water data are presented in five parts: (1) Pajarito Plateau, test and supply wells, and surface water; (2) Mortandad Canyon, surface water and observation wells; (3) Los Alamos and DP Canyon, surface water and observation wells; (4) White Rock Canyon, springs and streams entering Rio Grande; and (5) Rio Chama and Rio Grande surface water.

The water samples were collected by personnel of Group H-6 of the Los Alamos Scientific Laboratory and by the U. S. Geological Survey. Radiochemical analyses were made by Group H-6 ... Chemical analyses were made by Group H-7 ..."[39]

"Soil Adsorption of Radioactive Wastes at Los Alamos,"[2] appeared in the December 1958 **Sewage and Industrial Wastes.**

"Certain of the results obtained in this study are not in complete agreement with those of Swope[(1)] *who found that both cesium and hardness broke through resin columns at about the same point. McHenry et al.*[(2)] *indicate a marked effect of the presence of cesium on the breakthrough of strontium. These studies did not show a similar effect. It is possible that the discrepancies are related to the different exchange properties of the basic adsorbents under study.*

Orcutt et al.[(3)] *have developed excellent expressions for dispersion and exchange phenomena applicable to radionuclides as they move through soils. Whether nuclides in low concentrations that are amenable to soil disposal will follow accepted physical laws is not known. Thomas*[(4)] *has stated that it remains to be proved that elements at concentrations of* 10^{-7}**M** *follow classical chemistry or the accepted physical laws of ion exchange. It is possible that a demonstration of the applicability of the mathematical treatment of Orcutt et al. to solutions where concentrations of solute approach* 10^{-7}**M** *will indicate the nature of their chemistry.*

It has been demonstrated that the tuff local to Los Alamos has a rather high capacity for the retention of various nuclides. This is especially notable since this particular material has an ion exchange capacity which is about as low as any to be found in nature. Cs^{137} *is apparently very tightly bound to the tuff and resists leaching by any of the common agents.* Pu^{239} *likewise is readily retained by the tuff and from actual experience at Los Alamos, plutonium in wastes discharged into the ground appear* (sic) *to remain at the point of discharge. However, from what is known about the chemistry of plutonium, it is entirely possible that this nuclide could be released at some future time by inadvertent discharge of solutions such as versene in the same area. Work on this phase is being conducted at Los Alamos.*

Sr^{90} is not retained by the tuff nearly so well as cesium and plutonium and it is much more easily released. It is becoming increasingly apparent that its fixation poses a most important problem, and it remains the controlling isotope in the disposal of radioactive wastes. Disposal of this isotope to soils is to be undertaken with extreme caution and only with foreknowledge of the nature of the soil and its capacity for the ions known to be present in the waste. Because Sr^{90} can be leached by other ions, a disposal area receiving this isotope must be closely guarded so that no other wastes will be discharged which might contain concentrations of ions sufficient to dislodge the already adsorbed nuclide."[2]

"(1) Swope, G. H., "Ion Exchange Technology," Nachod and Schubert, Academic Press, Inc., New York, NY, pp. 458-520, (1956).

(2) McHenry, J. R., Rhode, D. W. and Rowe, P. P., "Sanitary Engineering Aspects of the Atomic Energy Industry." A Seminar Report TID-7517 (Part 1A), pp. 170-190 (Dec. 1955).

(3) Orcutt, R. G., Rifai, M.N.E., Klein, G., and Kaufman, W. J., "Underground Movement of Radioactive Wastes." This Journal, 29, 7, 791 (July 1957).

(4) Thomas, H. C., private communication."

Conclusions from the 1966 USGS study, "Hydrology of Waste Disposal Systems, Los Alamos, New Mexico, 1949 through 1961,"[41] state:

"Chemical and radiochemical contamination at Los Alamos is limited to the canyon disposal areas receiving treated industrial effluent. It is greatest near points of effluent discharge; even here concentrations are usually below MPC and they diminish downgradient in the canyons. Test and supply wells completed in the main zone of ground water saturation indicate no chemical or radiochemical contamination. Monitoring of ground water at the supply wells and of surface water in the Rio Grande and at springs emptying to the river confirms that no detectable contamination has reached these waters.

Chemical treatment of liquid wastes and burial of solid wastes as practiced by the Los Alamos Scientific Laboratory reduce likelihood of serious contamination. Chemical treatment is complemented by the effectiveness of local geologic and hydrologic conditions in containing chemical wastes within narrow areal and spatial limits.

Practices, conditions and their interrelationships pertinent to the conclusion that it is unlikely that significant contamination could reach the river or the supply wells are summarized as follows:

1. Liquid wastes are treated to one-tenth MPC of radioactivity before discharge into the disposal areas.

2. Storm runoff and treated sewage dilute the effluent and reduce the already low levels of radioactivity.

3. Chemistry of the liquid wastes, especially their high pH, promotes the exchange of radioactive components in the effluent with ions in clay, and attachment of effluent components to clay particles.

4. Clay minerals, montmorillonite and illite are weathering products of the tuff and are in large quantity in the canyons. They effectively bind radioactive ions or molecules. Clay particles, with attached radioactive materials, are dispersed down gradient and laterally in the canyon disposal areas by sudden strong flows of effluent or storm runoff. Seepage also disperses radioactive material by carrying some of it vertically and laterally to buried clays. These factors combine to decrease the likelihood of occurrence of a larger anomalous concentration.

5. Sludge produced in chemical treatment of liquid wastes is mixed with vermiculite or cement and put in barrels to prevent leakage or leaching.

6. Soil around the solids disposal pits and the compacted tuff used to cover the pits when they are filled inhibit the infiltration of water from precipitation through the waste.

7. The tuff of the plateau can retain certain nuclides by ion exchange.

8. The large volume of unsaturated volcanic rock and sediment under the plateau is a potential reservoir for storage of contaminated water.

9. The slow movement of ground water (about 360 feet per year) would allow an interval greater than 70 years for chemical reaction and for radioactive decay of contaminants between the time that they might enter the ground water and the time that water would reach the river or the zone from which water is being pumped."[41]

From 1968 through 1970 LASL reported measurements of air particulate radioactivity and activity in precipitation:

"Radioactivity in Environmental Air at Los Alamos, New Mexico, for the Period November 17, 1958 through December 31, 1959,"[42]

"Strontium-90, Cesium-137, and Radioactive Rare Earths in Environmental Rain and Air at Los Alamos, New Mexico, 1958-June 1963,"[43]

"Strontium-90, Cesium-137, and Radioactive Rare Earths in Environmental Rain and Air at Los Alamos, New Mexico, 1963-1964."[44]

"Beta-Gamma Radioactivity in Environmental Air at Los Alamos, New Mexico, for 1960."[45]

"Beta-Gamma Radioactivity in Environmental Air at Los Alamos, New Mexico, for 1961."[46]

"Beta-Gamma Radioactivity in Environmental Air at Los Alamos, New Mexico, for 1962."[47]

"Beta-Gamma Radioactivity in Environmental Air at Los Alamos, New Mexico, for 1963."[48]

"Beta-Gamma Radioactivity in Environmental Air at Los Alamos, New Mexico, for 1964."[49]

"Beta-Gamma Radioactivity in Environmental Air at Los Alamos, New Mexico, for 1965."[50]

"Beta Radioactivity in Environmental Air and Precipitation at Los Alamos, New Mexico, for 1966."[51]

"Beta Radioactivity in Environmental Air and Precipitation at Los Alamos, New Mexico, for 1967."[52]

"Beta Radioactivity in Environmental Air and Precipitation at Los Alamos, New Mexico, for 1968."[53]

"Beta Radioactivity in Environmental Air and Precipitation at Los Alamos, New Mexico, for 1969."[54]

"Beta Radioactivity in Environmental Air and Precipitation at Los Alamos, New Mexico, for 1970."[55]

In 1962, a study on "Plants As Monitors of Radioactive Contamination of the Environment of Los Alamos, New Mexico,"[56] was published.

The "Los Alamos Environmental Monitoring Program,"[57] published in 1970, gives an outline of

"the surveillance methods used throughout Los Alamos County and outside restricted areas to determine the effect of Laboratory operations on the environmental radioactivity. Gamma radiation measurements are routinely made. Scheduled samples of air and water are taken, assayed for gross alpha and beta activity, and also for certain specific nuclides which may be present in some concentration. Soil samples are taken when considered necessary."[57]

Beginning in 1970 there is a series of reports which give the data outlined above:

"Los Alamos Environmental Monitoring Program, July through December, 1970,"[58]

"Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, January through June, 1971."[59]

"Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, July through December, 1971."[60]

"Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, Calendar Year 1972."[61]

"Environmental Surveillance at Los Alamos during 1973."[62]

"Environmental Surveillance at Los Alamos during 1974."[63]

"Environmental Surveillance at Los Alamos during 1975."[271]

See Fig. 9 for thermoluminescent dosimeter (TLD) and air sampler locations, Fig. 10 for regional surface water, sediment and soil sampling locations; Fig. 11 for water sampling locations in White Rock Canyon of the Rio Grande; and Fig. 12 for water, sediment, and soil sampling locations on or near the LASL site.

Specific studies done in recent years are:

"Regional Survey of Tritium in Surface and Ground Water in the Los Alamos Area, New Mexico, August 1966 through May 1969."[64]

"Plutonium in Stream Channel Alluvium in the Los Alamos Area, New Mexico."[65]

"Plutonium and Strontium in Soil in the Los Alamos, Espanola, and Santa Fe, New Mexico, Areas."[66]

"Plutonium and Strontium in Soil Near Technical Area 21, Los Alamos Scientific Laboratory, Los Alamos, New Mexico,"[67] "Los Alamos Land Areas Environmental Radiation Survey 1972."[68]

"Ecological Investigation of Radioactive Materials in Waste Discharge Areas at Los Alamos for the Period July 1, 1972 through March 31, 1973."[272]

"Dispersion and Movement of Tritium in a Shallow Aquifer in Mortandad Canyon at the Los Alamos Scientific Laboratory,"[69]

"Storm Runoff and Transport of Radionuclides in DP Canyon, Los Alamos County, New Mexico,"[70]

"The Distribution of Plutonium in Liquid Waste Disposal Areas at Los Alamos."[273]

"Distribution of Plutonium in Soil Particle Size Fractions of Liquid Effluent-Receiving Areas at Los Alamos."[274]

"The Distribution of Plutonium and Cesium in Alluvial Soils of the Los Alamos Environ."[275]

"Cesium-137 and Plutonium in Liquid Waste Disposal Areas at Los Alamos."[276]

"Accumulation and Transport of Soil Plutonium in Liquid Waste Discharge Areas at Los Alamos."[277]

"The Availability of Environmental Radioactivity to Honey Bee Colonies at Los Alamos."[278]

A proposed plan for environmental monitoring of waste disposal areas was made by H-8, December 27, 1973.

"It is the intention of the Environmental Section to establish a routine environmental monitoring program around all waste burial or storage areas both active and inactive....

From the standpoint of environmental surveillance we would like to document any current release or dispersion of contaminants from the disposal areas whether by atmospheric dispersion or by hydrologic transport. In consideration of the local ecology we would like to determine whether or not the buried materials have any effect on revegetation programs or ecological succession over completed waste pits; this would be in contrast to the normal disruption of the areas resulting from physical disturbance and operation of heavy equipment. Finally, for the waste management studies we would like to provide data which could be used to evaluate the longer range probabilities of migration of materials from the disposal site.

For the evaluation of atmospheric dispersion from active waste pits, we plan to install high volume air samplers to be operated on limited duty cycles only during pit filling operations.... From these air samplers we would like to obtain data on general dust loadings of the atmospheric (sic) *resulting from waste burial operations in addition to the identification of any releases of radioactive or chemical contaminants from the burial operations.*

The monitoring of dispersion into the tuff or the migration of moisture through the filled pit and the surrounding tuff would be by means of sampling tubes extending from the surface to the level of the bottom of the pit or lower in an array around each pit.... We would intend to measure soil moisture profiles through these access tubes by means of a neutron moisture gauge. We would also sample any moisture that might be found in the sampling tubes as well as collecting core samples of the tuff at the bottoms of the access tubes.

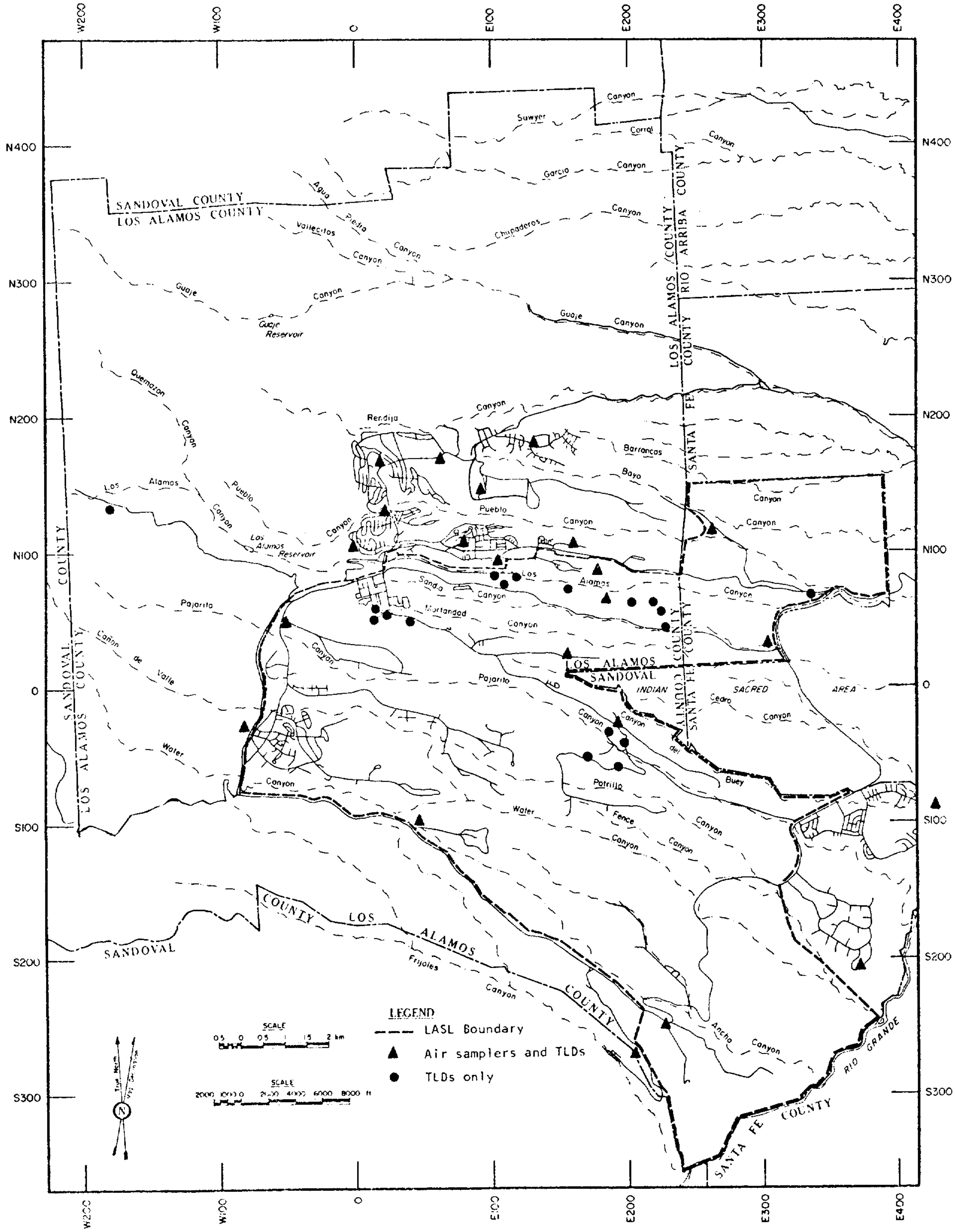


Fig. 9.
TLD and air sampler locations.

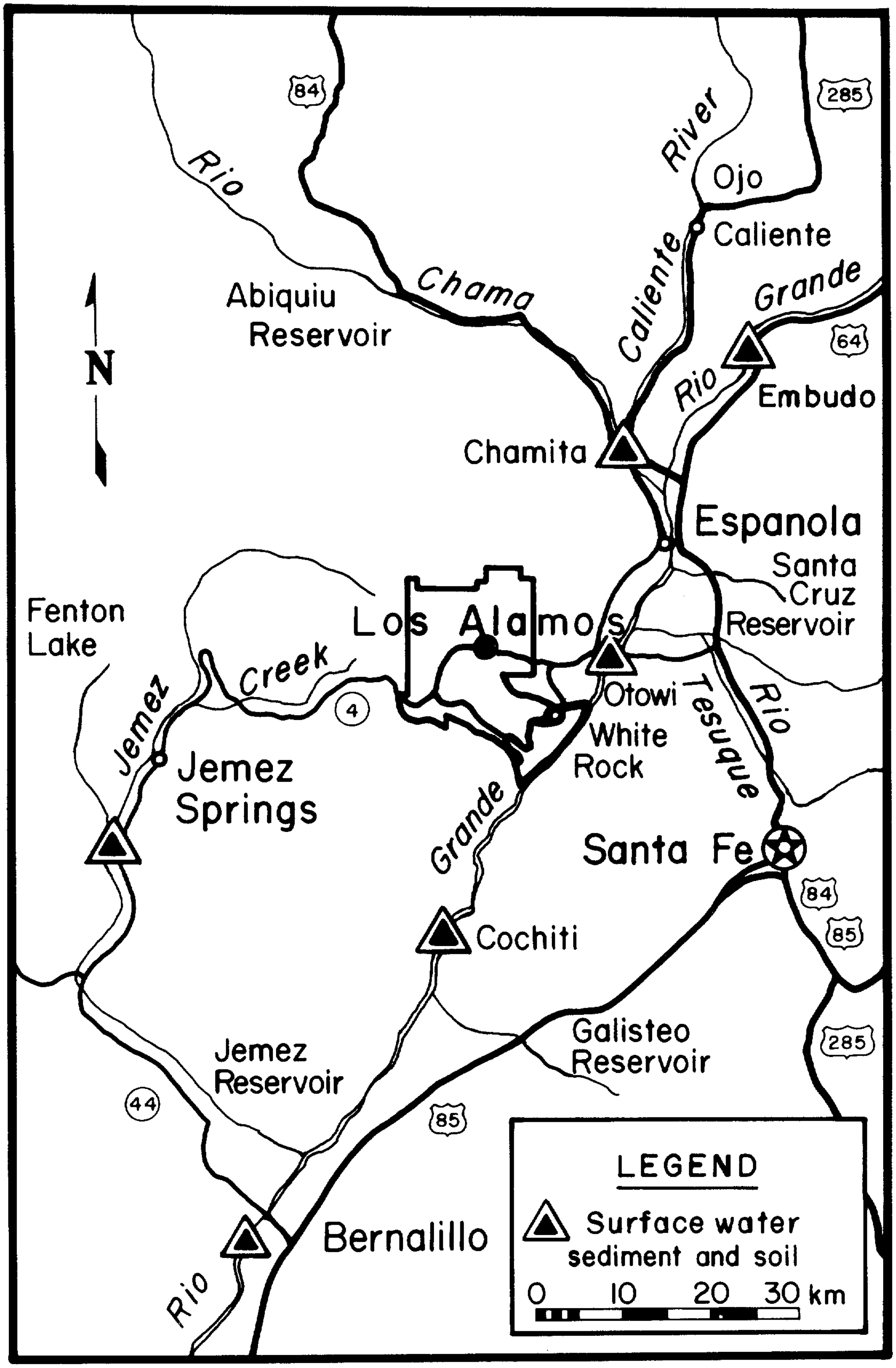


Fig. 10.
Regional surface water, sediment and soil sampling locations.

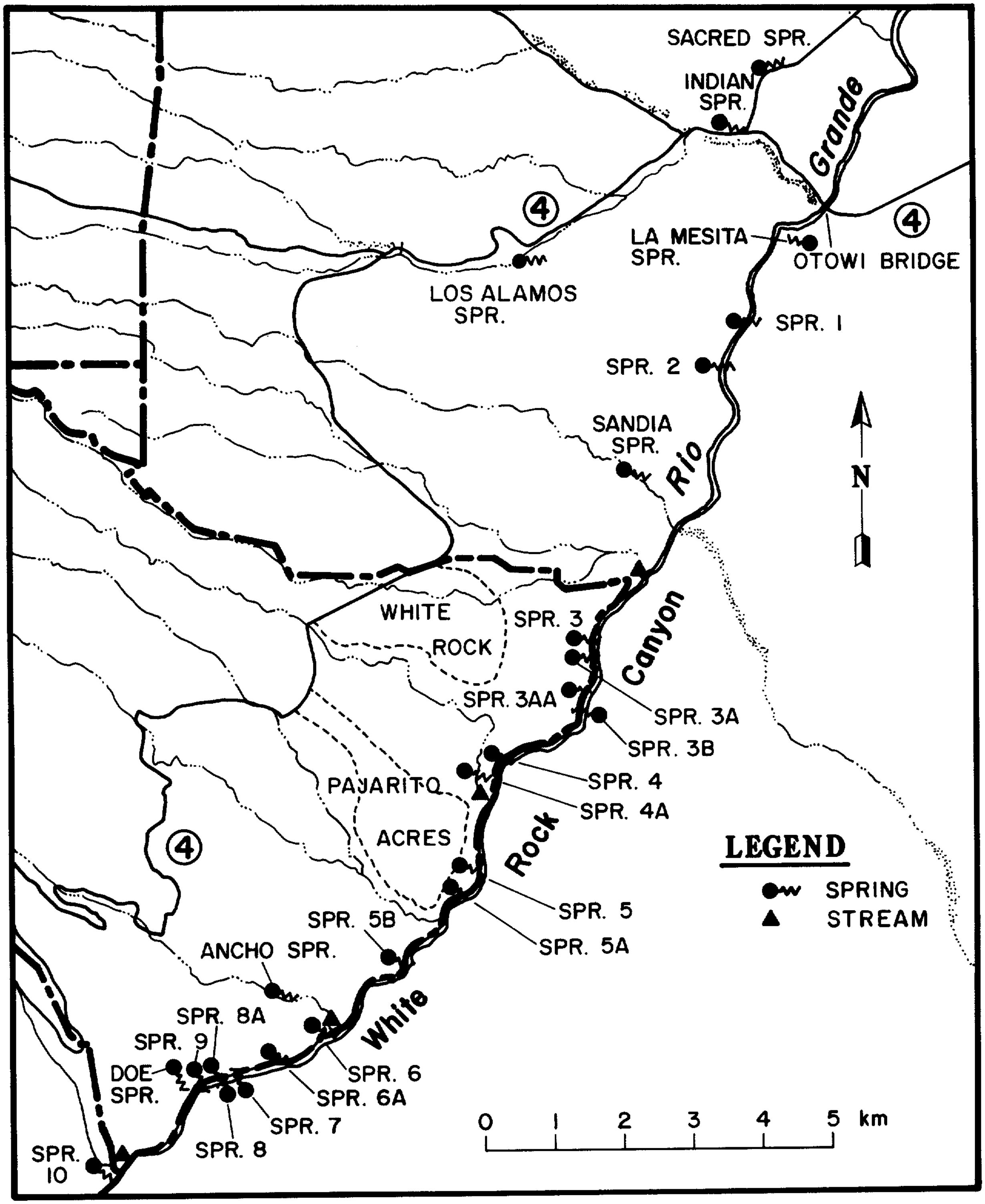


Fig. 11.
Water sampling locations in White Rock Canyon of the Rio Grande.

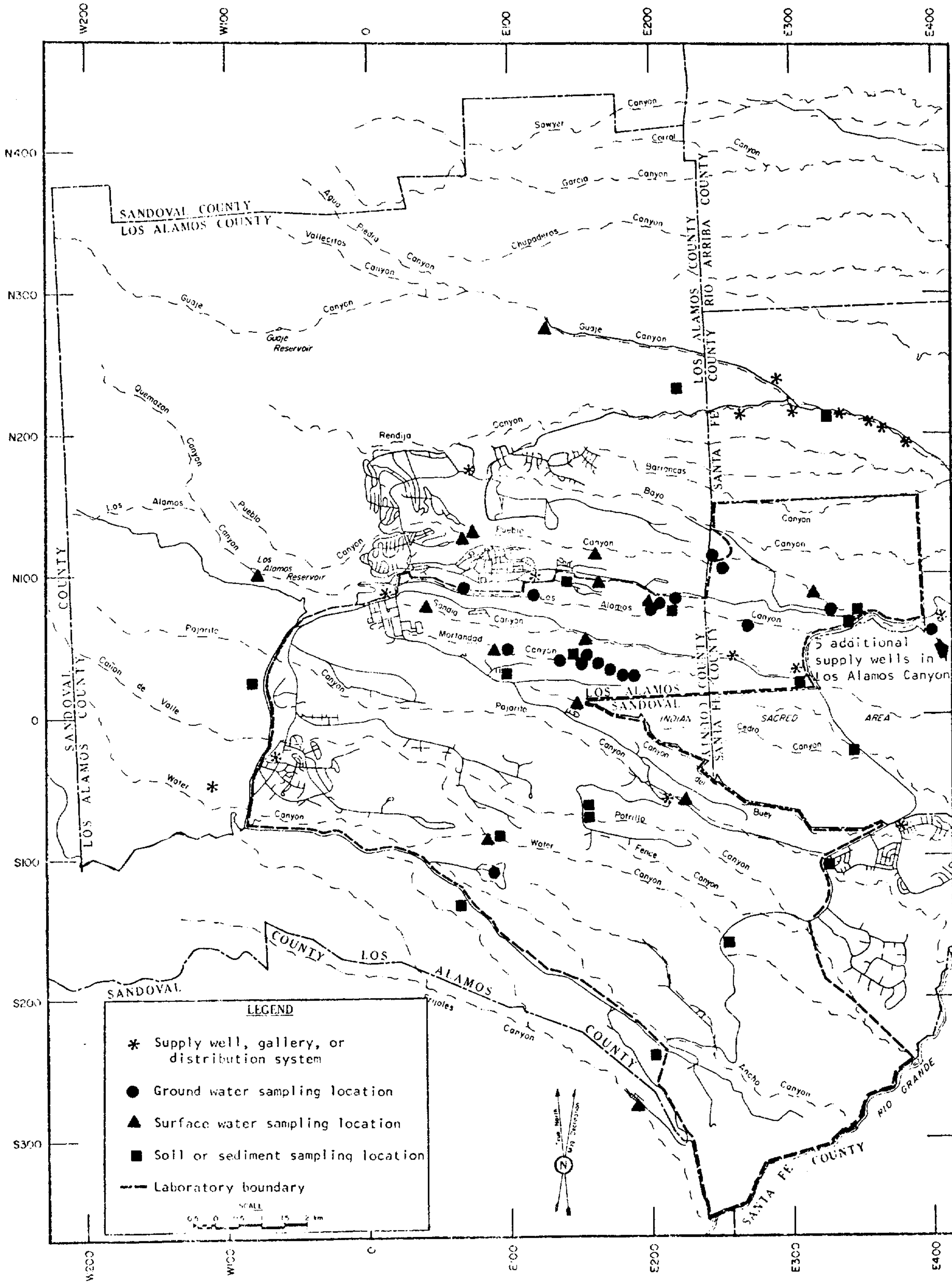


Fig. 12.
Water, sediment, and soil sampling locations on or near the LASL site.

An additional effort should be undertaken...to determine the moisture balance at or near the surface of filled pits. This would include meteorological data on precipitation (both total amounts and precipitation rates) and on evaporation rates in order to determine the net moisture budget of the fill material in the pit...

Sampling of vegetation over completed disposal pits will be undertaken to determine whether or not any of the contaminants buried in the pit have migrated to the surface and are being absorbed by plant tissues."[71]

AREA A

I. GENERAL INFORMATION

Area A is located in TA-21, a quarter of a mile east of the intersection of DP Road and the north perimeter road of TA-21. Specifically it is centered on LASL coordinate* E. 165+00 between coordinates N. 85+00 and N. 87+50 (see Fig. A-1), and coordinates E. 167+50 and E. 162+50. Surveyed corners in clockwise direction beginning with the northwest corner are: N. 86+58, E. 167+18; N. 85+14, E. 166+88; N. 85+42, E. 165+35; N. 85+78, E. 164+88; N. 86+00, E. 163+80; N. 86+13, E. 163+11; N. 86+33, E. 162+91; N. 87+34, E. 163+07 and N. 87+16, E. 164+04. It can also be located by township and range: SE 1/4 sec. 14, T. 19 N., R. 6 E.[30] Total area is 5058.6 m^2 (1.25 acres).

The history of Area A consists of two stages. The first involves the construction and use of pits and storage tanks between 1944 and 1947. and the second involves the construction and use of a pit between April 1969 and present (July 1976).

II. GEOLOGY AND HYDROLOGY

Area A is located on a narrow eastward-trending mesa which is part of the Pajarito Plateau. The land surface slopes north about a hundred yards and then breaks into steep bench and slope topography down to the channel of DP Canyon. The channel is approximately thirty and a half meters (a hundred feet) below the top of the mesa.

All excavations in Area A were made in Unit 3 of the Tshirege Member of the Bandelier Tuff. Unit 3 is approximately 36.6 m (120 ft)[183] thick in this locale. The lower part of the unit consists of a nonwelded tuff which grades upward into the moderately welded tuff of the upper parts.[183] It is unlikely that any excavation cuts through the upper part of Unit 3. Soil cover ranges from 0.6 to 1.5 m (2 to 5 ft) in thickness.[183]

"The attitude of most of the major joints is near vertical to vertical ranging from 70 to 90 degrees measured from the horizontal. Some of the joints were slightly curved, open in places and closed in others. All of the joints were filled with dark brown clay beneath the soil zone while at depth were filled or plated with dark-brown or gray clay.

The orientation and distribution of the major joints in the horizontal plane of the north and south walls of the pit are shown on a rose diagram (Fig. A-2). Three point sets occur true north to N 10° W, N 40°E to N 60°E and N 80°E. Though all the joint sets do not intersect at 60 degrees as they would if formed in a homogeneous liquid as it cooled, the predominance of the three joint sets and near vertical attitude of the joints suggest that the joints formed as the ash flow tuff of Unit 3 cooled after emplacement."[183]

Surface drainage of Area A is north into DP Canyon. There are approximately 350.5 m (1150 ft) between the top of the mesa at Area A and the top of the zone of saturation (water table) in the Puye Formation.[183] The Bandelier Tuff is estimated to be 243.8 m (800 ft) thick in this locality and is thought to to contain no perched water.[183]

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*LASL coordinates are the original Manhattan Engineering Project grid system.

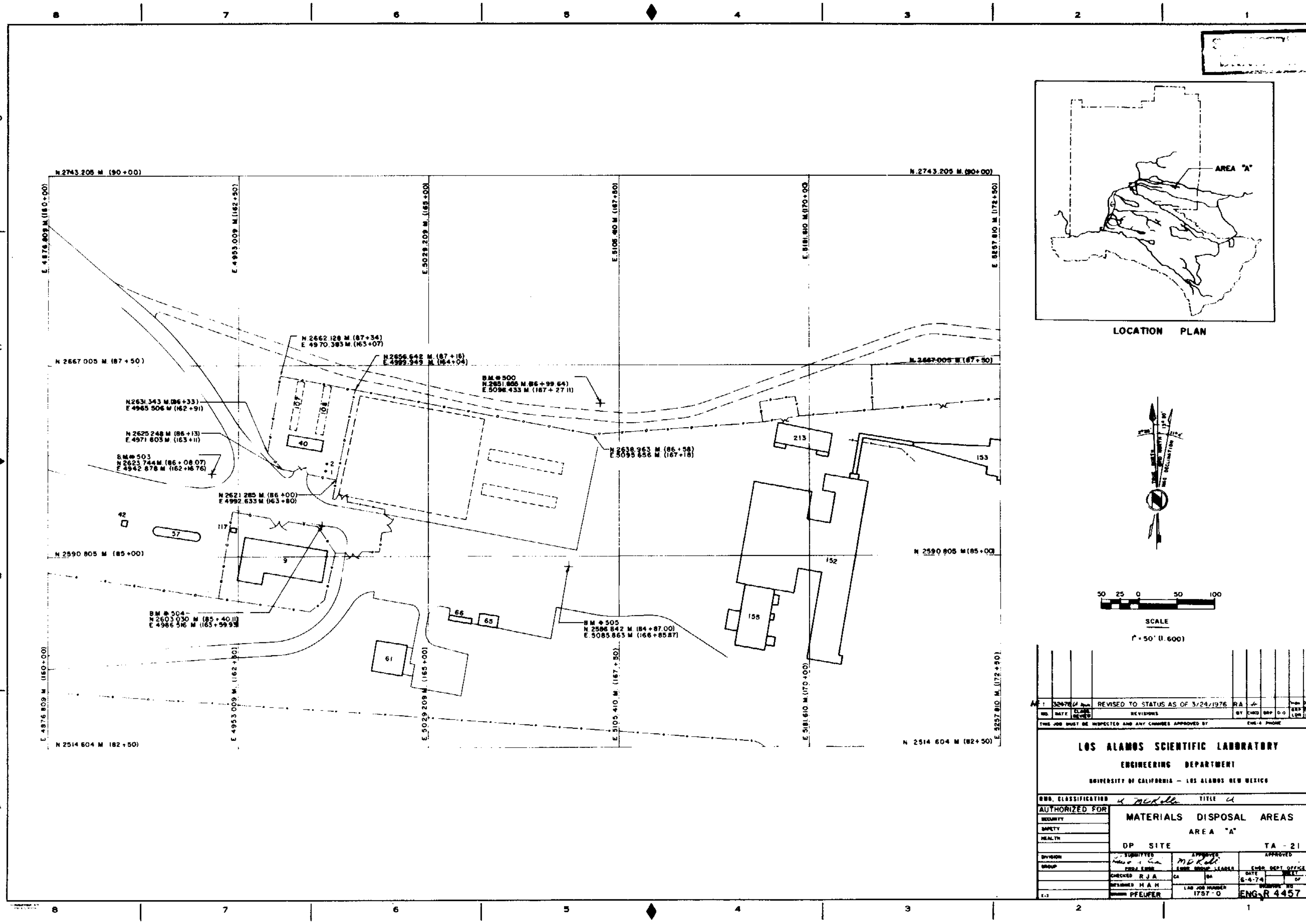


Fig. A-1.
Materials Disposal Area A, DP Site, TA-21.

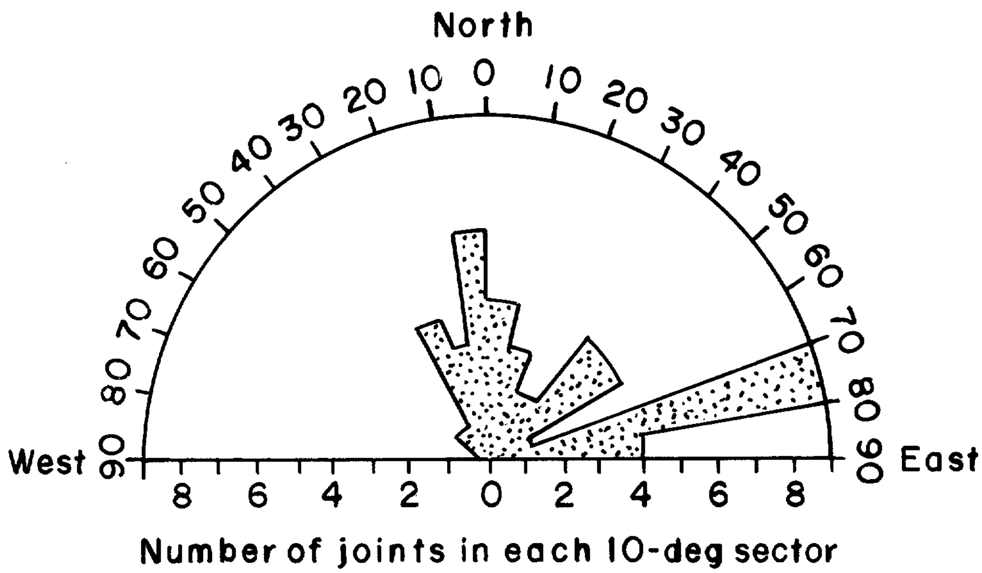


Fig. A-2.
Orientation of joints in north and south walls of 1969 pit.

III. PIT AND STORAGE TANK DESCRIPTIONS

Early Stage (1944 to 1947)

A. Background.

The early pits were dug in the eastern part of the area in late 1944 or early 1945. From a memo[184] dated July 5, 1945:

> *"The pits at DP Site are currently being filled at such a rate that they will be filled to capacity by the early part of August. This rate is far greater than was anticipated when* [the pits were] *requested last December, and because of the construction in this area there is no room for further pits to be dug. Nor, for that matter, is it desirable to dig any more pits anywhere in the DP area because of the dust problems that would be created."*[184]

The early pits were closed by July 1946.[185]

In the western part of the area are the two storage tanks built in 1945 which are called the "General's Tanks" after General Leslie R. Groves. They are identified as TA-21-107 and TA-21-108. The last time liquids were added to one of them was 1946.[186]

> *"In March of 1974, an SOP was written... to cover the excavation of an area over each of the two General's tanks and the transfer of the waste contained therein. The excavation was completed in 1974 and the first volumes of waste (40,000 liters) were transferred to TA-21-257, June 19, 1975. The treatment of this waste began the second half of CY1975..."*[187]

B. Type of Waste.

The early pits in the eastern end of Area A are thought to contain solid wastes with alpha contamination accompanied by slight amounts of beta and gamma.[188,189] The principal alpha contamination is said to be either long-life[189] or polonium[185] (short-life) with the possibility of trace amounts of ^{239}Pu (long-life).[185] The estimated volume of buried material is 1019.5 m^3 (4000 yd^3).[186]

The General's Tanks, in the western end of the area, contain liquid wastes as recorded in L.A. Notebooks 1595 and 1766.

> *"Champion's records which were made at the time solutions were transferred into the tanks, on the basis of radioassay (total alpha) of the individual trailer tank loads, showed a total of 334 grams* into the two tanks."*[173]

Records were kept to the nearest 0.01 g.[190] In 1950 or 1951 a corroborative sample from each tank was taken.

> *"...the results were in good enough agreement with the above so that no corrections were thought to be necessary. So far as* [is known], *no records of this sampling are still in existence, but...the NaOH supernatant tank had about 180 grams in 50,000 gallons, and the NH_4OH tank had about 160 grams in 35,000 gallons."*[190]

Another reference[30] states that the tanks were checked in the early 1950s and estimated to contain 160 to 1000 g of plutonium. In 1973 an estimate of the amount of radioactivity was

> *"an equivalent amount of about 230 grams of ^{239}Pu (about one-third of which is ^{241}Am)... Furthermore, only 0.7% of the radioactivity is in solution so that any leakage would have probably stayed very close to the tanks."*[186]

The volume is 151 424 ℓ (40 000 gal) in one tank and 34 070 ℓ (9000 gal) in the other.[186]

> *"In response to* [a] *phone conversation March 2, 1976, ... the following additional information concerning the liquid waste stored in the "General's Tanks" (DPW-107 and DPW-108), Area A, TA-21* [is available]:
>
> *I. The radioactivity data for the 40,000 liters of waste already transferred* [June 19, 1975] *from the west tank (DPW-107) Area A to TA-21-257 (Ref. Memo H7-76-PEM-86, page 2* [Ref. 187]) *were as follows:*

Gross α	1.7×10^6 d/m−ℓ
^{238}Pu	1.6×10^5 d/m-ℓ (4.1×10^{-6} mg/ℓ)
^{239}Pu	1.7×10^6 d/m-ℓ (1.25×10^{-2} mg/ℓ)
^{241}Am	1.2×10^4 d/m-ℓ (1.67×10^{-6} mg/ℓ)

> *In addition to the radionuclide content, the following NO_3-Nitrogen levels were determined:*

NO_3 as N	5.99×10^3 mg/ℓ

> *Using this data, the following totals are estimated for the entire 185,000 liters of General's Tanks Waste and compared to both the totals estimated in the Fall of 1973 (Ref. 10/30/73 G. L. Voelz Memo to E. E. Wingfield —* AEC/LAAO [Ref. 186]), *and the totals projected from analyses of a grab sample taken 10/19/73.*

---

*Author's note: Considered to be 334 g of ^{239}Pu by D. D. Meyer, personal communication, 1974.

II. Total Radioactivity and Nitrates in 186,000 liters estimated from grab sample analysis of 40,000 liters transferred from DPW-107 to DPW-257, June 1975.

A. Total Equiv ^{239}Pu (^{238}Pu, ^{239}Pu and ^{241}Am analyses)	*2.5 g*
B. ^{241}Am portion expressed as ^{239}Pu	*0.0 g*
C. Nitrate as Nitrogen (5.99×10^3 mg/ℓ)	*1.1×10^6 g*

III. Total Radioactivity and Nitrates Estimated and Reported in 1973 Memo (Voelz)

A. Total Equiv. ^{239}Pu	*230 g*
B. ^{241}Am portion expressed as ^{239}Pu	*77 g*
C. Nitrate as Nitrogen (2.9×10^4 mg/ℓ)	*5.4×10^6 g*

Note: Voelz memo states the Nitrate level 130,000 mg/ℓ as nitrates. Converting this to Nitrates as nitrogen yields the 2.9×10^4 mg/ℓ indicated above.

IV. Total Radioactivity based on grab sample analysis 10/19/73

		East DPW-108 (34,000 ℓ)	West DPW-107 (151,000 ℓ)
A.	Total Equiv. ^{239}Pu (based on gross α)	0.8 g	93 g
B.	^{241}Am portion expressed as ^{239}Pu	0.3 g	55 g
C.	Nitrate as Nitrogen	(3.45×10^4 mg/ℓ)= 1.1×10^6 g	(6.59×10^3 mg/ℓ)= 1.0×10^6 g

V. As you can see, the correlation between 1975 analysis and 1973 estimates is not too good.

"In conversation with C. W. Christenson, the difference between 1973 grab sample analysis and the 1973 memo were (sic) explained. Apparently C. W. and Voelz felt the safest approach was to use data from the General's Tanks Notebooks and data from sample analysis to determine the maximum amount of radioisotopes and nitrates possibly contained in DPW-107 and 108."[191]

C. Mode of Disposal.

Four pits are shown in the eastern end of Area A on Engineering Drawing ENG-1266. An arrow pointing to them has the note: "Scaled from W. C. Kruger map 'Special Sewers DP Site Construction Sheet O Outside Services 4,' 8-22-45." The pits are depicted as 38 m (125 ft) long by 5.5 m (18 ft) wide with rounded corners. Probably a more accurate depiction of the pits is on ENG-C 2076 (Fig. A-3). On this drawing there are two pits which are rectangular. The pits are in an area of 4007 m² (0.99 acres).

"At the present time [June 1949] *the solid contaminated wastes are buried. Since the start of the project we have filled six pits. Three of these are located between the trailer camp and the CMR laundry, two on the tank area near DP East* [1976 designation is materials disposal Area A] *and one*

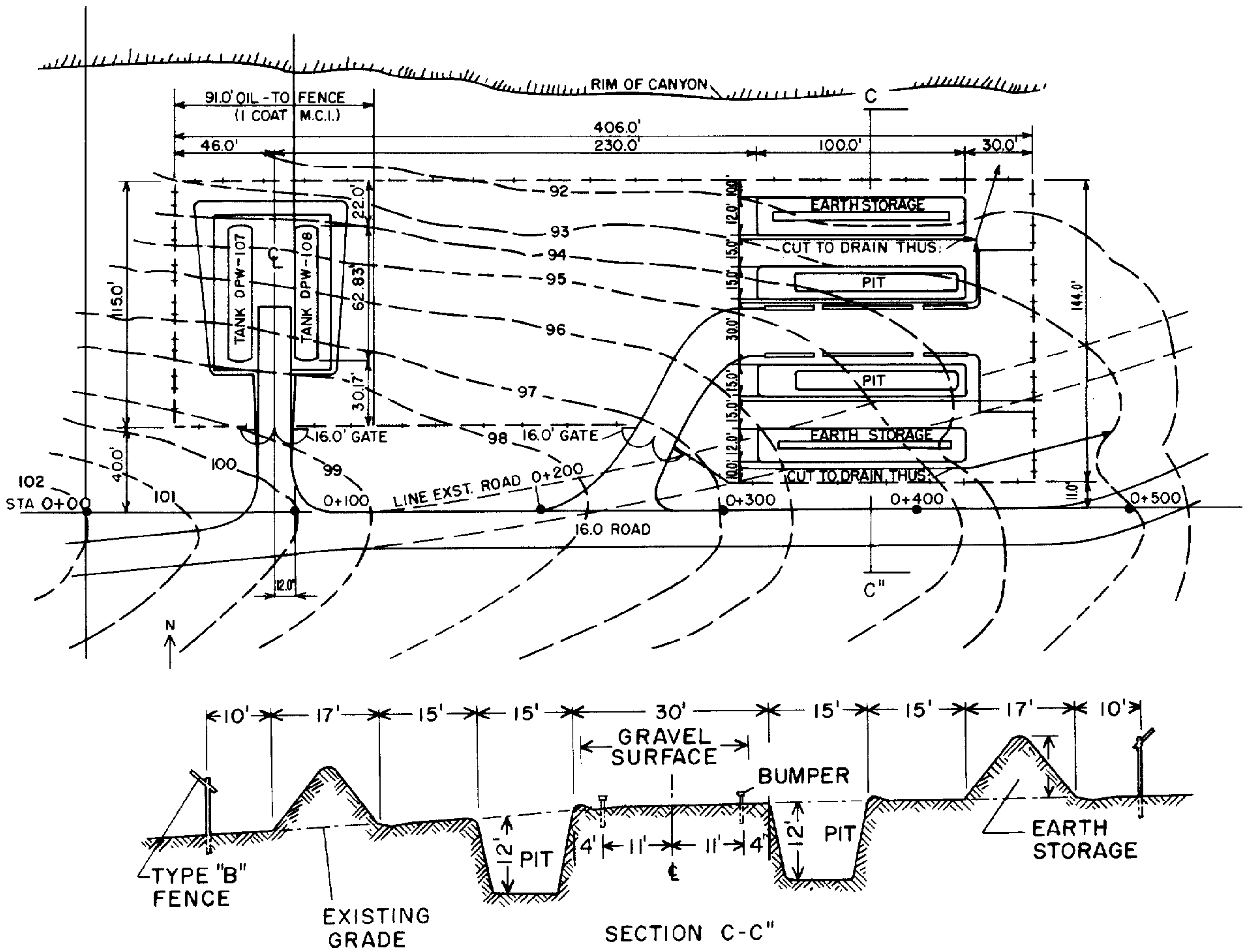


Fig. A-3.
Construction plan for Area A, January 24, 1945.

at the Alpha Site Dump [1976 designation is materials disposal Area C]. *The present dump* [Area C] *has been in use for one year and during that time we have filled one pit."*[188]

Author's note: 1976 designation for the 3-pit location is Materials Disposal Area B; for the CMR laundry is Materials Disposal Area V.

The previous quotation implies (1) Area A was not in use June 14, 1949, and (2) only two pits were excavated. Another reference to only two pits was *"The excavated tuff was piled over two sealed disposal pits (LASL ENG. Drawing 6260)."*[183]

The General's Tanks, TA-21-107 and TA-21-108, are two 189 280 (50 000 gal) cylindrical steel storage tanks. The following description of the construction of the tanks is taken from Engineering Drawing ENG-C 2076.

The tanks are 3.7 m (12 ft) in diameter and 19.1 m (62 ft 10 in.) long. They were placed 6.1 m (20 ft) apart in pits 3.7 m (12 ft) deep, 4.6 m (15 ft) wide, and probably 21.0 m (86 ft 10 in.) long on four concrete piers. Each pier was 1.5 m (4 ft 10 in.) high with the bottom 0.6 m (2 ft) below the bottom of the pit. Each tank rested on the piers 0.3 m (1 ft) above the bottom of the pit. Sand was placed in the bottom of the pit up to the top of the piers — a depth of 0.5 m (1 ft 10 in.). Thoroughly packed earth filled the area between the tank and most of the rest of the pit. Directly above the tanks loose earth fill was specified. A concrete slab 20.3 cm (8 in.) thick, 17.1 m (56 ft) wide and 21.0 m (68 ft 10 in.) long was poured 0.5 m (1.5 ft) above the tanks. Approximately 1.5 m (5 ft) of earth fill was placed above the concrete slab. This final earth fill formed a mound 0.7-1.8 m (2.25-5.75 ft) above grade. On the north end of each tank a vent extended 4.6 m (15 ft) above the mound. On the south end of each tank the fill pipe is enclosed in a concrete box with outside dimensions 0.9 m (2 ft 10 in.) high, 0.9 m (2 ft 10 in.) wide, and 1.3 m (4 ft 4 in.) long. The box extended 0.3 m (1 ft) above the mound.

"Disposition of the 185,000 liters of General's Tanks Waste

A. On June 19, 1975 40,000 liters from the west tank were transferred to TA-21-257. Shortly afterwards, the entire contents of the east tank (~34,000 liters) were transferred to the west tank. This action was taken to permit immediate utilization of the east tank for disposal of non-retrievable cement paste generated at TA-21-257.

B. The total 40,000 liters transferred to Bldg. 257 have been treated in the waste treatment facility at Bldg. 257 (TA-21-257) and Group H-7 is waiting for approval from Group H-8 to treat the remaining 145,000 liters of General's Tanks waste. Due to the inability of the Treatment facility at Bldg. 257 to significantly remove nitrates from influent waste, a large portion of the nitrates in the 40,000 liters treated was discharged to the canyon in the plant effluent. H-8 is presently conducting a ground water environmental impact study on these nitrates.

C. Group H-7 is anticipating chemical treatment of the remaining General's Tanks waste following H-8 approval and initiation of non-retrievable cement paste disposal in the empty General's Tank before July 1, 1976."[191]

"...In conjunction with these plans, two 4' dia. shafts were excavated in Area A December 3, 1975. The depths of these shafts are 65'1" and 64'10", and are located in the southeast corner of [the tank site of] *Area A. These shafts will be used to retain the transfer hose rinse water for clarification. After 24-48 hours the supernatant will be pumped to the influent holding tanks at Bldg. 257."*[187]

Late Stage (1969 to 1976)

A. Background.

In April 1969[183] a large pit was dug between the older pits to the east and the storage tanks to the west. A request[192] for the expansion of this pit, dated November 9, 1972, was met by steepening the slopes of the existing pit (J. L. Desilets, ENG-14, personal communication, 1974). As of January 1976,[193] the pit is about 3/4 filled with about 1/2 of it backfilled to ground level.

B. Type of Waste.

This latest and largest pit, located in the center of the area, contains building debris from demolition work at TA-21. This building debris is contaminated by ^{239}Pu, ^{238}Pu, ^{235}U, and depleted uranium along with decay products and other radioactive isotopes which are found with these materials (D. D. Meyer, personal communication, 1974). The first layer of waste was buried by June 30, 1969.[183] January 4, 1971,[185] the volume of debris in the pit was given as 2166 m^3 (8500 yds^3. The pit was not used from January 1, 1972 through June 30, 1972.[194] After it was enlarged in late 1972 or early 1973, debris from the demolition of TA-21-12 was placed in it. At present (July 1976) debris from TA-21 clean-up operations continues to be placed in it.

C. Mode of Disposal.

This pit had proposed dimensions of 45.7 m (150 ft) long by 15.2 m (50 ft) wide by 9.1 m (30 ft) deep (ref: LASL Engineering Drawing ENG-SK 6250. January 1969). The pit described in 1969[183] may have been 45.7 m × 12.2 m × 6.7 m (150 ft × 40 ft × 22 ft).

"The pit was excavated in a near east-west direction leaving steep ramps on each end (see Fig. A-4). The excavated tuff was piled over two sealed solid disposal pits (see LASL ENG Drawing 6250). An access road to the bottom of the pit was cut along the south wall. Parts of the north and south walls are nearly vertical with the remainder sloping at about 1 to 5. The walls at present are stable, though several small blocks were dislodged during construction."[183] (See Figs. A-4 and A-5).

November 9, 1972,[192] the pit was reported to be 12.2 m (40 ft) wide, and 6.7 m (22 ft) deep. Some time after November 9, 1972,[192] the original pit was enlarged. This enlargement may have provided the approximately 1529 m^3 (6000 yds^3) of additional burial space requested[192] for building materials from TA-21-12. The enlargement would have extended the surface dimensions of the original pit if that pit's dimensions were 45.7 m × 12.2 m × 6.7 m (150 ft × 40 ft × 22 ft) (D. D. Meyer and J. L. Desilets, personal communication, 1974). In March 1974, the existing pit could have been two-thirds full. It was placed on an engineering drawing for reference, May 1974. The drawing shows the pit to be 52.4 m (172 ft) by 40.8 m (134 ft).

IV. STUDIES AND MONITORING

The Environmental Studies Group, H-8, monitoring points in the vicinity of Area A are not designed to be Area A specific.

The General's Tanks were checked in the early 1950s for content;[30,190] the last sample was taken June 1952 (L. A. Emelity, H-7, personal communication, 1974). They were again checked in 1973.

"Although surveillance of these tanks has been, to say the least, minimal in the past, there has been no leakage determinable by our present information. The volume 40 000 gallons in one tank and 9 000 gallons in the other as well as chemical concentrations is comparable to the record data."[186]

In April 1974 four holes (depicted on Engineering Drawing ENG-21-31) were augered immediately east and west of the General's Tanks.

"The holes were augered to depths of 35 feet, using a truck mounted auger. Composite samples were collected at intervals of 5 feet, and double-bagged in plastic. The samples were submitted to H-8 Analytical Chemistry Section for gross alpha and gross beta determinations [see Table A-1].

The tanks contained liquid waste contaminated with both plutonium and americium. Analysis of the west tank contents by H-7 staff indicated concentrations as follows:

Gross-α	*1.7 × 10⁶ d/m/liter*
^{238}Pu	1.6 × *10⁵ d/m/liter*
^{239}*Pu*	*1.7 × 10⁶ d/m/liter*
^{241}*Am*	*1.2 × 10⁴ d/m/liter*

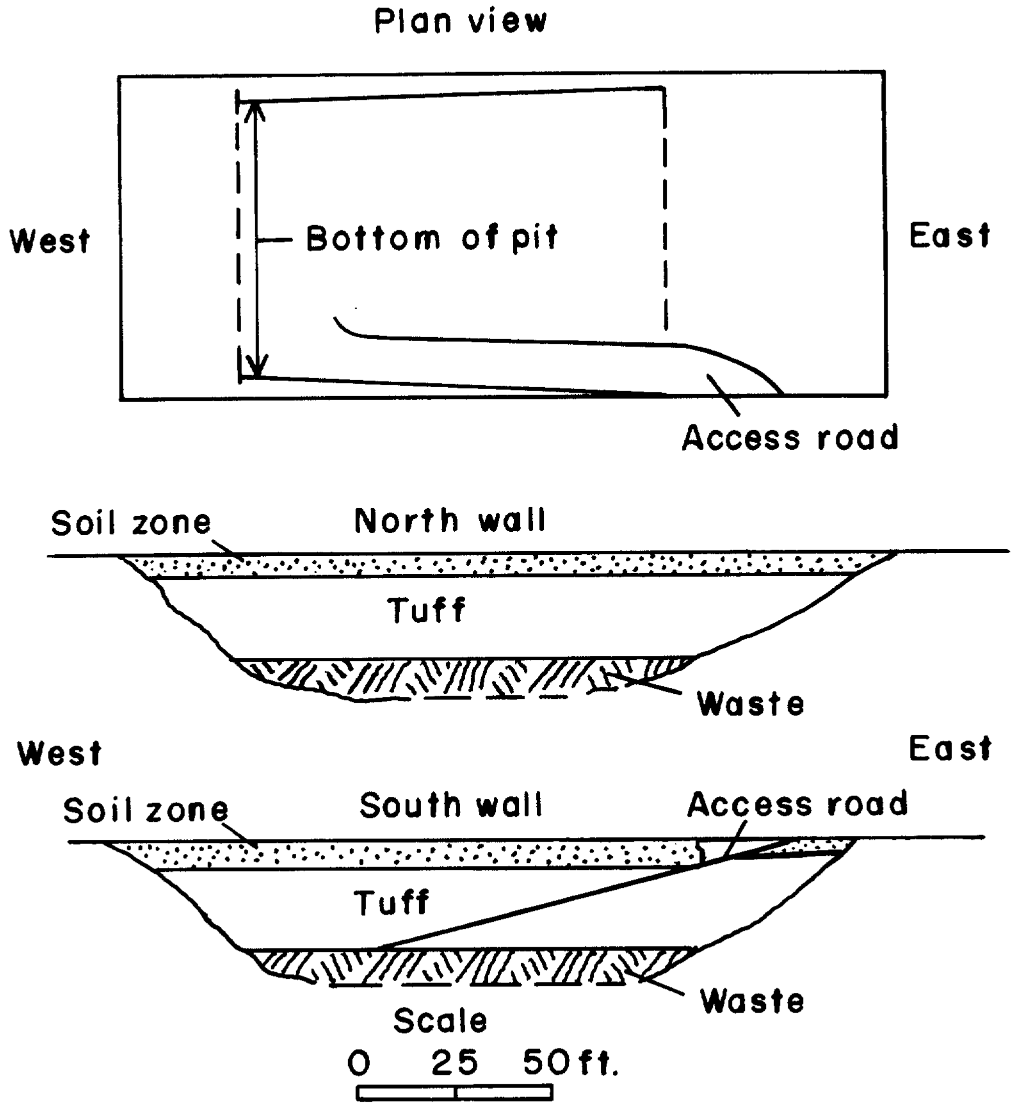
Analysis of the samples as indicated in [Table A-I] *indicates that reported gross-alpha content is in the range of 0.8 to 2.3 pCi/gm, and gross beta contents in the range of 0.8 to 3.2 pCi/gm. The minimum detection limits for these variables in 1974 were 1 pCi/gm respectively, indicating that many of the values reported are at or below such limits. Further analysis of regional soil samples, as reported in the 1974 Environmental Surveillance Report (LA-5977-PR) indicates that off-site soil materials average 1.0 pCi/gm gross-alpha, and 12 pCi/gm gross-beta. Thus, the samples collected at Area A are indistinguishable from these in areas affected only by atmospheric fallout. This is sufficient to conclude that the tuff sampled contained no contamination derived from the near-by storage tanks. By inference, no leakage of waste from the tanks has occurred into the surrounding*

TABLE A-1

BORING SAMPLE ANALYSIS

	Hole #1		Hole #2	
Depth ft	Gross-α pCi/g	Gross-β pCi/g	Gross-α pCi/g	Gross-β pCi/g
0 - 5	2.3	3.0	1.0	1.9
5 - 10	0.8	1.4	1.4	2.9
10 - 15	0.9	0.9	1.0	1.0
15 - 20	0.9	1.0	0.8	1.3
20 - 25	1.5	1.4	1.1	1.3
25 - 30	1.4	2.4	1.8	2.0
30 - 35	1,3	1,5	1,5	2,0

	Hole #3		Hole #4	
Depth ft	Gross-α pCi/g	Gross-β pCi/g	Gross-α pCi/g	Gross-β pCi/g
0 - 5	1.0	1.6	0.8	2.0
5 - 15	1.0	3.2	1.0	1.5
10 - 15	0.9	0.8	0.9	2.0
15 - 20	1.2	0.8	0.9	1.9
20 - 25	1.4	1.0	0.9	2.1
25 - 30	1.0	1.1	0.9	1.0
30 - 35	1.2	1.2	1.2	1.3



Purtymun, 1969

Fig. A-4.
Sketch of 1969 pit showing planview and north and south walls.

North Wall of Original Large Pit (Area A)

South Wall of Original Large Pit (Area A)

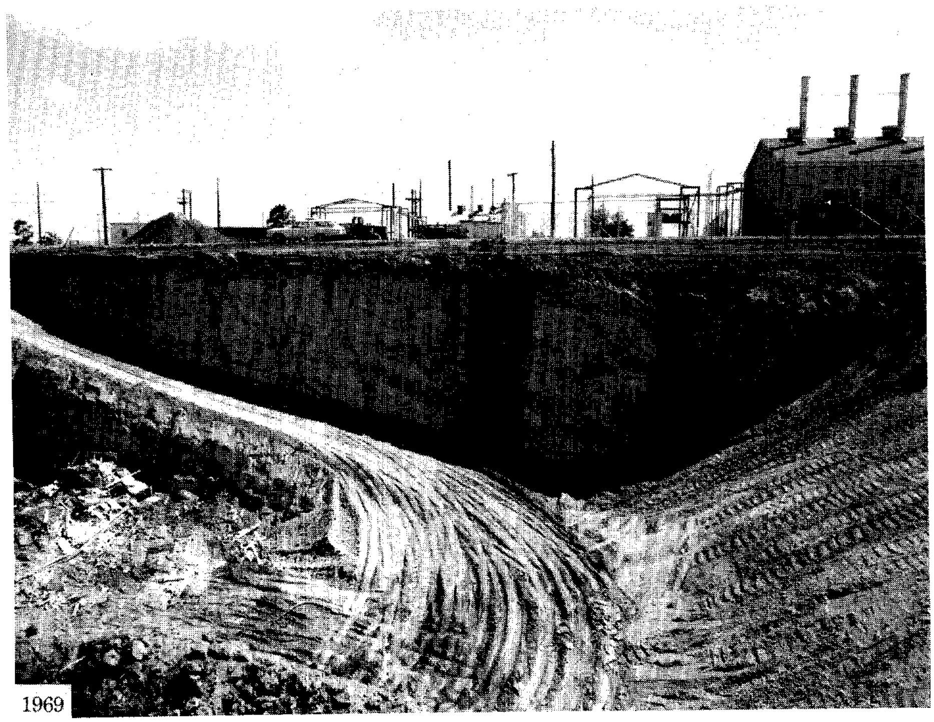


Fig. A-5.
North and south walls of original large pit at Area A showing soil zone, tuff and joints, first layer of waste, and access road.

AREA B

I. GENERAL INFORMATION

Area B is located on the south side of DP Road approximately 488 m (1600 ft) east of the intersection of DP Road and Trinity. It is east of the old trailer court area and west of TA-21 (see Fig. B-1). It is between LASL coordinates E.145+00, E.120+00, N.90+00, and N.95+00. Surveyed corners, clockwise from the northeast corner are N.91+92, E.143+35; N.90+72, E.142+96, N.93+90, E.134+08; N.92+45, E.123+06; N.91+00, E.123+14; N.91+08, E.122+35; N.93+64, E.122+38; and N.95+09, E.133+28. It can also be located by township and range — SE 1/4 sec. 15, T. 19 N., R. 6 E., and SW 1/4 sec. 14, T. 19 N., R. 6 E. Approximate acreage is 6.03.[196] The western two-thirds of Area B is presently covered by a layer of asphalt and is leased by Los Alamos County for storage of privately-owned boats and trailers.

Area B probably was the first common solid waste burial ground for LASL. It appears on Engineering Drawing ENG-R 4458 as one large pit; no individual pits are shown within the area. However, from old memos dated July 5, 1945 through January 31, 1952, it would appear that Area B is actually a series of pits. The July 5, 1945 memo[184] is a request for the provision of a new pit for disposal of contaminated trash from CM-Division laboratories.

> *"...suggest that a trench 15 ft wide and 300 ft long be bulldozed out as deep as practical before hard rock is encountered, starting just east of the now covered CM*[R] *disposal pits located SE of the coal storage yard, and running parallel to and about 40 or 50 ft north of the DP power lines. This trench should have a parking bumper along its north edge with a gravelled 20-ft clearing for truck access, and of course a fence surrounding the whole area.*
>
> *Such a trench in the suggested location would,... be a realistic solution to the contaminated trash disposal problem and would have the further advantage that it could be progressively filled and covered from the west end toward the east, and if necessary be extended for several hundred yards should the need arise."*[184]

By July 12, 1945,[197] the pit had been located, staked out, and a work order issued for completion by August 1, 1945. On July 30, 1945,[198] there was a request to extend the completion date for the new pit. The request asked, *"...that work on the new pit be continued until a 12' depth is reached, or until September first whichever is sooner."*[198] A pencilled note on this memo notes completion August 8th.

A January 10, 1947[199] memo states:

> *"The present contaminated materials disposal ditch is judged by the CMR Division maintenance engineer to be adequate for approximately three months from date. Past experience also indicates the necessity of starting the preparation of a new ditch of that size not less than a month before actual usage. It is therefore felt necessary to start digging about March 1.*
>
> *The present site is probably too small for expansion unless the south fence is moved closer to the canyon edge, or the east fence moved farther in that direction. Either of these moves would be a somewhat temporary expedient, and we suggest the assignment of a larger area permitting reasonable expansion. Perhaps east of the DP-East Site."*[199]

There are several notes on this memo. A typed note from H. R. Hoyt, Assistant Associate Director, sent this memo to the Maintenance Group on January 13, 1947, with the statement *"for necessary action."* A pencilled note dated February 5, 1947, says *"...will issue job order to enlarge ditch until some decision has been reached by the Director."* At the top of the January 10, 1947 memo is another pencilled notation indicating that someone could not decide whether the memo was discussing what is now called Area A or

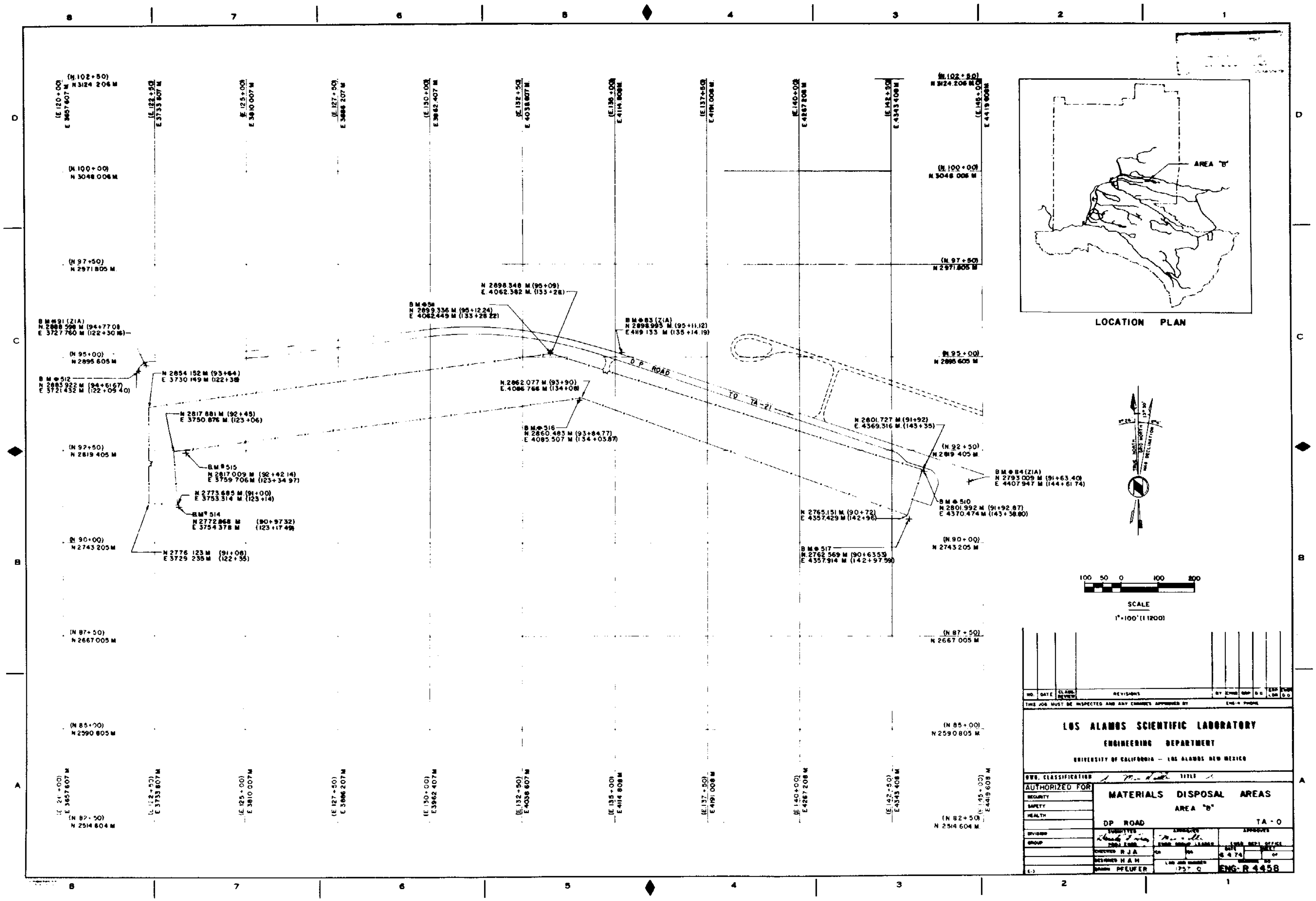


Fig. B-1.
Materials Disposal Area B, DP Road, TA-0.

Area B. (Area B is the pertinent area because the south fence of Area A would not have been near the canyon edge.) This memo is the first record of discussion to find a new location for the common burial ground; however, it was the May 3, 1948 fire in Area B which initiated construction of Area C.

II. GEOLOGY AND HYDROLOGY

Area B is located on the same narrow eastward trending mesa as Area A and T. The south side of Area B is approximately 30 m (100 ft) from a canyon tributary to Los Alamos Canyon. The Area B pits are probably cut in Unit 3a of the Tshirege Member of the Bandelier Tuff.

The thickness of the Bandelier Tuff beneath the disposal pits is estimated to exceed 243.8 m (800 ft).[200] The tuff is in the zone of aeration with the zone of saturation (water table) at a depth of approximately 365.8 m (1200 ft) below the surface of the mesa.[200]

III. PIT DESCRIPTIONS

A. Background

The question of how many pits and where they are located in Area B cannot be answered by available information. Area B may be the first Materials Waste Disposal Area at LASL.

> *"Letters in the CMR-12 files indicate that sometime in 1944 a pit located in the fenced area* [Area B] *between the Trailer Court and the CMR laundry* [Area V] *was in use. When this pit was filled two more were dug in the area now known as the General's Tank Area* [Area A]. *When these were filled (1945) three more pits were dug in the area between the Trailer Court and the CMR laundry. Space in this area was exhausted in 1948 and new pits were started at the present location* [Area C] *on Pajarito Road."*[201]

The 1944 *"pit located in the fenced area"*[201] could well be *"the now covered* [as of July 5, 1945] *CM Disposal pits located southeast of the coal storage yard."*[184] Three pits, constructed and filled after July 5, 1945, are referred to in memos dated June 14, 1949,[188] and January 31, 1952.[201] In a June 12, 1964 memo[202] Review of Preliminary Drawings: "Materials Disposal Areas" comment 6 states that

> *"There is a covered shallow trench in Area B (ENG-R 3641) which was used for disposal of hazardous materials. The trench was three feet in depth, two feet wide and about 40 feet long. It lies parallel to the south fence line E.140+00 and below line N.92+50. It extends about half the distance to E.142+50.*[202]

This *"shallow trench"*[202] lies in the extreme eastern end of Area B and therefore cannot be *the now covered CM disposal pits located southeast of the coal storage yard"*[184] which would have had to have been located in the extreme western end of Area B in order to have had 91.4 m (300 ft) long pits located to the east of them. It would thus seem that there are a minimum of five pits located in Area B.

> *"I am sure that the area contains six pits: two in the west end running north and south making the 'L' shape to the fence and four running east and west in the area parallel to DP Road. There was at least one small, shallow trench which was used by CMR-DO safety personnel to dispose of hazardous chemicals.* (Written communication, D. D. Meyer, Fall 1974).

B. Type of Waste

Solid waste placed in Area B was logged in LA Notebooks 1743 (January 6, 1947 through November 23, 1948) and 2587 (November 24, 1948 through April 28, 1950).[104] Opinions on the waste vary. January 30, 1952,[189] the waste was said to be predominately long-life alpha accompanied by slight amounts of beta and gamma. January 31, 1952,[201] the following was stated:

> *"The contamination on materials in these pits consists of all types of radioactive materials used at Los Alamos. Some of the known types of activity are: plutonium, polonium, uranium, americium, curium, RaLa* [radioactive lanthanum], *actinium, and waste products from the Water Boiler. No attempt has been made to keep the various materials separated."*[201]

January 4, 1971,[185] information was given that

> *"The total volume of the pits, after deducting the three foot of cover material, is 28,000 cubic yards. These pits actually contain very little Plutonium. At the time they were in use, Pu was scarce and only that which was present as contamination was buried.* [It is estimated] *that the entire pit area contains no more than 100 grams of ^{239}Pu."*[185]

Approximately 90% of the contaminated waste consisted of paper, rags, rubber gloves, glassware, and small metal apparatus placed in cardboard boxes by the waste originator and sealed with masking tape.[188] *"The rest of the material consists of metal such as airducts and large metal apparatus. This type of material is placed in wood boxes or is wrapped with paper."*[188] There is also reference to large quantities of wood from temporary storage cabinets used by the Quantity (sic) Control Department, several live storage batteries,[203] and contamined or toxic chemicals.[201]

C. Mode of Disposal

In the literature[200] and in conversation Area B is frequently referred to as a single pit with an approximate depth of 6.1 m (20 ft). Area B does not appear to be a single pit. Whether some of the pits in the area have a depth of 6.1 m (20 ft) is open to speculation. It could well be the 6.1 m (20 ft) is an estimate based on the average depth of most pits excavated in Areas C and G.

For reasons already stated, the depiction on Engineering Drawing ENG-R 4458 of Area B as one continuous pit is wrong. Consistent reference has been made through the years[188,201,185] to a series of pits in Area B. One might assume their construction to be similar to the 1945 Pit [4.6 m (15 ft) wide, 91.4 m (300 ft) long, and 3.7 m (12 ft) deep], with the exception of the hazardous materials pit which was described as a trench 0.6 m (2 ft) wide, 12.2 m (40 ft) long, and 0.9 m (3 ft) deep.

When Area B was in use, waste was handled in the following manner.

> *"The waste disposal program requires three men. Two of these work on the contaminated truck and are furnished by the Zia Company. The third man is a CMR-12 monitor. This monitor supervises the handling of material. Before loading he checks the boxes for external contamination and keeps records of any accountable property that is buried.*
>
> *The equipment used consists of a truck and a sedan. The material in the pits is covered once a week. This requires the use of a bulldozer and operator one day a week."*[188]

Unlike the current LASL practice of layering waste in pits, waste filled the depth and width of the pits in Area B before it was covered by fill dirt. As a result, subsidence occurred. Shortly after Area B was closed, subsidence over the pits was remedied by using the area for disposal of noncontaminated concrete and dirt from construction sites. (Written communication, D. D. Meyer, Fall 1974.)

IV. STUDIES AND MONITORING

A fire broke out in Area B at approximately 10:20 a.m., May 3, 1948.[203] When the fire department arrived,

"[they] *found sixty percent of the open portion of the dump ablaze and flames shooting approximately fifty feet into the air. The firemen had little trouble in subduing the blaze, but persistent efforts to put it out were of little avail because of the loaded condition of the dump area in which the blaze was confined. Dense, low-hanging smoke prevailed in large volume.*

At approximately 10:35 am, James Tribby was notified of the fire, in the absence of other Health Group personnel, and with representatives of the Safety Department went immediately to the scene of the blaze and took charge with Herbert Drager. Because of the dense smoke which scattered throughout the area, due to the condition of shifting winds, all areas east and west of the dump, from the food warehouses to the DP laundry, were evacuated of personnel. Respiratory protection was provided for all persons at the scene, and it was necessary to close the DP road to traffic."[203]

"*At 11:15 am, May 3, 1948, our monitoring section* [H-2] *drove to the DP contaminated dump section to assist the CMR group in surveying the extent of contamination, if any.*

General air count proved negative with a Pee Wee alpha survey meter ...

We later helped check personnel in and around the area including firemen and security guards. The grounds and vehicles in the area were also checked. All proved negative excepting one security car windshield which had about 50 c/m and one spot on the west fence had 200 c/m. The security car is believed contaminated from former contamination trouble or from accompanying a 'hot' run. The fence is believed contaminated from dust blown from the dump because it was localized in one spot only.

The smoke drifted west and close to the ground near the food storage plant corner of Trinity and DP road. The east wall was checked. No activity found.

It is believed there could not have been an air count present due to the absence of any deposit on local objects."[204]

"*By 12:15 pm, the fire had been extinguished except for two very small, isolated points and there was no longer any hazard from smoke. Fire department personnel were dismissed at 1:15 pm, but a stand-by crew of two men and one piece of apparatus were left until 5:30 pm to watch for rekindling of the fire.*

Investigation has failed to disclose any obvious cause for the blaze, and it is presumed that it started by spontaneous combustion. The area in which the blaze occurred had not had any trash dumped into it for about three days, and much of the trash in the fire area had been in the dump for three weeks. The trash included large quantities of wood from temporary storage cabinets used by the Quantity (sic) *Control Department, several 'live' storage batteries, large quantities of miscellaneous scrap metals, discarded contaminated clothing and boxes laundry waste. The conditions were ideally suited for spontaneous combustion.*

During the fire, there was some evidence that chemicals had been disposed of in the dump in an unauthorized manner in cardboard containers used for the regular disposal of common laboratory waste. Several cartons of waste gave off minor explosions, and upon one occasion a cloud of pink smoke arose from the debris in the dump. Whether this was due to the heat of the fire, the action of the water or chemical reaction is not known. The condition certainly did not help in keeping the fire under control.

This most recent dump fire should serve as an object lesson in many respects. It should point to the hazards of having the dump located in areas near or in line with living and working areas where toxic smokes and vapors can create an emergency condition. Even though we are presently short of dump space, it is poor policy to leave the dump uncovered for extended periods of time. If it is not practical to cover the trash with a light layer of dirt as a temporary measure before covering over any portion completely, it is suggested that the dump be wet down with large quantities of water at least twice a week until such a time as more adequate precautions can be taken."[203]

As a result of the fire, there were, no doubt, many other changes besides the relocation of the common burial ground.

The following is from a February 1963 USGS report. *"The highest concentration of gross alpha in soil samples collected in June 1955 a short distance downgradient in the canyon south of the pit* [Area B] *was 48 disintegrations per minute per dry gram."*[30] There is no map showing the precise location of the sampling point (which may have been closer to Area V than it was to Area B).

The USGS was asked to do a study of Area B in 1966.

"Expansion of laboratory facilities and increased growth of the community of Los Alamos has caused a re-evaluation of present land use to determine if the land is being utilized in the best possible way. It was proposed by the Los Alamos Scientific Laboratory and the U. S. Atomic Energy Commission that a portion of the filled-in contaminated waste pit, outside the radius of 1050 ft from TA-21 (an area approved for commercial property), be leveled, filled where necessary, and sealed with asphalt, and used for a storage area for trailers and boats. It is thought that a seal of asphalt will prevent any contamination from reaching the surface of the storage area."[200]

The USGS drilled test holes, 7.6 - 25.2 m (25-50 ft) deep, around the perimeter of Area B (see Fig. B-2). Moisture content of the soil and tuff penetrated by the test holes was determined by neutron scattering moisture probe. Samples of the drill cuttings were analyzed for gross alpha and gross beta-gamma, plutonium, and uranium. The results of the study were reported[200,77] in 1966 (see Table B-I). The study concluded

"Distribution of moisture in five test holes indicated some lateral movement of water, probably from the contaminated waste pit. The amount of water moving through the tuff was well below the estimated effective porosity of the tuff. Radiochemical analyses of the soil and tuff from the test holes showed no indication of radioactive contamination. A much larger amount of water than occurs from precipitation would be required to move radioactive contaminants from the waste pit into the adjacent soil and tuff. An asphalt covering on the pit with adequate drainage could prevent any movement of radioactive contaminants from the waste pit.*[200]

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*The USGS considered Area B to be one large pit.

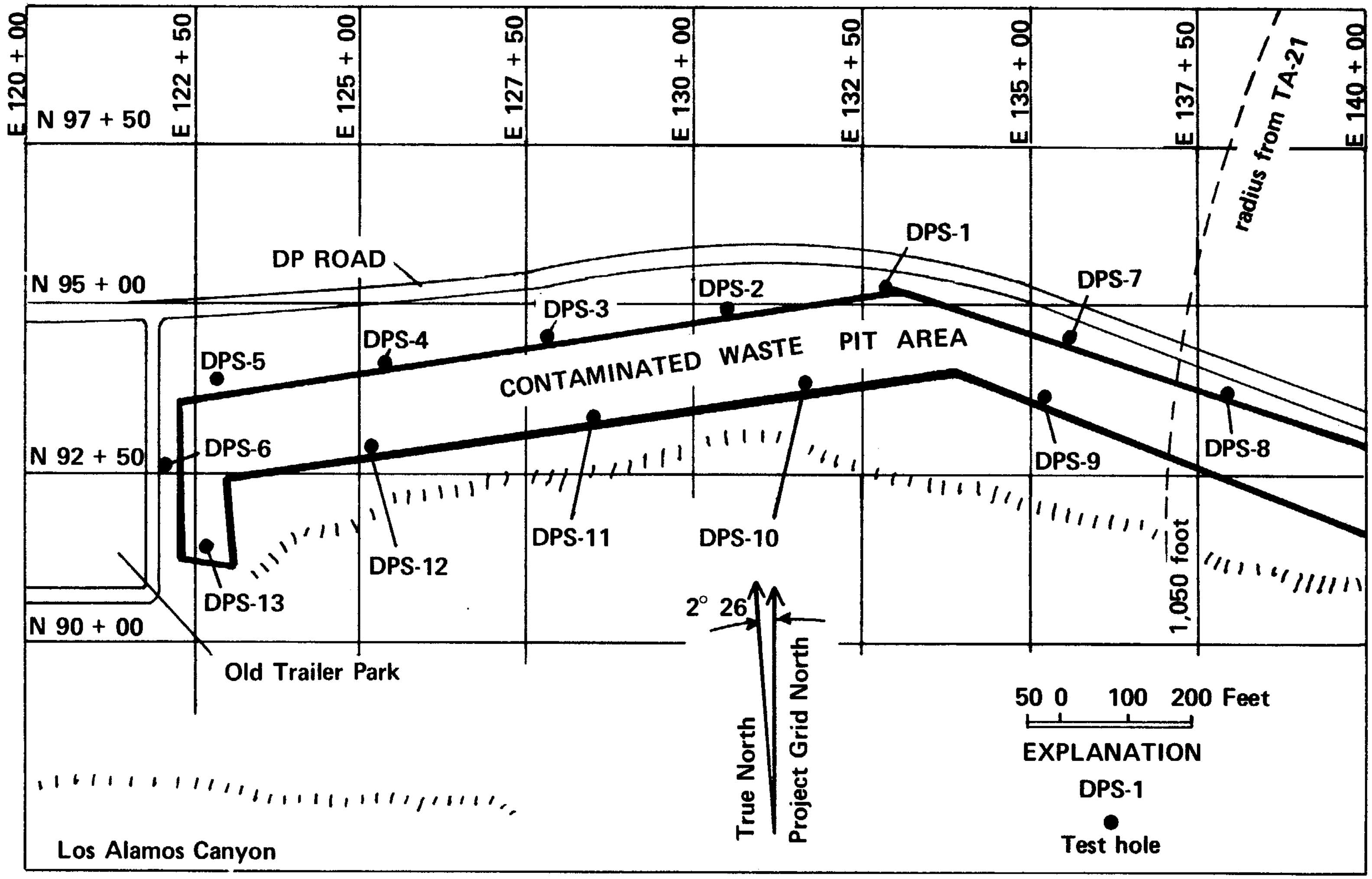

Fig. B-2.
Location of test holes drilled near the contaminated waste pit [Area B] west of TA-21.

TABLE B-I

DATA FROM 1966 USGS TEST HOLES DRILLED ON THE PERIMETER OF AREA B

USGS Designation	Date	ERDA & LASL Coordinates	Diameter (in.)	Depth (ft.)	Altitude (ft. above mean sea level)	Log: Soil (ft.)	Log: Bandelier Tuff (ft.)	Moisture Content Percent by Volume	Gross Alpha (dmg)	Gross Beta-gamma (dmg)	Plutonium (dmg)	Uranium (μgg)
DPS 1	2/7/66	N 95 + 13 E132 + 97	4	50	7,190	3	47	4-12.5	0.2-0.7	.0- 6.0	<.4	<.5
DPS 2	2/7/66	N 94 + 78 E130 + 56	4	25	7,191	3	22	6-23	0.3-0.9	0.3- 9.1	<.4	<.5
DPS 3	2/7/66	N 94 + 43 E127 + 87	4	50	7,194	3	47	4-22	0.0-1.2	0.0-12.6	<.4	<.5
DPS 4	2/7/66	N 94 + 16 E125 + 89	4	25	7,202	3	22	7-29	0.0-1.1	0.0- 4.9	<.4	<.5
DPS 5	2/7/66	N 93 + 80 E122 + 85	4	50	7,214	3	47	6-23	0.1-1.0	0.9- 7.6	<.4	<.5
DPS 6	2/8/66	N 92 + 58 E122 + 10	4	50	7,216	6	44	11-30	0.2-1.2	2.7- 6.1	<.4	<.5
DPS 7	2/8/66	N 94 + 41 E135 + 69	4	25	7,185	3	22	5-25	0.2-1.2	1.3- 5.5	<.4	<.5
DPS 8	2/8/66	N 93 + 66 E138 + 06	4	50	7,181	6	44	4-24	0.1-0.6	1.0- 5.8	<.4	<.5
DPS 9	2/9/66	N 93 + 66 E135 + 19	4	25	7,180	4	21	4-12	0.3-0.7	1.0- 3.7	<.4	<.5
DPS 10	2/9/66	N 93 + 66 E131 + 55	4	35	7,182	4	31	4-16	0.2-1.0	0.7- 4.3	<.4	<.5
DPS 11	2/9/66	N 93 + 21 E128 + 50	4	50	7,192	4	46	4- 9.5	0.3-0.9	1.2- 4.0	<.4	<.5
DPS 12	2/9/66	N 92 + 79 E125 + 21	4	36	7,192	3	33	8-35	0.3-0.8	0.0- 3.0	<.4	<.5
DPS 13	2/9/66	N 91 + 39 E122 + 72	4	35	7,210	2	33	4-11	0.4-1.0	0.0- 4.3	<.4	<.5

Compiled from data in Purtymun and Kennedy, 1966,[200]
and John, Enyart, and Purtymun, 1966,[77]

A beta gamma survey of the material waste pit at TA-21 [Area B] *was conducted on September 16, 1966. Dose rate measurements were taken at a distance of twenty inches from the surface of the black topping with an Eberline Mod. E-112-B Geiger counter. No appreciable reading above the normal background of 0.07 mr/hr was detected."*[205]

The accompanying map showed the survey was down the center of the storage area portion of Area B. November 10, 1971, the asphalt was surveyed with an alpha counter, Ludlem Model 139, and beta-gamma counter Model E-112-B. *"No alpha contamination was detected, and the beta count was background."*[206]

"On 8/26/76, M. A. Rogers and Merle Wheeler, H-8, and I [John Warren] *inspected the Los Alamos County operated storage area located near TA-21 over the LASL radioactive waste disposal Area B. In general the condition of the area paving and fencing may be described as very good; some preventive maintenance and minor repair work are suggested.*

There is no major growth of vegetation through the pavement, nor was there any indication of any new area settling as had been seen a few years ago [Fall 1973]. *All of the repair work done then is in very good condition. The area fencing, with one possible exception, is quite secure. We see absolutely no reason why the area cannot continue to be used at this time by the Los Alamos County for its present purpose.*

Specific preventive maintenance and repair measures that should be considered at this time are:

(1) All cracks in the pavement area should be resealed with hot tar to prevent any future damage and plant growth.

(2) All plant growth through the asphalt (seen especially around the edges at the west end of the area) should be removed and hot tar applied as a sealant.

(3) The area fencing in the one location on the DP-road side (approximately across from Morgans and the Los Alamos Monitor) should be repaired.

(4) Several of the fence grounding cables appeared to be either detached or broken. If this is of any importance the appropriate repairs should be made.

Several pictures [Polaroid SX-70 prints] *of the area were taken; these are enclosed..."*[280]

AREA C

I. GENERAL INFORMATION

Area C is located on Pajarito Road (see Fig. C-1), to the south of TA-50, east of Pecos Drive, and north of Pajarito Road. It is defined by LASL coordinates (beginning with the northeast point and moving in a clockwise direction) N.28+93, E.101+05; N.26+70, E.100+79; N.26+74, E.100+43; N.24+55, E.100+18; N.25+36, E.93+23; N.27+37, E.89+31; N.28+64, E.87+52; and N.30+36, E.88+52. Its location can also be given using township and range as on the mesa in the E 1/2 sec. 22, T. 19 N., R. 6 E.[30] The approximate acreage for Area C is 11.80.[207]

A memo[208] dated seven days after the May 3, 1948, fire in Area B stated

"On May 6, 1948 we forwarded an X priority #153078 to the Zia company...for the construction of a new contaminated dump. The work of digging the ditch commenced Friday morning, May 7, and was continued through Saturday, May 8th. Work is being resumed this morning, Sunday work having been skipped.

The location for this new contaminated dump has been agreed to by authorized Safety and Health personnel and by CMR Division. Since it is located near the Junction of the Alpha Site Road and the Pajarito Road, we are for record purposes considering it as part of the Alpha Site installation.[208]

Selection of the location of Area C is reportedly the first involvement of the USGS in disposal site approval (personal communication, D. D. Meyer, 1974). There are a total of 6 pits, a chemical pit, and 107 numbered shafts in Area C.

II. GEOLOGY AND HYDROLOGY

The mesa at Area C slopes gently eastward. Canyons approximately 304.8 m (1000 ft) north and south of the area are 30.5 - 45.7 m (100 - 150 ft) deep.[30] Ten-Site Canyon heads immediately northeast of the area about 45.7 m (150 ft) north of Pit 5. The soil covering is approximately 0.9 - 1.5 m (3 - 5 ft) thick above the Tshirege Member of the Bandelier Tuff.[30] There are two prominent, nearly vertical, joint sets which intersect at approximately 60°.[41] Most major joints are filled with sediments or altered material to a depth of approximately 3.0 m (10 ft)[41] and spaced 3.0 m (10 ft) apart.[30] All of the pits[41] and probably all of the shafts are dug in the Tshirege Member.

"The soil cover on the surface of the mesa prevents most of the water on the surface from infiltrating underlying tuff. Where the soil has been removed or disturbed, water might infiltrate the underlying tuff and open joints in the tuff. Beneath the soil there is about 850 ft of the Bandelier tuff which consists of a series of ash fall and ash flows of a friable to welded rhyolite tuff. This tuff is underlain by about 575 ft of volcanic debris of the Puye Conglomerate. The main zone of saturation occurs in the Puye at a depth of about 1300 ft. Perched water may occur above the main zone of saturation, although none was encountered in test well 8 located 1.5 miles northeast of Area C."[209]

III. PIT AND SHAFT DESCRIPTION

A. Background

Pit 1 was put in use June 10, 1948 (written communicaton, J. Enders, H-7, 1974). June 14, 1949,[188] it was reported *"the present dump* [Area C] *has been in use for one year and during that time we have filled one pit. We are now using the last pit and it should last until June 1950."*[188] The "last pit" referred to in

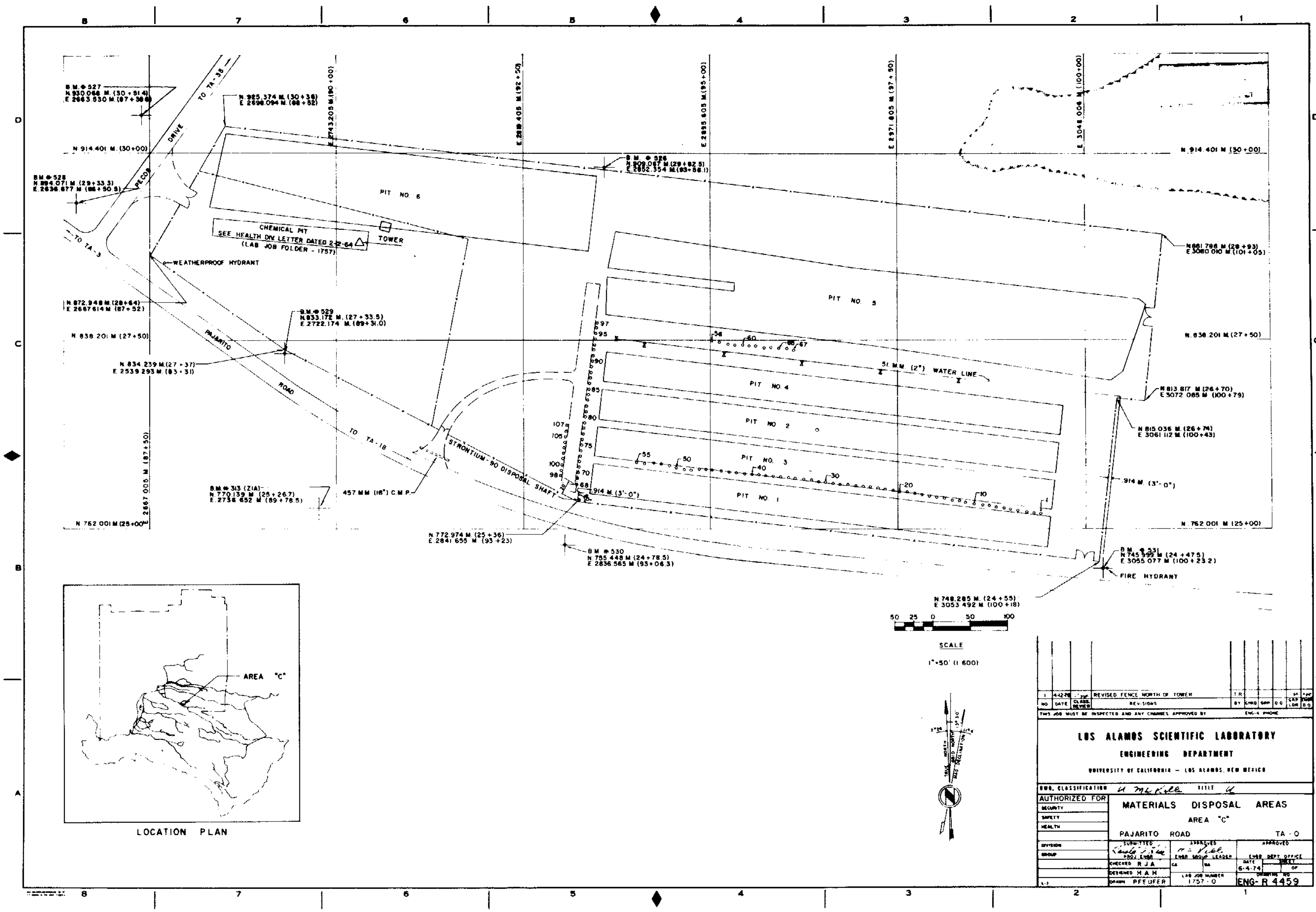

Fig. C-1.
Materials Disposal Area C, Pajarito Road, TA-0.

previous quote could be Pit 2, Pit 3, or Pit 4. Pits 2 and 3 show use dates from April 1950 through April 1953.[104] Pit 4 shows a use date from April 1950 through February 1955.[104] Pit 5 shows a use date from April 1953[104] through November or December 1964.[87,182] Pit 6 shows a use date from February 1956 through August 1959.[210] The chemical pit was probably dug in the first part of 1960[211] and closed out in the summer of 1964.[212] In the second quarter of 1957, Area G had been located and Pit 1 of that area had been dug.[100]

Twelve shafts were dug from February 29, 1958 through October 29, 1959 (written communication, J. Enders, 1974). The first shafts were for the use of the CMB-DO-GS (known as the CMB dogs). These first 12 shafts are numbered 56-67. (The shafts were renumbered by S. E. Russo, ENG-3 on November 20, 1962; per written communication, J. Enders, 1974.) By the third quarter of 1959 an additional 55 shafts were ordered dug.[210] These shafts are numbered 1-55. Twenty new shafts, numbered 68-87, were dug the last half of 1962.[108] During the first quarter of 1964 an additional 20 shafts, numbered 88-107 were dug.[84] In an April 23, 1965 memo[213] the statement appears: *"It is understood that when these new shafts are all filled no new wells will be drilled in this Area."* Table C-I shows the use dates for the 107 shafts in Area C.

The history of Area C extends from May 7, 1948, the date the first pit was started, through April 8, 1974, the date the last shaft was filled and plugged with concrete. It is sometimes felt that the last routine radioactive contaminated waste placed in Area C, December 1958,[101] marks the closing of Area C and the opening of Area G. Neither idea is true. Area G pits had received nonroutine radioactive waste before that date and Area C pits continued to receive nonroutine radioactive contaminated waste until Pit 6 was filled August 1959[210] and Pit 5 was filled November or December 1964.[87,182] Since quarterly and annual reports on solid radioactive waste disposal fail to mention Area C after 1968, it can be assumed the area was not in regular use past that time. The plugging of the last Area C shaft, Shaft 89, on April 8, 1974, marked the formal closing of the area.

B. Type of Waste

Records of solid radioactive waste going into Area C can be found in LA Notebooks 2587, 3478, 4644, 6030, 7277, 8453, 9293, 9593, and 12442.[104] These notebooks are used to log information on type, date, location, and volume of waste placed in the disposal area. *"...records prior to 1954 are incomplete."*[30]

During the pit history of Area C, hazardous chemicals and uncontaminated classified materials were buried with radioactive contaminated materials. Routine radioactive contaminated trash for the period consisted of cardboard boxes 33 cm × 33 cm × 61 cm (13 in. × 13 in. × 24 in.), 5-mil plastic bags, 33 cm × 61 cm (13 in. × 24 in.) and 256 cm × 61 cm (40 in. × 24 in.) of material generated in the chem labs, and 0.20 m^3 (55 gal) barrels of sludge from the waste treatment plants at Bldg. 35, DP West, and at TA-45. Nonroutine contaminated waste included debris from the demolition of Bayo Site and TA-1, classified materials, and tuballoy chips from the shops.

The following preliminary values are decay corrected from original magnitude to that as of January 1, 1973. In the disposal pits of Area C there are 25 Ci of uranium which include isotopes 234, 235, 236, and 238; 26 Ci of ^{239}Pu; and 149 Ci of ^{241}Am.[79] In the shafts of Area C there are 49 136 Ci[214] of ^{3}H, 40 Ci of ^{22}Na, 20 Ci of ^{60}Co, 31 Ci of $^{90}Sr/^{90}Y$, 1 Ci of ^{226}Ra (personal communication, M. Wheeler, H-8, 1974), 5 Ci ^{233}U, <0.1 Ci of uranium (including isotopes 234, 235, 236, and 238), 50 Ci of fission products, and 200 Ci of induced activity.[79] Total number of curies for the pits is 196 and total number of curies for the shafts is 49 483.

An earlier report[78] listed the following figures for Area C: D-38, 34 445 lbs; ^{235}U, 13 853 g; ^{239}Pu, 2063 g; ^{233}U, 1467 g; and ^{3}H, 10 g (for Areas C and G, based on estimated curies and 9600 Ci $\simeq$ 1 g ^{3}H).

It seems appropriate to comment on the establishment of the Hazardous Chemical Area in Area C. As pit use was phasing out in Area C and beginning in Area G, the idea of separate disposal for hazardous nonradioactive chemicals (which were responsible through the years for many fires in the disposal area [personal communication, J. Enders, H-7, 1974]) was accepted. There is no indication[101,210,211] that Pit 6 of Area C was, at any time during its history, dedicated to the exclusive disposal of hazardous nonradioactive chemicals. A memo[211] dated November 12, 1959, suggests it was proposed that part of Pit 6 be used for

TABLE C-I

AREA C SHAFTS

Prepared By: John Enders, H-7, 1974

SHAFT #	FIRST LOG ENTRY	LAST LOG ENTRY	LA NOTEBOOK #	PAGE #
1	11/10/59	11/10/59	9593	120;121 122;123
2	11/30/59	3/23/60		
3	1/ 7/60	2/23/60		
4	2/11/60	9/20/60		
5	4/ 6/60	11/ 1/60		
6	4/14/60	12/22/60		
7	5/10/60	2/21/61		
8	5/10/60	3/24/61		
9	7/19/60	11/10/60		
10	7/25/60	7/25/60		
11	7/29/60	11/10/60		
12	10/ 3/60	10/ 3/60		
13	10/18/60	11/28/60		
14	10/ 5/60	4/18/61		
15	11/28/60	4/18/61		
16	11/30/60	6/ 5/61	11363	130;131
17	1/13/61	4/25/61		
18	1/27/61	2/21/61		
19	3/23/61	3/23/61		
20	3/28/61	3/29/61		
21	4/18/61	4/18/61	9593	123
22	6/ 5/61	6/ 5/61	11363	130;131
23	5/ 2/61	6/ 5/61	11363	130;131
24	5/10/61	5/26/61	11363	130;131
25	5/22/61	2/ 8/62	11363	136;137
26	6/ 6/61	2/26/62	11363	136;137
27	6/ 6/61	6/26/61	11363	131;132
28	6/16/61	6/16/61	11363	131;132
29	6/26/61	7/16/61	11363	132;133
30	7/ 7/61	7 7/61	11363	132;133
31	7/17/61	7/24/61	11363	132;133
32	7/26/61	3/20/62	11363	138;139
33	8/14/61	2/ 5/62	11363	136;137
34	10/31/61	1/ 5/62	11363	136;137
35	12/26/61	12/26/61	11363	134;135
36	12/28/61	12/28/61	11363	134;135
37	12/29/61	12/29/61	11363	134;135
38	1/ 3/62	1/ 3/62	11363	136;137
39	1/ 4/62	1/ 4/62	11363	136;137
40	1/ 4/62	1/ 5/62	11363	136;137
41	1/ 5/62	2/ 6/62	11363	136;137
42	1/15/62	1/18/62	11363	136;137
43	1/18/62	3/20/62	11363	138;139
44	2/ 7/62	2/ 7/62	11363	136;137
45	3/22/62	4/25/62	11363	138;139
46	2/ 6/62	2/ 8/62	11363	136;137
47	4/20/62	5/ 8/62	11363	138;139
48	5/ 8/62	6/ 5/62	11363	110;111
49	7/17/62	7/17/62	11363	110;111
50	6/ 6/62	7/26/62	11363	110;111
51	7/ 3/62	8/ 7/62	11363	110;111
52	8/ 7/62	9/19/62	11363	112;113
53	8/24/62	9/25/62	11363	112;113
54	9/25/62	10/ 3/62	11363	112;113
55	12/13/62	5/26/67	11363	118;119

TABLE C-I (continued)

AREA C SHAFTS

SHAFT #	FIRST LOG ENTRY	LAST LOG ENTRY	LA NOTEBOOK #	& PAGE #
56 (old 1)	2/28/58	2/28/58	9593	120
57 ("2)	7/ 3/58	7/ 3/58	9593	120
58 ("3)	9/22/58	9/22/58	9593	120
59 ("4)	11/20/58	12/ 3/58	9593	120
60 ("5)	12/10/58	2/ 4/59	9593	120
61 ("6)	5/26/59	5/26/59	9593	120
62 ("7)	7/ 8/59	7/ 8/59	9593	120
63 ("8)	7/10/59	7/10/59	9593	120
64 ("9)	7/10/59	7/10/59	9593	120
65 ("10)	9/10/59	9/10/59	9593	120
66 ("11)	9/16/59	10/15/59	9593	120
67 ("12)	10/20/59	10/29/59	9593	120
68	10/ 8/62	11/ 2/62	11363	114;115
69	10/23/62	11/ 1/62	11363	114;115
70	11/ 6/62	12/13/62	11363	118;119
71	11/ 8/62	4/ 9/63	11363	118; and #12442 Page 6;7
72	2/15/63	3/ 1/63	12442	2;3
73	3/ 5/63	4/ 8/63	12442	6;7
74	4/ 8/63	5/27/63	12442	6;7
75	4/10/63	7/ 9/63	12442	6;7;8;9
76	5/ 2/63	7/ 9/63	12442	6;7;8;9
77	6/12/63	7/19/63	12442	6;7;8;9
78	7/ 5/63	7/17/63	12442	8;9
79	6/ 5/63	7/30/63	12442	8;9
80	7/18/63	10/ 7/63	12442	8;9;10;11
81	8/20/63	10/24/63	12442	8;9;10;11
82	8/27/63	8/30/63	12442	8;9
83	9/ 4/63	12/20/63	12442	10;11
84	9/16/63	1/10/64	12442	10;11;14;15
85	10/30/63	2/27/64	12442	10;11;14;15
86	1/27/64	5/14/64	12442	14;15;16;17
87	4/ 6/64	7/ 9/64	12442	14;15;16;17
88	5/21/64	12/ 9/64	12442	16;17;20;21
89	4/23/64	4/ 8/74	12442	14;15
90	8/19/64	1/ 4/65	12442	22;23
91	8/19/64	3/30/65	12442	16;17;24;25
92	8/19/64	5/13/65	12442	16;17;24;25
93	8/19/64	2/29/68	12442	16;17;46;47
94	8/19/64	4/20/65	12442	16;17;28;29
95	5/19/65	10/ 6/65	12442	26;27;28;29
96	5/19/65	7/12/66	12442	26;27;36;37
97	5/19/65	4/14/66	12442	26;27;34;35
98	8/18/64	9/23/64	12442	16;17;20;21
99	11/18/64	4/20/65	12442	20;21;24;25
100	7/26/65	10/24/66	12442	26;27;38;39
101	8/24/65	10/12/65	12442	28;29;30;31
102	11/ 5/65	4/18/66	12442	34;35
103	1/17/67	10/17/67	12442	40;41;46;47
104	10/27/67	4/ 1/68	12442	46;47;48;49
105	12/12/68	12/12/68	12442	50;51
106	8/24/65	10/12/65	12442	28;29;30;31
107	2/11/66	2/11/66	12442	34;35

the "permanent chemical disposal area," but another memo[210] dated November 2, 1959, states covering of Pit 6 to ground level began September 24th and finished October 2nd. Apparently, the chemical pit south of Pit 6 was dug in early 1960.[211]

> *"A brief review of the use of this pit shows that a variety of chemicals, pyrophoric metals, hydrides and powders, sealed vessels containing sodium-potassium alloy or compressed gases, and equipment not suitable for salvage, public dump or the contaminated dump have been placed in the pit. No high explosives have ever been disposed of in this pit. Normal uranium powders and hydrides have been disposed of in this pit. Inadvertently, some plutonium-contaminated objects were placed in the pit but have long since been covered. Because of the uranium disposed it should be assumed that the pit is mildly alpha contaminated."*[212]

The Hazardous Chemical Disposal Area was fenced off from the rest of Area C. When the Hazardous Chemical Disposal Area was closed out in Area C it moved to Area L, Mesita del Buey.

Another disposal practice, disposing of nonradioactive classified waste with contaminated waste, was under discussion about the same time as separate disposal for nonradioactive hazardous chemicals.

> *"It was rather disappointing to learn during the course of our inquiries on this matter that, despite the general agreement some two years ago* [1957], *burial in contaminated pits would essentially be a last resort method of disposing of classified waste, nevertheless, a substantial part of the capacity of the existing pit* [probably Pit 6] *in Area C has been taken up with materials which are not contaminated, not of obvious security interest, and which it would seem could be disposed of by some other method. For example, I* [P. F. Belcher, Assistant Director for Classification and Security] *am informed that something more than seventy yards has been taken up by Security Branch, LAAO, for the dumping of technical badges. It would seem to me that badges can be chopped up and disposed of in some other manner. I will concede that it perhaps is a tedious job, but in view of the fact that we have only a limited amount of real estate for disposal of classified waste it does not seem to me proper to dispose of badges by burial simply because it is easiest.*
>
> *By the same token it appears that there have been large quantities of safety film from various laboratory operations placed in the contaminated pits at Area C. Again, it would seem that there must be alternate methods of disposing of safety film which would not involve using up the limited space available in contaminated waste disposal dumps."*[215]

Eventually, Area H, Mesita del Buey, was designated as the nonradioactive classified waste disposal area.

Originally the shafts in Area C were dug for the disposal of beta-gamma active waste by the CMB-DO-GS at Ten-Site. Shafts were to be used by many other groups for disposal and storage. Appendix H lists the contents of the 107 shafts in Area C.

C. Mode of Disposal

Pits 1 - 4 are located in the southwest quarter of the area (see Fig. C-1). These pits are 185.9 m (610 ft) long by 12.2 m (40 ft) wide. On Engineering Drawing ENG-R 1264 these are shown as scaled dimensions. Apparently, the Engineering Department was neither asked to stake these pits before they were dug nor asked to survey these pits while open, as there is no record of it being done. Pit 5, located to the north of Pits 1 - 4, is 33.5 m (110 ft) wide by 214.9 m (705 ft) long and has a maximum depth of approximately 5.5 m (18 ft). Pit 6, in the northwest quarter of Area C is 30.5 m (100 ft) wide by 153.9 m (505 ft) long with a maximum depth of approximately 7.0 m (23 ft). The chemical pit is 7.6 m (25 ft) wide by approximately 54.9 m (180 ft) long and may be 3.7 m (12 ft) deep.[211]

Numbers on the 107 disposal shafts in Area C do not reflect their excavation or use dates. The first shafts, 56-67, are located between Pit 4 and Pit 5; they are numbered from west to east. The next shafts, 1-55, are between Pit 1 and Pit 3; they are numbered from east to west. They were followed by Shafts 68-107 which run south to north immediately past the western ends of Pits 1-4. Shafts 98-107 parallel shafts 68-97; they are numbered from south to north. Shafts 68 and 98 are 6.1 m (20 ft) from the southwest fence of Area C.

The shafts are located on 2.3 m (7 ft, 6 in.) centers. Like the pits, they vary in size and depth. Shafts 56-67 are 0.6 m (2 ft) in diameter by 3.0 m (10 ft) deep.[101] Shafts 1-55 are 0.6 m (2 ft) in diameter by 4.6 m (15 ft) deep.[210] Shafts 68-107 include both 0.3-m (1-ft) diameter 30.5-cm (12-in.) thick concrete-lined shafts and 0.6-m (2-ft) diameter shafts. Shafts 98-107 are concrete lined. In shafts 68-107 the depth may vary from 6.1 m (20 ft) to 7.6 m (25 ft).

A ^{90}Sr disposal shaft, no number, is located a few feet from the south fence corner designated by LASL coordinates N.25+36, E.93+23.

The fence, which runs north-northeast across the western half of Area C, was erected to end confusion over which part of Area C was used for radioactive contaminated waste disposal and which part was used for hazardous chemical disposal (personal communication, J. W. Enders, H-7, 1974). At the time the fence was erected it was common practice for hazardous chemicals to be placed in the chemical disposal pit and then burned. People frequently reported the contaminated dump to be on fire. Therefore, the fence was erected to end the confusion of what was on fire.

"A meeting was held on December 28, 1950, concerning contaminated dump. It was decided at that time that H-1 Monitoring would be responsible for Rad-Safety of all persons entering the dump commencing January 5, 1951.

Our responsibilities are as follows: 1. Furnish full protective clothing including respirator to [the man from]*Zia Co. who covers the trash every Friday.* [This man] *has to be monitored after eaach job and nose swipes taken. He is scheduled for routine Health Pass test. By copy of this memo I'm* [Carl Buckland] *requesting that Glenn Vogt write monthly work orders to cover the bulldozer work. The maintenance men of D-Bldg. formerly took care of this detail.*

2. H-1 Monitoring will be notified, upon arrival of highly active beta-gamma contaminates (sic) requiring a knowledge of tolerance times. We will also be notified upon arrival of hot filters from DP Site. This advance information will assist us in case of fire for which we are responsible.

3. Film badges and pocket chambers should be issued in cases of high beta-gamma activity.

CMR-Safety and CMR-12 will continue to dump chemicals in the proper place and contaminated items in another. Dean Meyer has stated that if at any time we feel that things are not dumped where we think they should, to contact him."[216]

Numbered reference posts for waste record purposes were used for the first time July 19,1951 (written communication, J. W. Enders, H-7, 1974).

A February 5, 1957, memo[217] entitled, "Covering Contaminated Trash at Contaminated Dump," reflects some operational changes as follows:

It is my [John Enders] *understanding that the dump* [referring to a single pit] *was formerly covered once per week. This was done at a time when trash was piled into the dump and covering once per week was a means of reducing the danger of fire.*

At present, it seems that the Dump is covered whenever: (a) requested by ENG-4, (b) there is a slack period for Zia Roads Section. After talking to Mr. Anglin and Mr. Raper of the Zia Roads Section, I find that they point out that the more frequent the covering, the more fill dirt is used.

At present, the trash is placed into the Dump in single layers of boxes, etc., which cover about one-half of the width of the Dump. The fire hazard is reduced because the fire department's efforts to extinguish a fire in a single layer should be successful.

Therefore, I am suggesting that the routine dump covering operation should be done only after a single layer of trash is placed into the Dump — the width of the layer to be about one-half the width of the Dump."[217]

In 1956[218] collection of trash from laboratories was done in the following way. Zia janitors removed trash from lab hot-waste cans and put the trash into cardboard boxes. The boxes were then sealed and set outside the building for pickup by truck. June 27, 1957,[100] Dempster Dumpster boxes were delivered to Wings 2 and 4 of the CMR Building. *"It is planned to put boxed contaminated trash in these boxes and deliver the filled boxes to the Dump,"*[100] (see Fig. C-2). By the end of 1957[99] Dempster Dumpster boxes were also placed at TA-2 (Omega Site) and TA-35 (Ten Site). At the start of the third quarter of 1958[105] Dempster Dumpster boxes were put into service at nearly all Laboratory Sites where radioactive trash was picked up. All Dempster Dumpster boxes were painted on the interior and the doors marked FOR RADIOACTIVE TRASH ONLY. *"A yellow band was painted around the top of the box with black wording designating the site location of the box."*[219]

During the third quarter of 1957[220] a trial use of 5-ml thick plastic bags began. The bags were not placed[198] into cardboard boxes before being taken to the burial ground. Waste during this time was not covered weekly. To demonstrate differences in weathering, a cardboard box and a plastic bag containing laboratory waste were marked with the date and left exposed in the burial pit for approximately 3 months (Fig. C-3). The cardboard box weathered considerably and broke open. The plastic bag was still intact.

The following excerpt is from the "Annual Report for 1958 on Disposal of Contaminated Solid Waste."[101]

"At the CMR-Bldg. and at Sigma Bldg. loose office and change room trash is now being packaged in plastic bags. Seven six-bushel capacity trash dollies have been purchased for this operation. Five-mill (thickness) 40" × 24" plastic bags are used as liners for the trash dollies. When these bags are filled they are sealed with masking tape and placed into the Dempster Dumpster containers. It is estimated that one plastic bag will hold more trash than four or five 13" × 13" × 24" cardboard boxes. The time spent by Zia Janitors in preparing the bags, filling and sealing them is about one-half that needed to do the same operation using cardboard boxes. It has been observed that these bags are more easily emptied at the disposal pit from the Dempster Dumpster containers than are the cardboard boxes which have a tendency to hang up inside the containers. At the disposal pit the bags also withstand the effect of weathering much better than the cardboard boxes.

Prior to putting the trash dollies into use, the plastic bags used in the labs for holding contaminated trash were 2 mil thick. The bags were removed, sealed, and placed into cardboard boxes. After the trash dolly system was started, these bags are also being placed into the trash dolly and because of this it was felt that an additional safety factor would be needed so 5-mil thick bags were issued as liners for the trash cans in the laboratories."[101]

The 1959 Annual Report[106] states:

"Cardboard boxes located in the utility corridors of the CMR Bldg. laboratory wings are being replaced with metal cans provided with a plastic bag liner. The changeover was made in order to provide a more fireproof container for solid radioactive waste."[106]

Fig. C-2.
Dumping radioactive contaminated trash from a Dempster Dumpster into Pit 6, Area C, 1958.

Trucks were still in use to haul 0.2 m^3 (55-gal) sludge drums from the waste treatment plants at TA-45 and TA-21 to Area C at the end of 1958,[101] (see Fig. C-4). In March 1959, Dempster Dumpster trucks using skip-type containers began to haul the sludge drums to the burial ground.[106] Trucks continued to be used to haul nonroutine contaminated waste to the disposal area.

Early shaft disposal was described in the Annual Report for 1958 on Disposal of Contaminated Solid Waste.[101]

"At infrequent intervals, CMB-DO-GS group at Ten Site has beta-gamma active waste material that must be buried. In the past the material was taken to the Disposal Pit where a hole was dug into the ground and the material thrown into the hole and covered with dirt. In February, 1958, an order was submitted to have a dozen holes drilled measuring 2 feet in diameter and about 10 feet

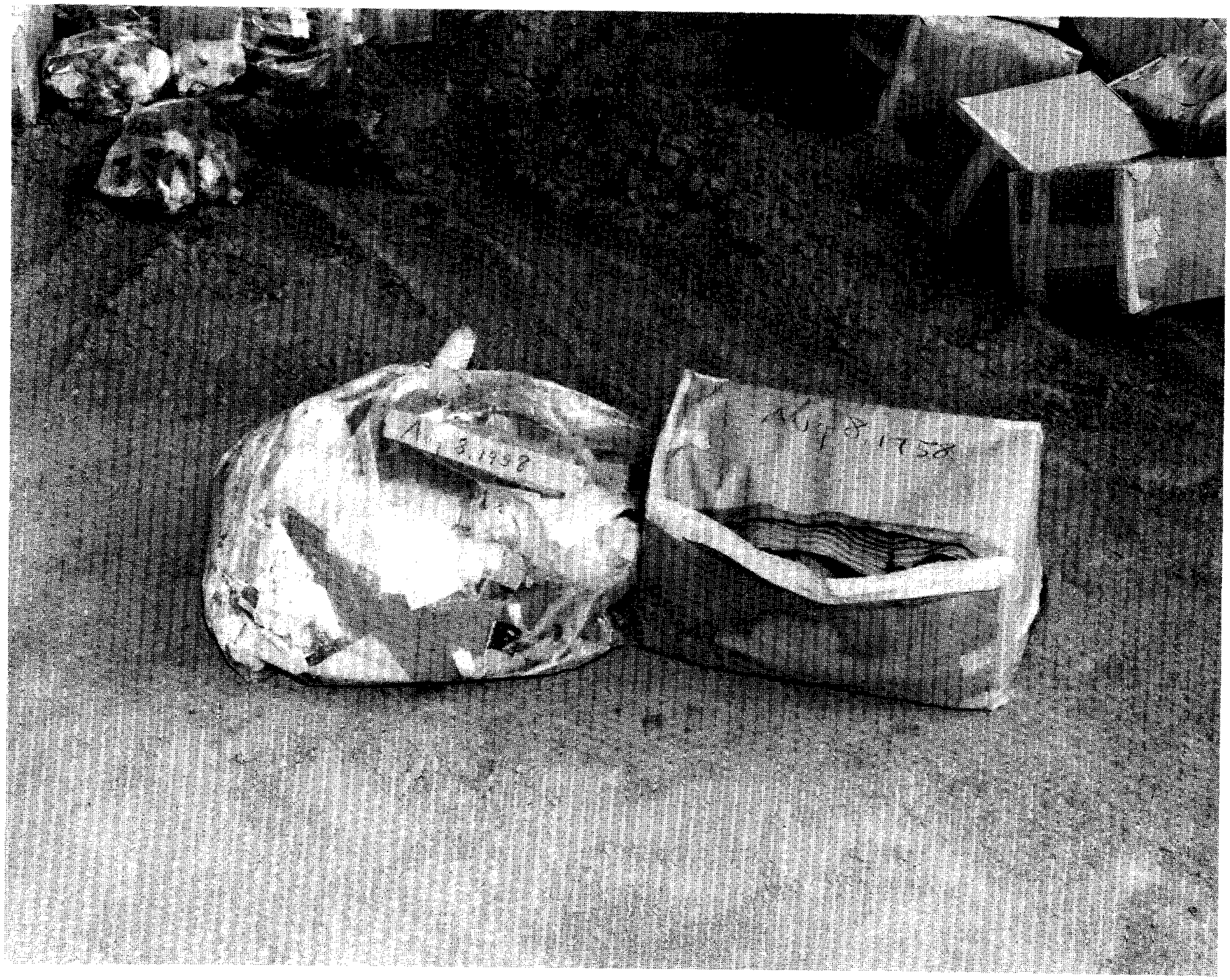

Fig. C-3.
Weathering difference in approximately 3 months between plastic bags and cardboard boxes, 1958.

deep. The holes were located between Pits 4 and 5, Area C. These holes are now being used for disposal of the gamma active waste from Ten Site. Space is available at this location for at least 30 to 50 more holes for future disposal.*

The technique used by CMB-DO-GS for handling this waste is briefly as follows: (1) the material to be thrown away is evaporated to dryness in a hot cell at Ten Site and then placed inside a Dural container. This container is then sealed and placed inside a steel container which is in turn sealed. (2)

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*More shafts were not drilled because it was not possible to drive any further east along the border between Pits 4 and 5. (Written communication, J. W. Enders, H-7, 1974).

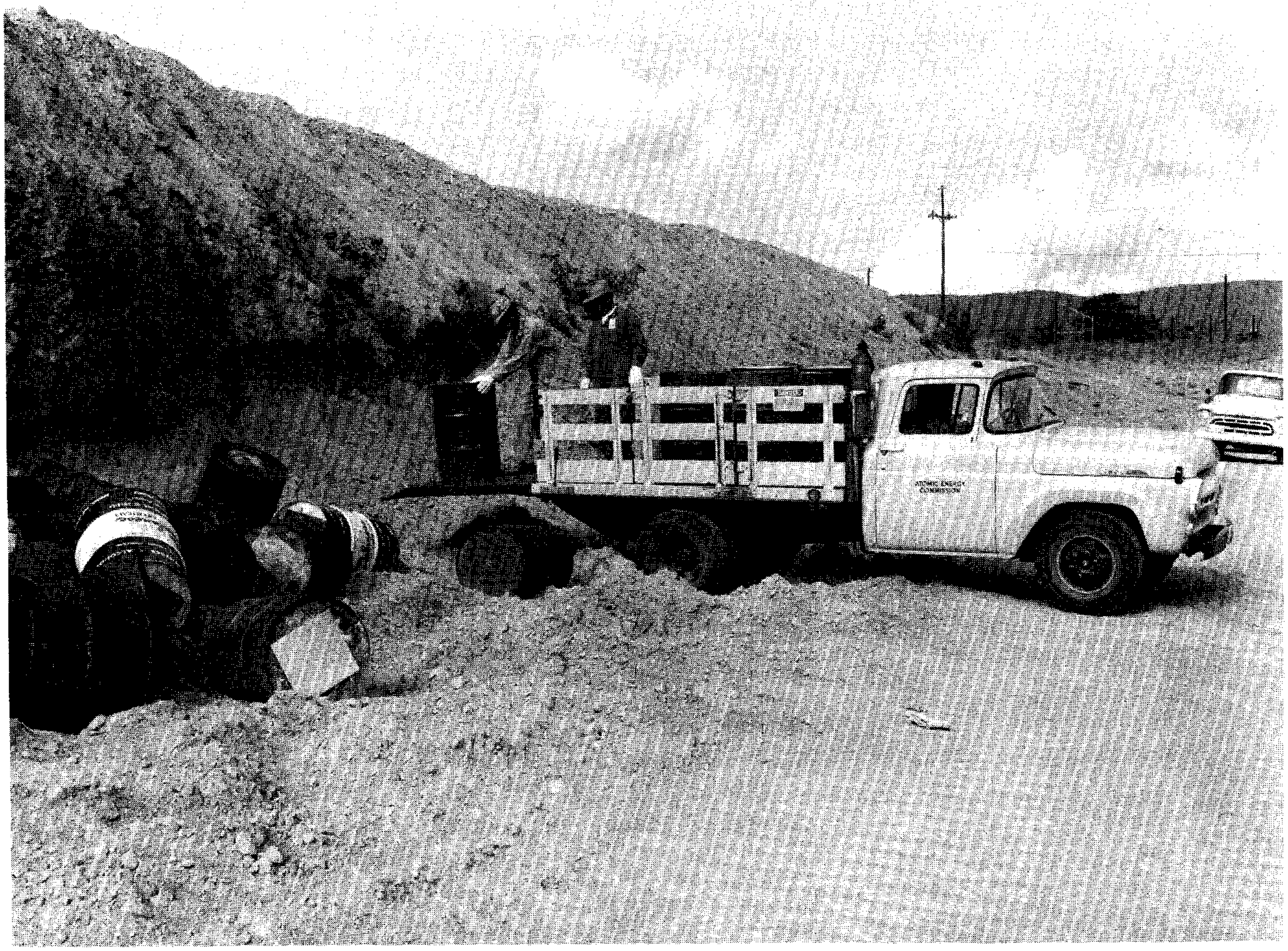


Fig. C-4.
Off-loading sludge drums from the waste treatment plant in Pit 6, Area C, 1958. Sludge in drums was not dewatered; therefore, each drum weighed approximately 149 kg (400 lb) (personal communication from J. Enders, H-7, 1974).

The steel container is then removed from the hot cell and placed into a lead transfer case which is thick enough to handle up to 40 curies of material. (3) The transfer case is positioned on the back of a 1 1/2 ton truck and fastened securely with a chain. (4) The truck is then driven to the disposal area and positioned above one of the holes. (5) A tripod with a long boom arm attached is used to transfer the material from the transport case to the hole. The steel container is pulled up out of the case by means of a string to which is attached a rope that runs through a pulley on the end of the boom. When the container is over the hole, the string is cut and a few shovels of dirt are shoveled on top of the container so as to reduce the gamma radiation at ground level to less than 1 mr/hr."[101]

A modification of the procedure was reported in the Annual Report for 1959 on Disposal of Solid Radioactive Waste.[106]

"This year 10-Site personnel modified the equipment used for containing and shielding their waste material during transit to the disposal area. This modification included an improved container and a tuballoy cask that is provided with a trap door in the bottom that permits dropping the waste material (sealed in the canister) from the cask directly into the disposal well through a hole in the truck bed. This design improvement has permitted handling of wastes that range up to 400 curies of activity with very little personnel exposure. CMB 11 (DP West) has plans to use this equipment when possible for their waste disposal from the hot cells."[106]

Permanent markers, metal stakes with numbered tags, were placed by each shaft in 1959.[106] Deliveries to any shaft were logged.[106] In 1961

"...metal covers were fabricated and installed over the 'active' disposal wells and wood covers were obtained for use on unused wells. At each corner of the wooden covers metal stakes have been located so as to prevent movement of the covers."[221]

In 1967 Solid Waste Operations personnel proposed that H-1 seal the disposal shafts.[222]

"Often it is highly desirable for radiation safety and/or security reasons (or both) to seal items placed in the shafts immediately with concrete. It is now standard practice to seal filled disposal shafts with concrete.

The current procedure of obtaining Ready-Mix cement for the above operations is to (1) write a memo to ENG-4, through H-1 Group office, requesting the work to be done, (2) ENG-4, upon receiving the memo, may or may not issue a work order, apparently depending on whether ENG-4 thinks the request is necessary or not. There have been instances where the H-1 Group office has had to repeat the request and by the time the Ready-Mix finally arrives there has been a time lag of (in some cases) several months.

The simple logistics of the operation are also involved in that the Ready-Mix truck, ENG-4 representative, H-1 representative all need to be at the Area at the same time and this has also been difficult at times. In the event of an 'emergency delivery' it would be almost impossible to schedule delivery of Ready-Mix to the disposal shaft."[222]

The proposal to purchase a small cement mixer, some cement and one wheelbarrow so that H-1 could do the job themselves was accepted. (Written communication, J. W. Enders, H-7, 1974.)

"While burial of contaminated waste was the method of disposal, it was recognized that other ideas should be investigated. Dr. Jette decided that sea burial should be considered. A number of large steel containers were fabricated with gasketed lids and sea cocks. These were used for a period of time; however, when they were filled, the cost of transportation and fabrication of more boxes was so high that the idea was dropped and the full boxes were placed in pits in Area C."[223]

In 1961[221] six Standard Operating Procedures were prepared on waste disposal operations. Three additional S.O.P.'s were written to cover nonroutine disposal operations.

IV. STUDIES AND MONITORING

The USGS did an infiltration study north of Pecos Drive near Area C (personal communication. W. D. Purtymun, H-8, 1974). Two[146] infiltration pits, Pit A and Pit B, 0.6 m (2 ft) in diam by 0.3 m (1 ft) deep were constructed during September 1956.[22 6]

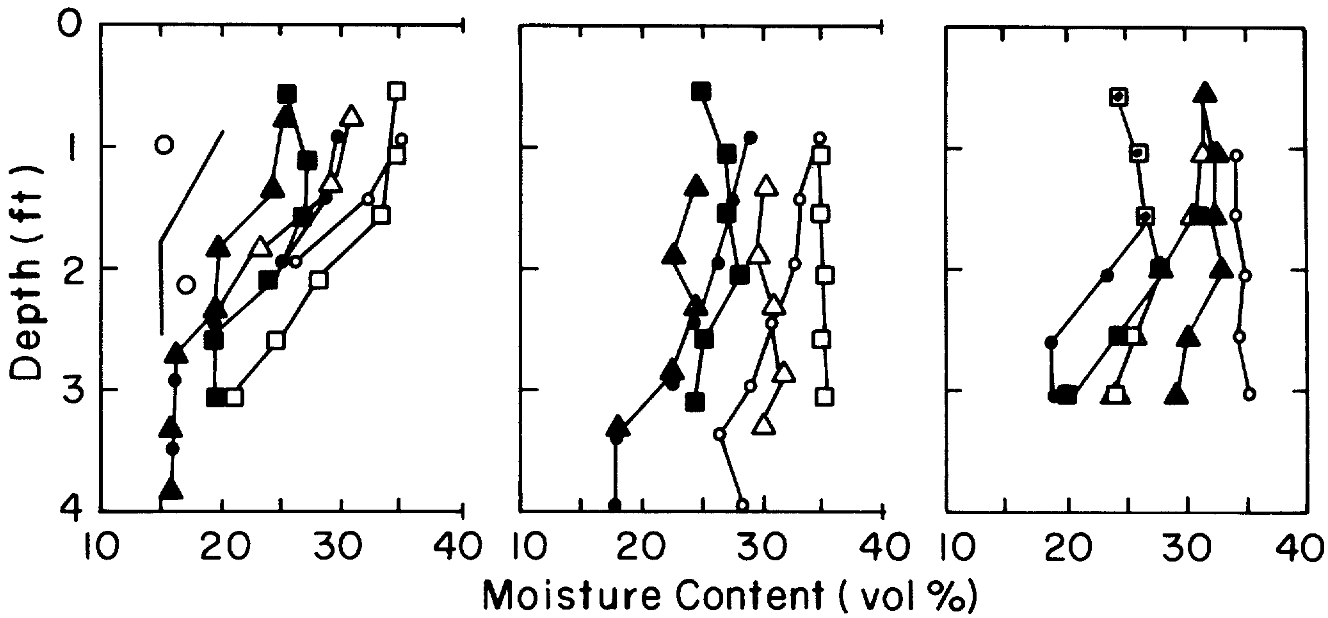
The 1958 study, which seems to have been conducted September through October, used Pit A. Pit A had three access tubes spaced 0.6 m (2 ft) apart with access tube No. 2 centered in the pit.[160] *"Cores for natural moisture-content determination were collected at the site on October 10, 1958."*[160] Water supply was intermittent during the 1958 study.[160] It was difficult to determine precisely how the 1958 study was conducted from the USGS report[160] of it. Data are shown in Fig. C-5.

The 1959-1960 study, September 21, 1959 through September 2, 1960,[226] used Pit B.[160]

> *"The high moisture content beneath the pit before infiltration started was due in part to heavy rains in August, 1959, and the relatively poor drainage in the sandy surface soil."*[160] [See Fig. C-6]
>
> *The soil is similar to that on Frijoles Mesa; it is about 6 feet thick and is underlain by welded tuff. The area is moderately well drained. A test hole 20 feet deep was drilled in the center of the infiltration pit and a 2-inch plastic pipe was installed so that it projected about 1 foot above the pit. Soil and tuff were packed around the casing to prevent seepage down alongside the casing. Moisture measurements were made prior to application of water. Water was introduced into the pit and a constant head maintained at three-quarters of a foot for 99 days.*
>
> *The wetted front* [Fig. C-6] *moved to a depth of about 4 1/2 feet during the first 2 days of infiltration and to a depth of about 6 1/2 feet during the next 97 days, but water did not move through the transition zone into the tuff, except in the lower moisture range. The moisture content decreased with depth from a maximum of about 38 percent in B zone of the soil to less than 4 percent within a foot of the surface of the tuff.*
>
> *Water apparently was perched on the C zone of the soil and the moisture content within the B zone approached saturation. After the first several days of infiltration, most movement of water probably was lateral, as indicated by measurements in a series of holes around another infiltration pit* [Pit A] *nearby. Some water undoubtedly was lost by evaporation and transpiration.*
>
> *Although the quantity of water used during the study was equivalent to almost 50 years of precipitation on the Pajarito Plateau, the moisture content in the A and B zones had returned to nearly normal after 8 months of drainage; the moisture content in the C zone and top 2 feet of tuff was slightly higher than before the experiment, and the moisture content of tuff between 8 and 20 feet was unchanged. However, conditions during this study cannot be considered normal because the clogging or silting of pores probably was greatly accelerated when this volume of water moved into the soil within a period of 99 days without the normal seasonal distribution which involves alternate percolation and drainage."*[226]

The 1960-1961 study,[160] September 2, 1960 through October 2, 1961, used Pit B. No water infiltrated the pit other than precipitation.

> *"The May 19, 1961, measurements were high because of snowmelt, and the October 2, 1961 measurements were low because of low precipitation."* [See Fig. C-6.]



Profile I
September 1958

○
Moisture content from core sample collected before infiltration tests

Moisture content before infiltration tests

■ *or* □
Hole 1

● *or* ○
Hole 2

▲ *or* △
Hole 3

Solid symbols indicate conditions after 14 d of drainage

Open symbols indicate conditions after 6 hr of infiltration after 14 d of drainage

Profile II
October 1958

■ *or* □
Hole 1

● *or* ○
Hole 2

▲ *or* △
Hole 3

Solid symbols indicate conditions after 19 d of drainage

Open symbols indicate conditions after 23 d of infiltration after 19 d of drainage

Profile III
September 1958

Note: All measurements made in hole 1

●
Moisture content after 14 d of drainage

■
Moisture content after 6 hr of infiltration following 14 d of drainage

□
Moisture content after 19 d of drainage following 6 hr of infiltration

△
Moisture content after 1 d of infiltration following 19 d of drainage

▲
Moisture content after 3 d of infiltration following 19 d of drainage

○
Moisture content after 23 d of infiltration following 19 d of drainage

Fig. C-5.
Moisture content beneath infiltration pit A ... [near Area C] during intermittent infiltration and drainage, 1958.

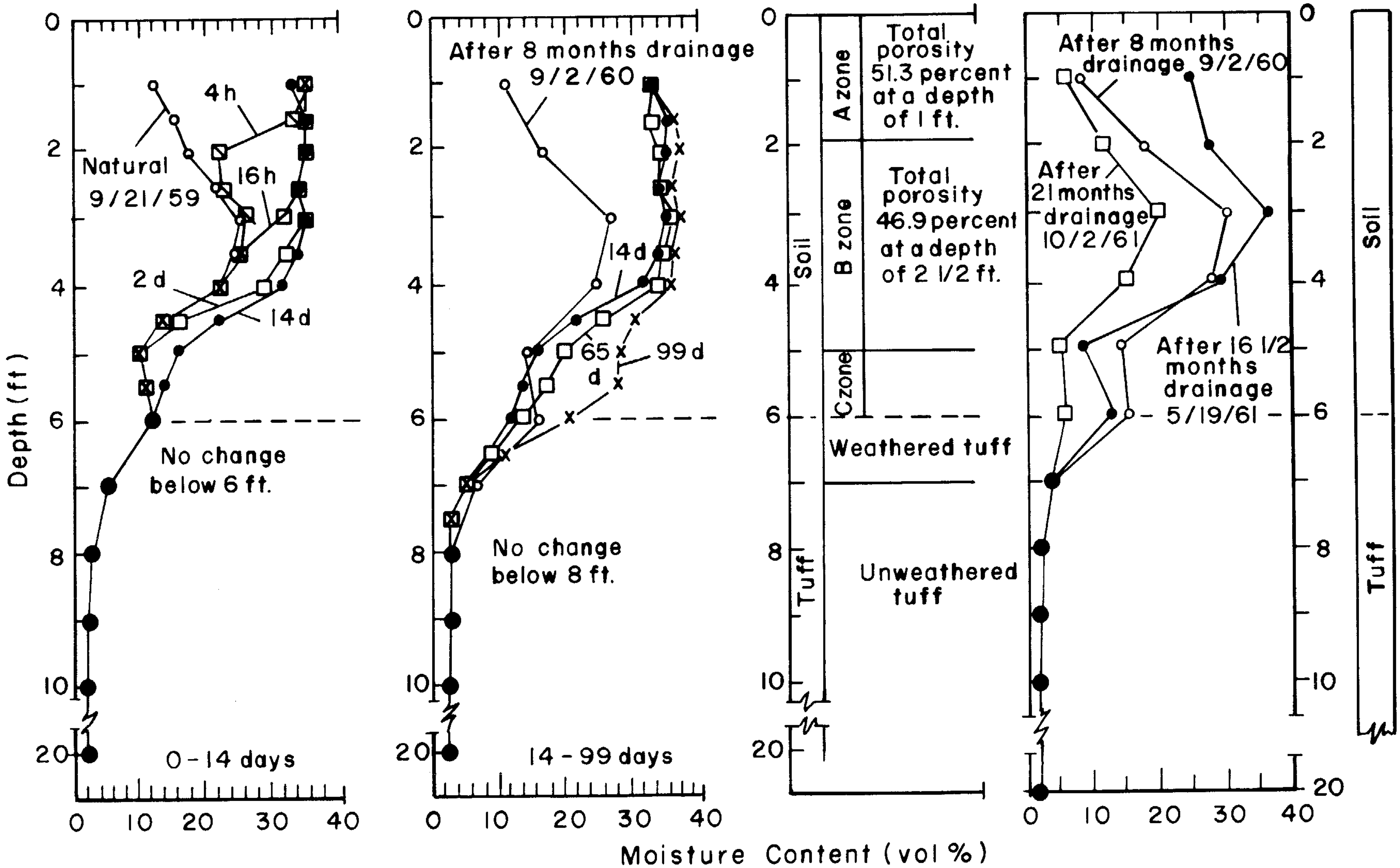


Fig. C-6.
Changes in moisture content beneath the infiltration pit near Area C during 99 days of continuous infiltration from Sept 21 through Dec 29, 1959 and subsequent drainage for 21 mo.

"The fact that water did not penetrate the dense transition zone between the soil and tuff during the study [1959-60] *or in the following year* [the 1960-61 study] *indicates that the soil cover will impede vertical movement into the underlying tuff. Capillary rise, evaporation, and transpiration were perhaps the principal reasons that the water did not penetrate the underlying tuff, rather than the low permeability of the transition zone."*[160]

In 1962[209] the question of 18.3-m (60-ft) deep shafts at Area C was considered by the USGS.

"There is no serious objection to the burial of radioactive waste in holes 60 feet deep at Area C, although several precautions should be taken. They are: (1) Solid wastes should be packaged for normal underground burial; (2) Liquids and sludges should be contained so no leakage occurs; (3) The soil zone on the mesa should be disturbed as little as possible near present and future waste disposal areas. After the holes are filled, the surface should be sealed with 2 to 3 feet of packed clayey soil; (4) Adequate erosion and drainage maintenance should be provided; (5) The holes should be drilled at least 100 feet from the edge of the mesa at Area C. The principal concern is to prevent water from carrying the radioactive materials to the underlying bodies of ground water.[209]

A fluid dynamics study was reported in progress by the USGS in 1966.[77] The study was conducted across Ten-Site Canyon from Area C. The study area was approximately 137.2 m (450 ft) north of the east end of Pit 5. Eight holes were augered to study the behavior of gas injected into the rock; and 12 holes were augered to study the behavior of liquid injected into the rock (see Fig. C-7 and Tables C-II and C-III).

April 29, 1971,[227] the results of test drilling and penetration tests in the west end of Area C were reported. The purpose of the tests was to help establish the location for the meteorological tower (see Figs. C-8, C-9, C-10, and C-11).

"Tests at the 120 SW guy indicated that the location is underlain by a disposal pit, probably the chemical pit. No holes were drilled at the 240 N guy, the 120 N guy or the 120 SE guy."[227]

"...cuttings from all holes drilled [were monitored]. *No radioactive contamination was detected."*[227]

Notes[on Figs. C-9, C-10, and C-11]

"1. — "N" is equal to the number of blows required to drive a 2-inch outside diameter by 1.375-inch inside diameter standard split spoon sampler through a vertical distance of one foot using a 140 lb. hammer with a free fall of 30 inches.

2. — Penetration count at 6 inch interval.

3. — Natural or existing moisture content of recovered core of soil, fill, or tuff is listed to right of penetration test results. Moisture contents are circled and are in percent moisture by weight.

4. — General description of soil, fill, and tuff

***Soil,** weathered in place, a light brown, containing small crystal fragments of quartz and sanidine, rock fragments of tuff, pumice, latite, and rhyolite generally less than 1-inch in diameter in soil matrix (see particle size distribution).*

***Fill,** reworked material consisting of pebble, cobble to boulder size fragments of tuff in a matrix of soil.*

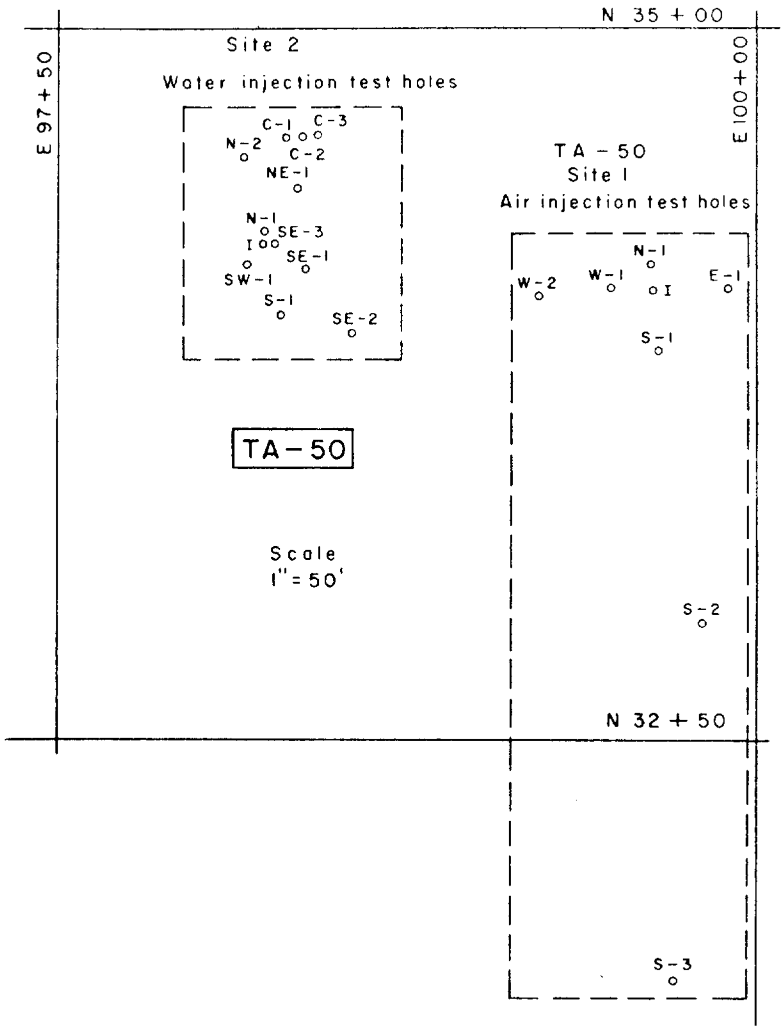


Fig. C-7.
Location of 1966 test holes at Sites 1 and 2, TA-50, north of Area C.

***Tuff** beneath the soil zone is weathered, consisting of crystal and crystal fragments of quartz and sanidine with small rock fragments of latite, rhyolite and pumice in a light brownish gray ash matrix. Pumice fragments are weathered to a light brown and are less than 1 inch in length. The unweathered tuff at depth (hole C, Fig. C-11) same as above except ash matrix and pumice fragments are unweathered; matrix light gray; pumice fragments, dark gray.*

5. — *Particle size Distributionof Soil*

Classification	*Particle Diam. mm*	*Distribution Wt. %*
Silt and clay	<0.062	8
Very fine sand	0.062 - 0.125	4
Fine Sand	0.125 - 0.250	7
Medium Sand	0.250 - 0.500	9
Coarse sand	0.500 - 1.00	16
Very coarse sand	1.00 - 2.00	11
Gravel	>2.00	45

Ref. 227

TABLE C-II

SITE 2, TA-50, LIQUID INJECTION TEST HOLES

USGS Hole Desig- nation	USGS Location Number	ERDA-LASL Designation (structure) number	ERDA-LASL Coordinates	Drilling Date	Altitude of Land Surface (feet above mean sea-level)	Diameter of hole (inches)	Depth (feet)	Type of Drilling
N-2	19.6.22.31a	TA-50-16	N 34+55 E 98+18	Sept 1965	7,247.7	5	112	Auger
NE-1	19.6.22.312b	TA-50-17	N 34+34 E 98+36	Sept 1965	7,246.6	5	118	Do.
N-1	19.6.22.312c	TA-50-18	N 34+29 E 98+26	Nov 1964	7,245.2	5	97	Do.
I	19.6.22.312d	TA-50-19	N 34+24 E 98+26	Nov 1964	7,244.7	5	67	Do.
SE-3	19.6.22.312e	TA-50-20	N 34+23 E 98+28	Oct 1965	7,244.6	4	295	Rotary, air
SW-1	19.6.22.312f	TA-50-21	N 34+17 E 98+19	Nov 1964	7,244.4	5	97	Auger
SE-1	19.6.22.312g	TA-50-22	N 34+15 E 98+39	Nov 1964	7,243.9	5	97	Do.
S-1	19.6.22.312h	TA-50-23	N 33+99 E 98+30	Oct 1965	7,242.9	4	295	Rotary, air
SE-2	19.6.22.312j	TA-50-24	N 33+92 E 98+56	Sept 1965	7,241.6	5	112	Auger
C-1	19.6.22.312k	TA-50-13	N 34+62 E 98+33	Dec 1964	Approx. 7,248	5	18	Auger
C-2	19.6.22.3121	TA-50-14	N 34+62 E 98+38	Dec 1964	Approx 7,248	5	18	Do.
C-3	19.6.22.312m	TA-50-15	N 34+63 E 98+43	Dec 1964	Approx. 7,248	5	18	Do.

Note: All holes are drilled in tuff. Hole I, the injection well, has an injection tube and an observation tube set in gravel from 55 ft to 65 ft. The bottom 2 ft from 65 ft to 67 ft are filled with crushed tuff. The hole is cemented from the surface to the top of the gravel pack at 55 ft. Hole C-1, a calibration hole, is cased with 1.5 in. steel tubing. Hole C-2, a calibration hole, open hole. Hole C-3, a calibration hole, is cased with 2 in. plastic tubing.

John, Enyart, and Purtymun, 1966[77]

The Ecology Section of the Environmental Monitoring Studies Group, H-8, is studying honeybees as a potential environmental contaminant indicator organism as honeybees accumulate tritium from the environment.[228] November 1, 1973, vegetation surrounding TA-35 (north and east of Area C) and in Area C was sampled and analyzed for tritium.[229]

"*Maximum concentrations (pCi* ^{3}H/m/plant moisture) surrounding 10-Site [TA-35] *measured about 250 pCi/ml for 10 sampling locations. Maximum concentrations in Area C vegetation measured about 185 500 pCi* ^{3}H/ml for eight sampling locations. The ^{3}H concentration in Mortandad Canyon

TABLE C-III

Site 1, TA-50 Air Injection Test Holes

Location

USGS Hole Designation	USGS Location Number	ERDA-LASL Designation (structure number)	ERDA-LASL Coordinates	Drilling Date	Altitude of land Surface (ft above mean sea level)
E-1	19.6.22.321a	TA-50-29	N. 34 + 08 E. 99 + 89	Nov 1964	7240.4
N-1	19.6.22.321b	TA-50-25	N. 34 + 16 E. 99 + 62	Nov 1964	7241.8
W-1	19.6.22.321c	TA-50-27	N. 34 + 08 E. 99 + 48	Nov 1964	7241.7
W-2	19.6.22.321d	TA-50-26	N. 34 + 05 E. 99 + 22	Nov 1964	7241.7
I	19.6.22.321e	TA-50-28	N. 34 + 07 E. 99 + 64	Nov 1964	7241.6
S-1	19.6.22.321f	TA-50-30	N. 33 + 86 E. 99 + 65	Nov 1964	7239.7
S-2	19.6.22.321g	TA-50-31	N. 32 + 89 E. 99 + 81	Nov 1964	7231.6
S-3	19.6.22.321h	TA-50-32	N. 31 + 63 E. 99 + 77	Nov 1964	7218.3

Construction

USGS Hole Desig-nation	Dia-meter (in.)	Depth (ft.)	Depth Injec-tion Zone No. 1	Depth Injec-tion Zone No. 2	Depth Injec-tion Zone No. 3	Depth Injec-tion Zone No. 4	Type of Drill-ing	Remarks
E-1	3	86	3- 8	37- 43	69-74	81-86	Rotary-air	Monitoring tubes
N-1	5	94	3- 6	25- 30	54-60	86-94	Auger	Injection and monitoring tubes
W-1	3	91	3- 8	39- 44	69-74	86-91	Rotary-air	Monitoring tubes
W-2	3	114	3- 8	109-114	-	-	do.	Do.
I	5	60	3- 8	25- 30	55-60	-	Auger	Injection and monitoring tubes
S-1	5	90	3- 8	24- 29	50-55	83-90	do.	Do.
S-2	5	56	49-56	-	-	-	do.	Water injection test
S-3	5	43	-	-	-	-	do.	Open hole

Note: Injection zone consists of 3/8" diameter gravel. Monitoring tube is 1/2 inch plastic tubing perforated about 1 foot from bottom. Injection tube is 3/4" plastic tubing perforated about 3 feet from bottom. Perforations in each tube are separated from those in the other tube by lead plate. Tubes are cemented into the gravel-pack intervals.

John, Enyart, and Purtyman, 1966[77]

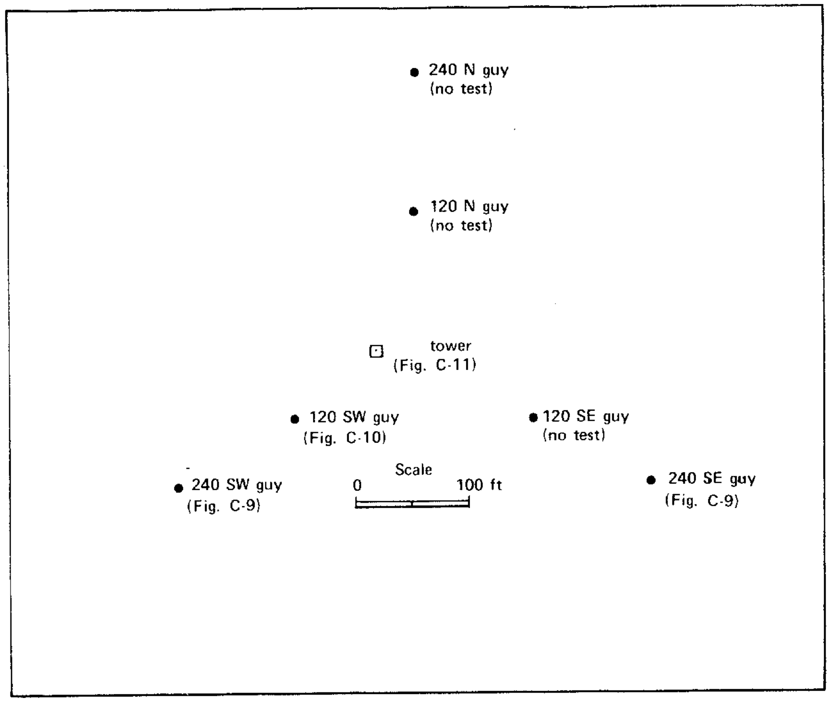


Fig. C-8.
Layout of guy and tower at Area C.

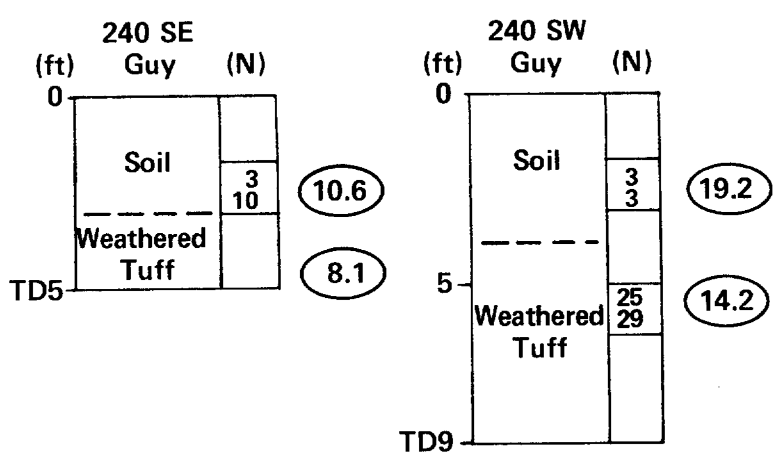
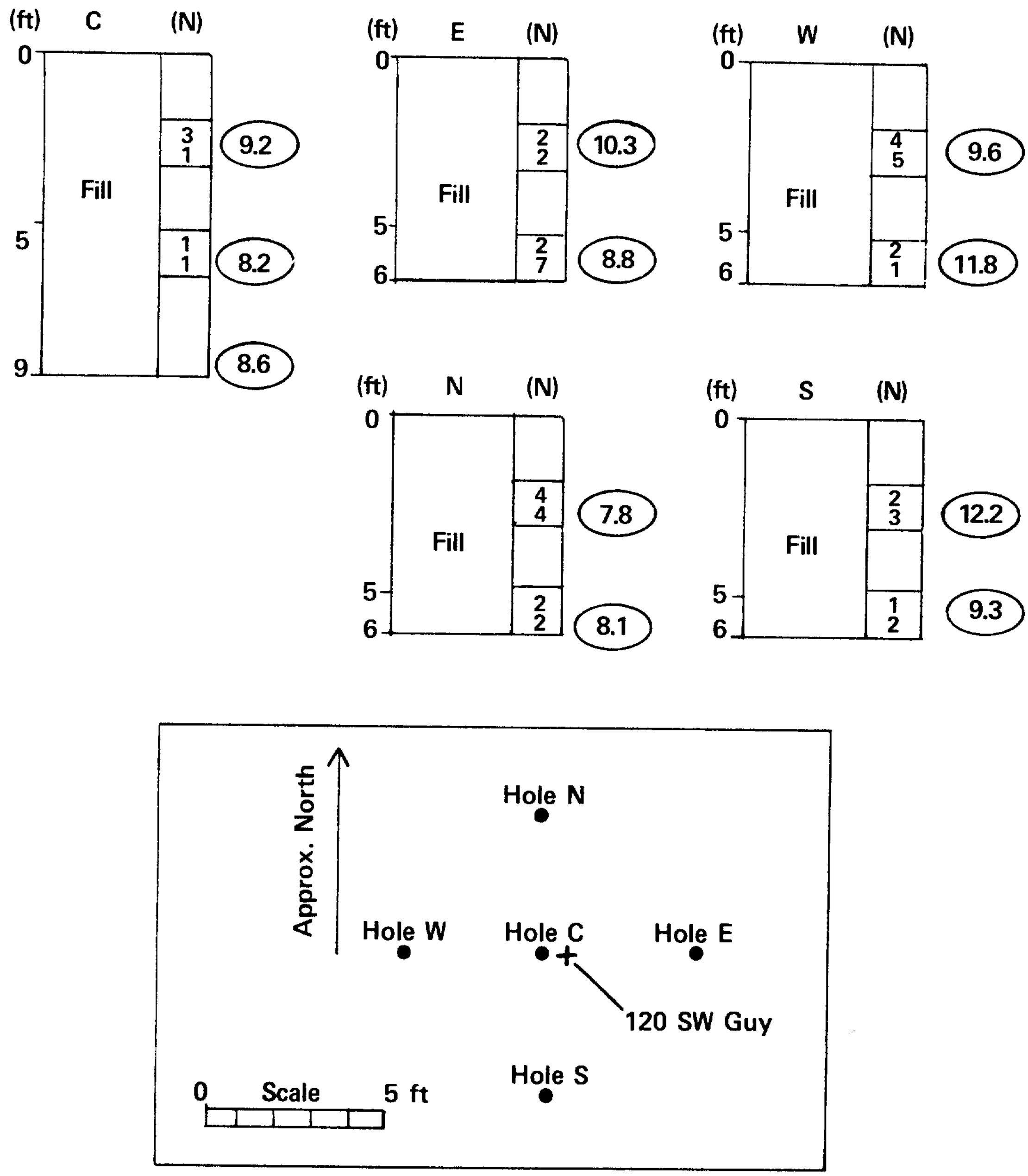


Fig. C-9.
Geologic logs including penetration tests and moisture content of soil and tuff at 240 SE Guy and 240 SW Guy of meteorological tower in Area C.



Planview of Holes at 120 SW Guy

Fig. C-10.
Geologic logs including penetration tests and moisture content of fill at 120 SW Guy of meteorological tower in Area C.

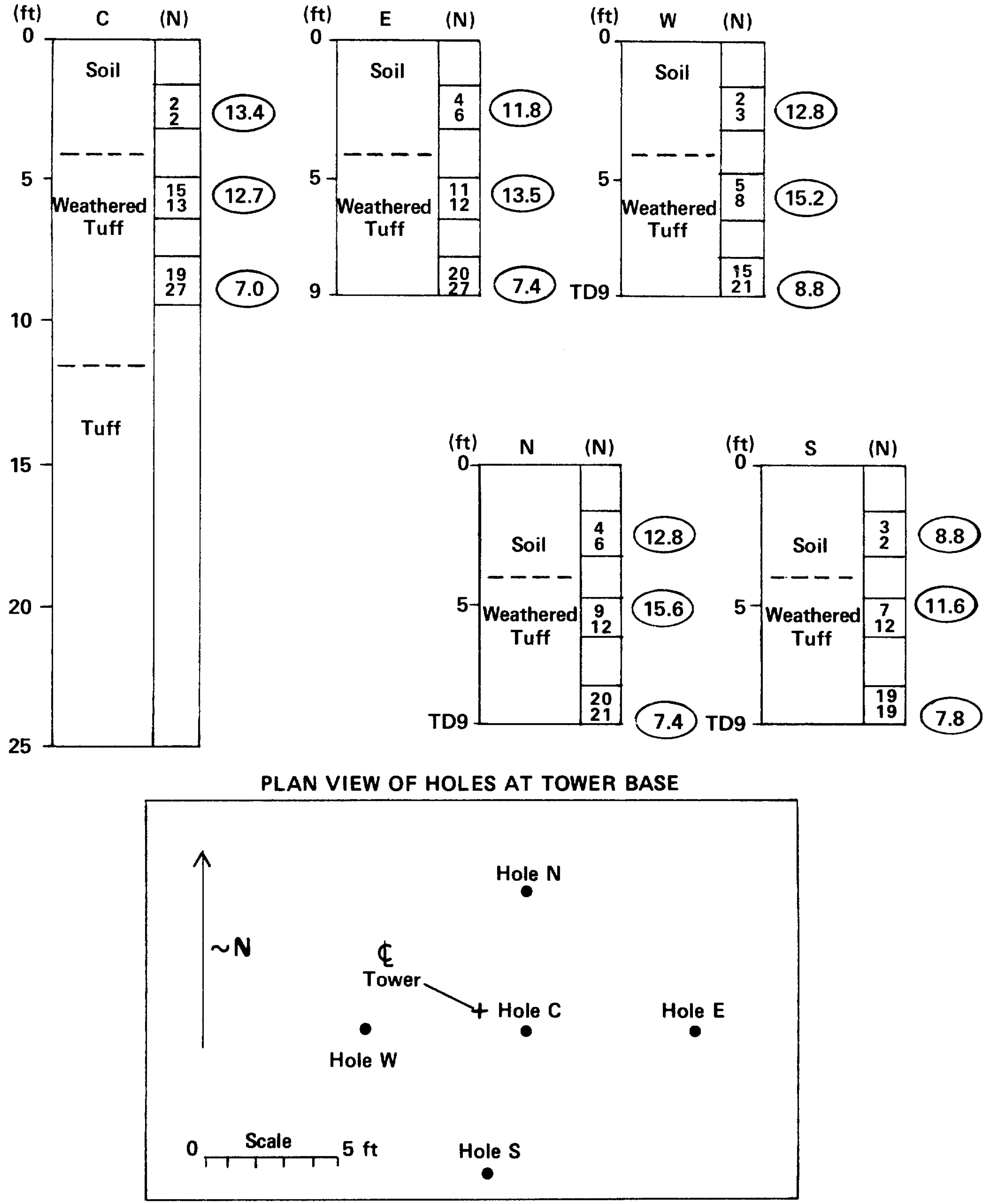


Fig. C-11.
Geologic logs including penetration tests and moisture content of soil and tuff at meteorological tower base in Area C.

[the major canyon north of Area C] *bees on this date measured 2630 pCi/ml. While 10-Site vegetation did not contain sufficient concentrations to account for levels in bees, Area C vegetation did. It seems evident that some of the ^3H buried in Area C is available to vegetation and hence honeybees."*[229]

September 9, 13, and 14, 1976 soil and vegetation were sampled at 86 points in Area C.

"...The area was also surveyed with a phoswich detector. The purpose of the study was to determine the amount of radioactivity on or near the surface...

A vegetation sample over an area of 0.1 m² and a soil sample 10 cm × 10 cm × 5 cm deep was collected at each grid location. More intensive sampling was done around Waste Disposal Shafts #9, #77, #88-90, #107 and the ^{90}Sr shaft (18 samples within a radius of 5 m around each shaft). [These] *selected ... shafts ... contained large amounts of ^3H, U, fission products of Sr. Analysis of these samples will be started in October.*

The phoswich detects gamma radiation. Twenty-six 'hot spots' were found. ... Background on the phoswich is 1.2 × 10³ cpm or '1.2K'. The activity on the 'hot spots' ranged from 1.3K to 90K. These readings cannot be translated to pCi/g unless one knows the geometric distribution of the contaminant. There is some correlation between the phoswich 'hot spots' and the amounts of fission products that went into the shafts.[a] *This appears in the accompanying table.* [See Table C-IV]. *What went into the pits isn't known well enough to make any correlations. Samples will be collected at each 'hot spot' and analysis will be begun in October.*

---

[a]*...some shafts which contained large amounts of fission products were not detected with the phoswich. This could be a function of depth of FP from surface or type of containment, etc."*[282]

There are reports of five fires at Area C. The first took place at 8:35 a.m., November 7, 1950.[224]

"An air sample was taken with the hand air sampler. Its negative results were reported to headquarters. There was no detectable beta or gamma in the pit or at its edge so two firemen, in full protective clothing and respirators, entered the area with hoses from the tank truck which had just arrived. While steam was rising from the fire, a second air sample was taken in the steam and smoke cloud. It too was found to be negative. The fire was brought under control using two tank trucks full of water."[224]

The second fire was reported June 5, 1952 (written communication, J. W. Enders, H-7, 1974). LA Notebook 4664, p. 70, records: *"When boxes were being unloaded, one box caught fire and was immediately put out...."*

The third fire occurred at 4:25 p.m., March 24, 1953.[225] The burial ground had been checked at approximately 3:00 p.m. when the crew left after the last delivery. Later, smoke was seen coming from the burial ground.

"Upon arriving at the dump we [C. D. Blackwell and J. Oakes] *discovered a fire that had burned itself out with the exception of several barrels of paraffin which were boiling and burning to a small extent... Two 5-gallon cans of foam were used to completely blanket the fire, and it was completely out by 5:25 pm. The wind was from the west and brisk, so that smoke was carried east and traveled a path between Ten Site and Beta Site... The dry box from the Omega Fast Reactor, which had been placed in the dump on March 23, 1953, had been completely burned, leaving only the steel frame.*

TABLE C-IV

PHOSWICH READINGS FOR SEPTEMBER 1976 AREA C SURVEY[282]

"Hot Spot" # Near Shafts	Phoswich Reading (cpm)	Amount of Contaminant That Went Into The Nearby Shaft
#12	50 K	839→1291 Ci of Ba-La waste in Shafts 2, 3, 4
13	1.5 K	500 Ci ^{3}H + 350 Ci of Ba-La in #9
14	>1.2 K	738.6 Ci FP from Ra-La in #16
15 → 19	5 K → 90 K	Nothing remarkable in the nearby shafts (will be researched more)
20	40 K	645 → 755 Ci Ra-La in #46 & 48
21	5 K	Nothing remarkable
#10	1.5 K	Near ^{90}Sr shaft
23	3 K	89 Ci FP & MAP & 500 g U in Shaft #71 & 500 g U in #72
24	1.3 K	880 Ci Ba-La & 1221 g U in #77
25	5 K	Nothing remarkable

The dump had last been covered on March 20, 1953, so that the results of only 2-days hauling were exposed to the fire. No one could determine the cause of the fire, but it was generally believed to have been caused by chemicals being accidentally placed in the boxes with some of the trash. A survey was made around the dump on the morning of March 25, 1953, to check for possible contamination from the smoke. The area east of the pit and parts of the canyon from Beta Site to Ten Site were checked, but no trace of contamination could be found. Any contamination that may have gotten into the air was well diluted and carried away rather than being deposited in the vicinity."[225]

The fourth fire was reported April 22, 1953 (written communication, J. W. Enders, H-7, 1974). LA Notebook 4644, p. 148, records: *"One box from Sigma Building was smoking while being thrown into dump. Was put out with fire extinguisher."*

The fifth fire took place November 28, 1958, in Pit 6.

"Two boxes were found burning during a covering operation. It is suspected a volatile, flammable chemical was involved, as near the boxes...a flask [was found] *that possibly had been used to hold acetone."*[180]

AREA D

I. GENERAL INFORMATION

Area D is located at TA-33, 2.9 km (1.8 miles) east of the guard station (Fig. D-1). By the LASL coordinate system it is located between coordinates S.287+50 and S.282+50, and E.310+00 and E.305+00. The location by township and range is SW 1/4 sec. 20, T. 18 N., R. 7 E.[30]

Two underground chambers have been designated as Area D. ENG-3 memo[230] dated May 23, 1967, states that Area D is two open areas 6.1 by 9.1 m (20 by 30 ft).

II. GEOLOGY AND HYDROLOGY

Area D is located on top of a mesa formed by Ancho Canyon and White Rock Canyon of the Rio Grande (see Fig. D-2). The surface appears flat and is underlain by the Tshirege Member of the Bandelier Tuff. The soil cover is thin. The site is approximately 304.8 m (1000 ft) above the Rio Grande and about 243.8 m (800 ft) above the bottom of Ancho Canyon.

III. CHAMBER DESCRIPTIONS

A. Background

Underground Chamber 1 is HP-4; underground Chamber 2 is HP-6. An experiment had been detonated in HP-4 before July 22, 1948.[231] Excavation of HP-6 began August 25, 1948, and was completed September 5, 1948.[232] The experiment in Chamber 2 was detonated at 9:00 p.m., December 23, 1948.[233]

B. Type of Waste

According to a 1963 USGS report,[30] the Area D underground chambers were contaminated with explosives containing ^{238}U. Health Physics, H-1, considers the chambers to have been contaminated by polonium and perhaps a trace amount of uranium. (Personal communication, C. D. Blackwell, H-1, 1974). A trace amount of ^{60}Co from a fired projectile may be present at the site. (Personal communication, D. D. Meyer, 1974).

C. Mode of Disposal

The HP-6 shaft was 1.8 m × 2.4 m (6 ft × 8 ft) with a depth of 14.0 m (46 ft).[234] It was completely shored with 5.1-cm × 30.5-cm (2-in. × 12-in.) timbers.[234] The octagon-shaped chamber, 4.3 m (14 ft) wide with a 3.7-m (12-ft) ceiling, is concrete reinforced with steel and extends southeast from the bottom of the shaft.[234] The door of the chamber

> *"...was made of steel plate and wood filled. The edges of the door were wedgeshaped, so that the more pressure applied on the door from within, the tighter the door would be closed. The door was secured by a steel latch 3/8" thick and 3" - 4" wide, operated by a handle on the outside of the door."*[234]

HP-4 was probably very similar in construction to HP-6.

No equipment in HP-6, except half of the hemisphere which had a count of approximately a million counts per minute, was brought to the surface because of the high level of contamination.[234]

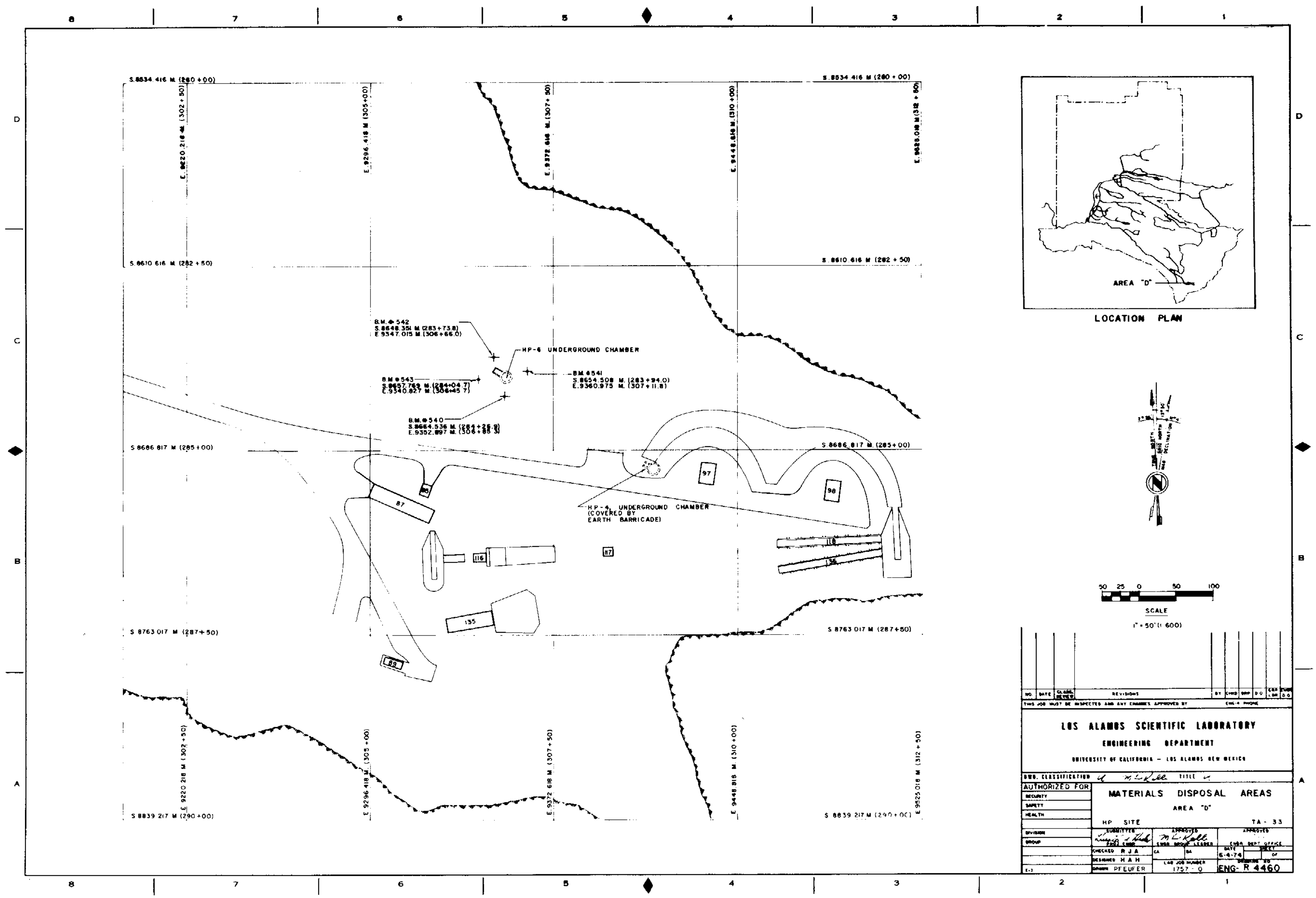


Fig. D-1.
Materials Disposal Area D, HP Site, TA-33.

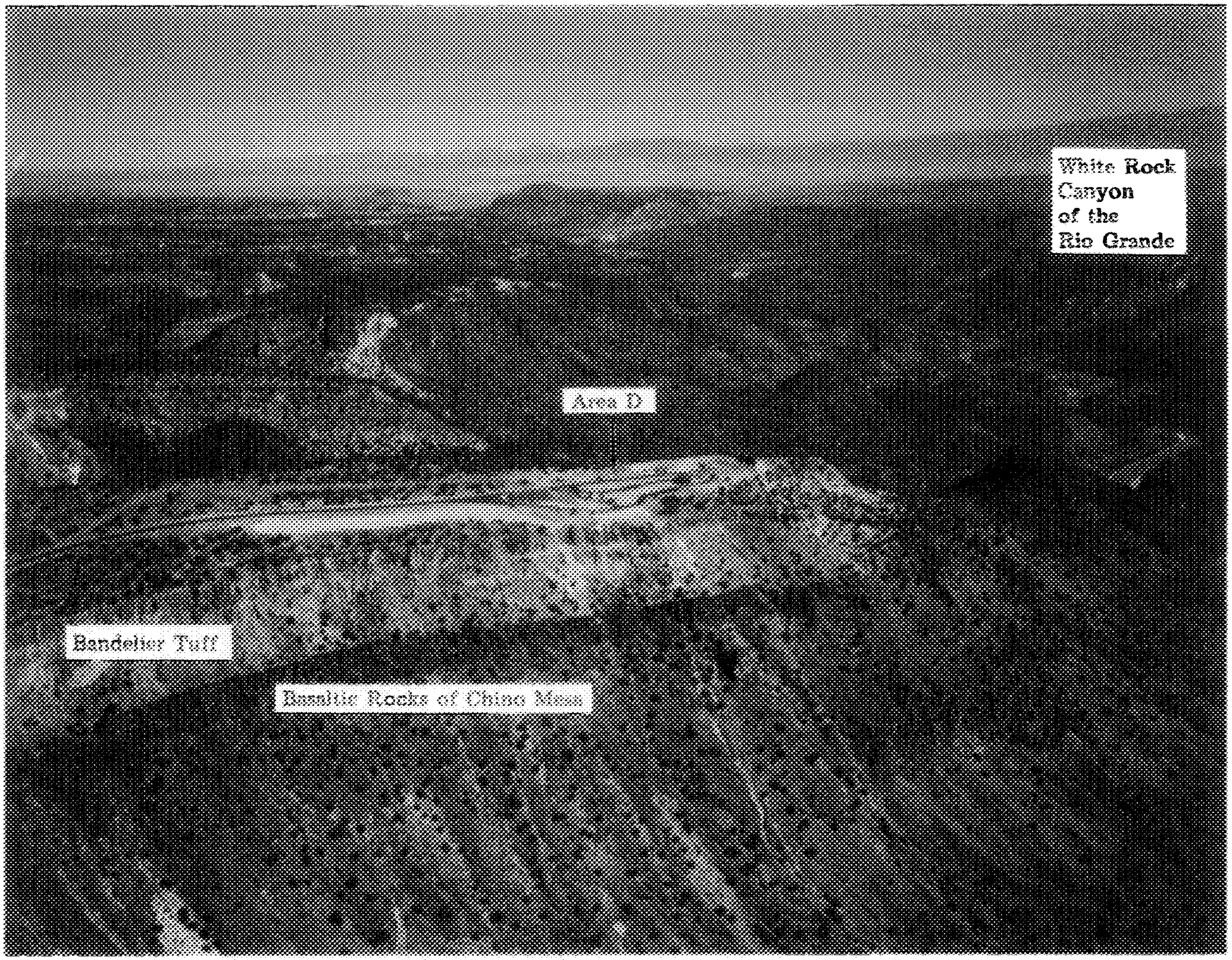


Fig. D-2.
Aerial view of Area D looking north.

> *"A table was placed in the center of the room* [chamber] *to support 600 lb of TNT. The TNT was so arranged that the center of the explosives would be six feet from the floor...approximately 600 mc of Po* [was supplied] *in a vial which was placed in with the charge. The door was closed and equipment that was in the shaft only was brought to the surface and monitored... On April 15, 1952, the shaft was refilled and a tank truck filled with water was on hand to wet down the sand as the shaft was being filled."*[234]

The shot was fired at approximately 11:15 a.m. on April 15, 1952.[234]

> *"As the explosion came, a mass of dirt and debris reached an altitude of approximately 75 feet above the mesa. The dust was quickly carried away by the wind but the mesa was covered with coarse dirt and pieces of burned wood and some metal fragments... A crater over the shaft was formed to a depth of approximately 10 feet. The steel pipes containing the cables were pulled loose from the wall and pushed over in the pit. The concrete block, where cables terminated, was turned over."*[234]

There are no records which indicate HP-4 was disturbed after its experiment.

IV. STUDIES AND MONITORING

Chamber 1 (HP-4) was surveyed July 22, 1948.[231]

"As per request, enclosed area directly over the vicinity of the elevator shaft to the first experiment at TA-33 was monitored this a.m. Results were negative. Area south of the fence was monitored also. Results negative. Both areas are therefore considered safe for entry."[231]

During the excavation of Chamber 2 (HP-6) monitoring work was carried out.

"Monitoring operations by the monitoring section of H-Division started on 26 August 1948 and continued each day for eleven days through 5 September 1948. A monitor entered the shaft each morning and afternoon of each day checking approximately at intervals of about 2.5 ft of excavation. At the same time the rock and dirt removed from the shaft were monitored and a dirt sample taken and given to ... the Medical Lab for polonium analysis. This was also done each morning and afternoon...

During the entire monitoring no alpha activity was detected. Meter used [was] *a Pee Wee Alpha Survey."*[232]

After the detonation of the experiment, December 23, 1948, in Chamber 2, the site was inspected.

"On driving to the covered-in shaft, no cracks in the ground could be found. The entire area over the shaft was checked with an Alpha survey meter. The results were negative. The area was rechecked on December 29,1948. Results were again negative. Snow and mud hampered a complete survey on this date."[235]

On April 7, 1952, the re-excavation of Chamber 2 began.[234] Before heavy equipment was placed over the shaft the ground was checked for contamination and found to be negligible. On April 8 the sand was removed from the shaft by clam shell. As the sand was removed, it was surveyed for alpha contamination. The results were negative as was the survey of the shaft as the sand was removed.

"The first contamination to be found was on the steel box on the south side of the room. It had ruptured during the shot, leaving a crack about 1/4" wide. This box housed wiring from the room and was fed from the box to the surface by three steel pipes. Approximately 8000 c/m was found on the steel box about four inches above where the seam had ruptured. The rest of the steel box had very little or no count. Contamination on the steel box would not rub off but seemed to be imbedded in the pores of the metal. The sand removed from the steel door was free of contamination but contamination in the amount of 15,000 c/m could be found along the top of the door where it fitted against the concrete. The door had a felt seal and some felt was hanging loose as a result of the blast, and this felt gave a reading of approximately 30,000 c/m"[234]

The door was jacked open with two 50-ton jacks on April 11, 1952.

"As the door was opened inch by inch, the area around the door was monitored and the count began to go up very rapidly. It was very damp around the room [chamber] *and drops of water and white mold could be seen on all the ledges. Everyone had been very concerned about the dust problem when the room was entered, but with so much condensation on the concrete, the Po was sticking to the surface very well.*

[The chamber] *was covered with twisted metal and all the equipment was battered and tossed about the room. The rubble was from 1' to 2' high all over the room and our meter gave a reading of 200,000+ c/m on any equipment that was checked...several pictures* [were shot]..."[234]

A path was cleared from the door to the center of the chamber where 600 lb of TNT were placed on a table. *"By this time,* [April 12] *the surface in the room was beginning to dry out because of the presence of outside air and the level of detectable contamination had risen to 250,000 c/m."*[234]

"On April 15, 1952, the shaft was refilled and a tank truck filled with water was on hand to wet down the sand as the shaft was being filled. This was to relieve the dust problem in case the shaft was to be re-excavated after the shot and if no contamination could be found on the surface. Three filter queens in the area near the shaft and one placed 1000' away where personnel were to be located were run from 1 h 15 min before the shot to record a background for the area and for the filter queens. The filters were changed before shot time and filters run for 1 h 9 min, being stopped 30 min after the shot was fired. All personnel, camera crew and firing crew were stationed outside the fence over 1000 ft from firing area and all personnel were issued a respirator. The camera crew was stationed at approximately 800 ft and firing crew 600 ft from firing area. These crews were issued assault masks equipped with ultra filters. The wind, at shot time, was blowing in the direction of observers, so the shot was held up for a few minutes. It was fired at approximately 11:15 am, on April 15, 1952, and the wind was blowing from northeast to southwest. As the explosion came, a mass of dirt and debris reached an altitude of approximately 75 feet above the mesa. The dust was quickly carried away by the wind but the mesa was covered with coarse dirt and pieces of burned wood and some metal fragments. Monitors approached the area about 15 min after shot time in full protective clothing. The area was free from radioactivity (sic) *contamination until we reached the fenced area, where 2000 c/m was recorded. The dirt in the area showed a count of 20,000 c/m with bits of wood going as high as 200,000 c/m. Bits of twisted metal from the room were found in the shot area. A crater over the shaft was formed to a depth of approximately 10 ft. The steel pipes, containing the cables were pulled loose from the wall and pushed over in the pit. The concrete block, where cables terminated, was turned over. Filter queens were covered with wet dirt, some going in the intake when the dirt cloud descended after the shot. Filters were recovered and returned to Tech Area for counting."*[234]

The results of the filter queen samples are listed below:

Filter Queen Samples for 1 h 9 min During and After Shot:

Filter Queen Samples 1 h 9 min	During Shot c/m	After Shot c/m/ℓ
#1 West side 40 ft from shaft	730	0.0936
#2 East side 40 ft from shaft	460	0.0590
#3 South side 40 ft from shaft	95	0.0122
#4 Personnel area 1000 ft from shaft (1 h 2 min)	10	0.0014

A polonium analysis of soil samples was reported November 15, 1952.[235] Seven samples from Area D were analyzed. Sample A — 50,000 c/m/25 g; Sample B — no polonium; Sample C — 150 c/m/25 g; Sample D — 25 c/m/25 g; Sample E — 5 c/m/25 g; Sample F — 5 c/m/25 g; Sample G — no polonium. These samples may have been centered over Chamber 2 (see Fig. D-3 for sample location).

"On August 24, 1953, a contamination survey was made within the fenced-in area of underground Chamber #2 at Hot Point at TA-33. This survey was made to establish the alpha contamination level within the area and results were to be used as a guide in determining the safety precautions to be used in clearing the area of debris, removing existing mounds of dirt, and filling the open pits so that the area could be made level for building purposes."

The surface of the ground showed no detectable alpha contamination, but some of the timbers in the area gave counts ranging up to 500 c/m. Some dirt was removed around the large open pit and soil at a depth of 2 ft gave a reading of 500 c/m.

The crater of underground Chamber #2 appears to be large enough to hold all the contaminated dirt and all mounds of dirt found to be contaminated could be pushed directly into the crater. Then a layer of dirt free from contamination could be used to leave all exposed surfaces without detectable counts."[236]

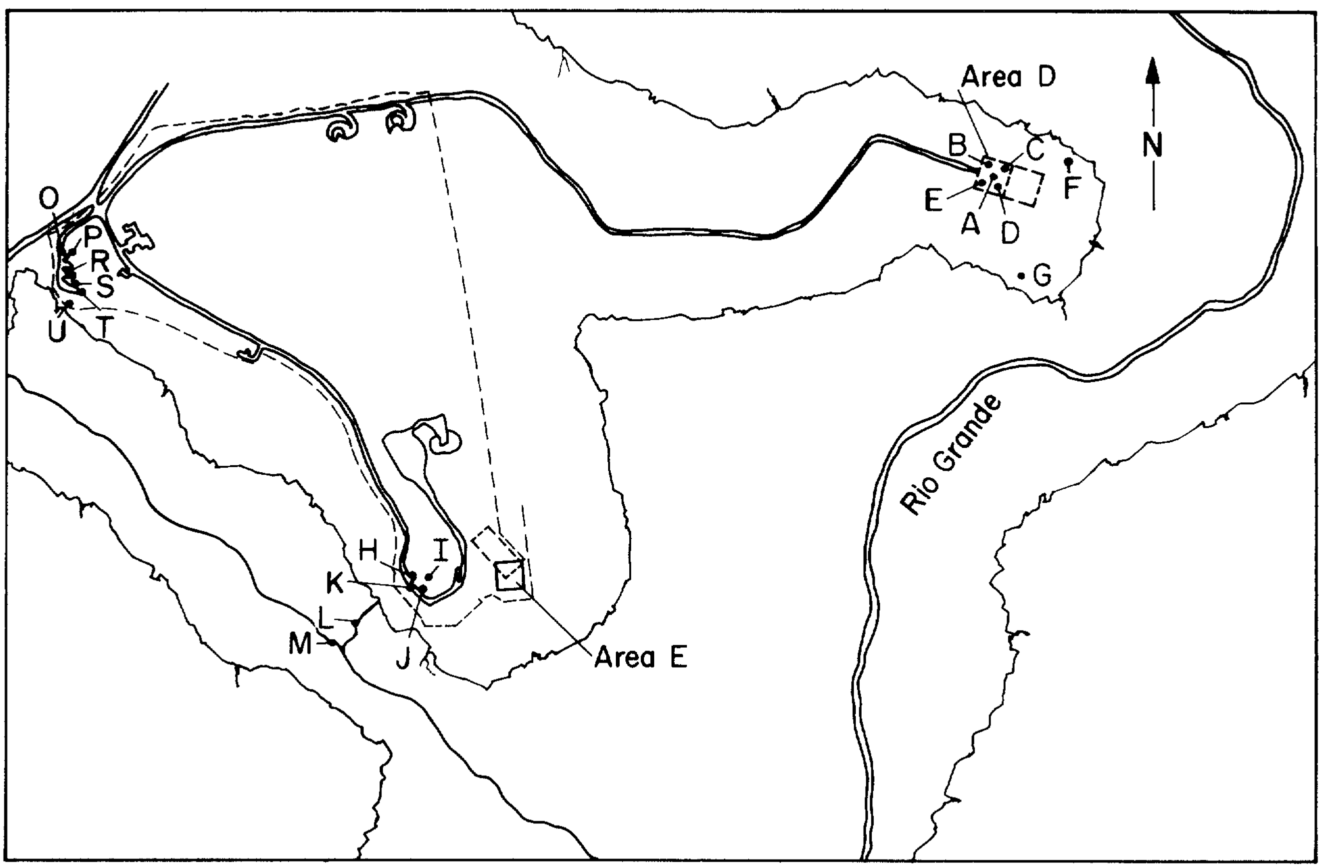


Fig. D-3.
Location of 1952 soil samples A through G at Area D, TA-33.[235]

On October 21, 1953,[237] the area around Chamber 2 was bulldozed. A radiation survey was then made and the results were negative. *"The contamination that had been in the area has been reduced by normal decay and some will be buried under a heavy layer of dirt in the area."*[237]

A preliminary survey of local wind conditions with primary emphasis on terrain effects under relatively light wind conditions was reported May 2, 1955.[238] Area D is now referred to as the "New Area."

> *"This area is located in the eastern portion of TA-33 and is surrounded on the south, east, and north by relatively deep and rugged canyons. In addition there are two bunkers surrounding the firing pads. In this area the wind flow is much more complicated than that in Areas 6* [probably Area K] *and 7* [probably Area E] ... *The flow in New Area will be marked by turbulent eddies and erratic changes in direction. No confidence could be placed in a persistence forecast of an observed wind direction."*[238]

AREA E

I. GENERAL INFORMATION

Area E is located at TA-33, 1.9 km (1.2 miles) south of the guard station (see Fig. E-1). It is located between LASL coordinates S.292+50 and S.295+00, and E.250+00 and E.245+00. Specifically, the coordinates of the fenced area in clockwise direction beginning with the northeast corner are: S.292+96, E.249+16; S.294+36, E.249+15; S.294+35, E.247+15; and S.292+91, E.247+16. Location by township and range is SE 1/4 sec. 24, T. 18 N., R. 6 E. It has an approximate acreage of 0.69.[230]

II. GEOLOGY AND HYDROLOGY

Area E lies on a point formed by Chaquehui Canyon and one of its tributaries. It is on the mesa approximately 122 m (400 ft) above the bottom of the canyon. The surface of the mesa slopes gently to Chaquehui Canyon approximately 6 m (20 yards) to the south of Area E.[30] The soil cover is very thin and supports little or no vegetation. The joint pattern is variable and joints are not prominent or persistent.[30] The Tshirege Member of the Bandelier Tuff crops out within a few feet of the burial ground.

III. PIT DESCRIPTIONS

A. Background

The history of Area E is not well known. According to Engineering Drawing ENG-R-2457, underground Chamber 3, TA-33-29, was destroyed in 1950. Pits 1 through 4 were used. It is not clear whether Pits 5 and 6 were used. According to Engineering Drawing ENG-R-3644, Pit 1 was inactive July 1951; Pit 2 was reported November 7, 1962[239] as open; Pit 3 was closed September 1951; and Pit 4 was still active when Engineering Drawing ENG-R-3644 was drawn in the sixties. A 1963 USGS report[30] states that the area was used between 1949 and 1955.

B. Type of Waste

"Area E at TA-33 has been used as a storage area and for burial of low-level radioactive contaminated equipment."[239] The area contains several hundred kilograms of ^{238}U (Ref. 30). Another source[223] also states the burial pits contain ^{238}U and ^{238}U alloys.

Chamber 3, HP-29, is contaminated by the device which was fired in it. Pit 1 contains LC, LE miscellaneous polonium-beryllium fired targets with a total of 240 curies. Pit 2 contains Wally, 60 curies. Pit 3 contains a GI can of beryllium dust immersed in kerosene. Pit 4 contains Button and miscellaneous hot material. There is no information available on the contents of Pit 5 or Pit 6 (Ref. Engineering Drawing ENG-R-3644).

C. Mode of Disposal

Chamber 3, HP-29, is probably constructed similarly to Chamber 2, HP-6, at Area D. It has been backfilled. Underground Chambers HP-70 and HP-71 are north of the Area E fence. These chambers were not used and remain open today.

The pits are probably shallow. The USGS reported in 1963[30] that there were four pits, each 1.8 - 2.1 m (6 - 7 ft) deep. Pit 1, located along the west fence line, is approximately 5 m (15 ft) wide and 23 m (75 ft) long. Pit 2, located along the south fence line, is approximately 5 m (15 ft) wide and 14 m (45 ft) long. Pit 3, located near the southeast corner, is approximately 1.5 m (5 ft) in diameter. Pit 4, located near the southeast corner along the east fence line, is approximately 5 m (15 ft) wide and 30 m (100 ft) long. Pit 5 and Pit 6 intersect. They are located west and north of Pit 4. Pit 5 is approximately 4 m (12 ft) wide and 24 m (80 ft) long. Pit 6 is approximately 4 m (12 ft) wide and 19 m (63 ft) long.

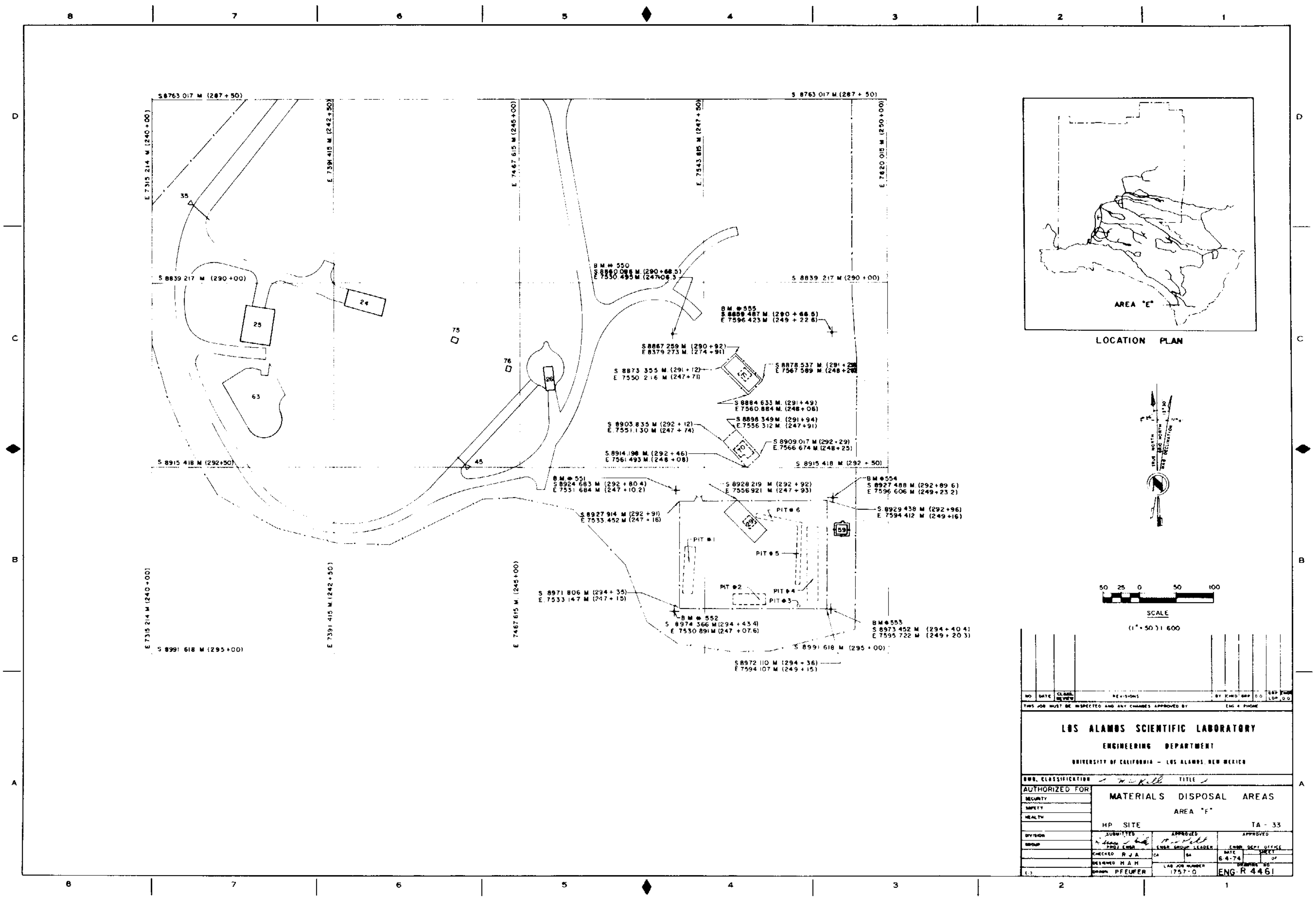


Fig. E-1.
Materials Disposal Area E, HP Site, TA-33.

IV. STUDIES AND MONITORING

February 28, 1952,[240] two 50-g soil samples were taken from Chaquehui Canyon west of Area E. They were analyzed for polonium. The approximate values for both in counts per minute (50% geometry) were 100.

The analysis of soil samples (H through M, Fig. E-2) was reported on November 15, 1952.[235] Samples L and M were probably taken in the same place as the February 28 samples. The analysis was for polonium. Sample L had 22 c/m/25 g; and Sample M had 17 c/m/25 g. Samples H through K showed no polonium.

A fire was reported early in the morning of April 15, 1953, in Pit 4 at Area E.[241] Shortly after 8:00 a.m., H-Division, W-3, and Fire Department personnel arrived.

> *"...It was apparent that some oily rags covered with loose earth were smouldering and causing small quantities of smoke to rise. The Fire Department was then called in to flood the small smouldering portion of the pit with water. Respirators and coveralls were worn during the initial inspection and water application."*[241]

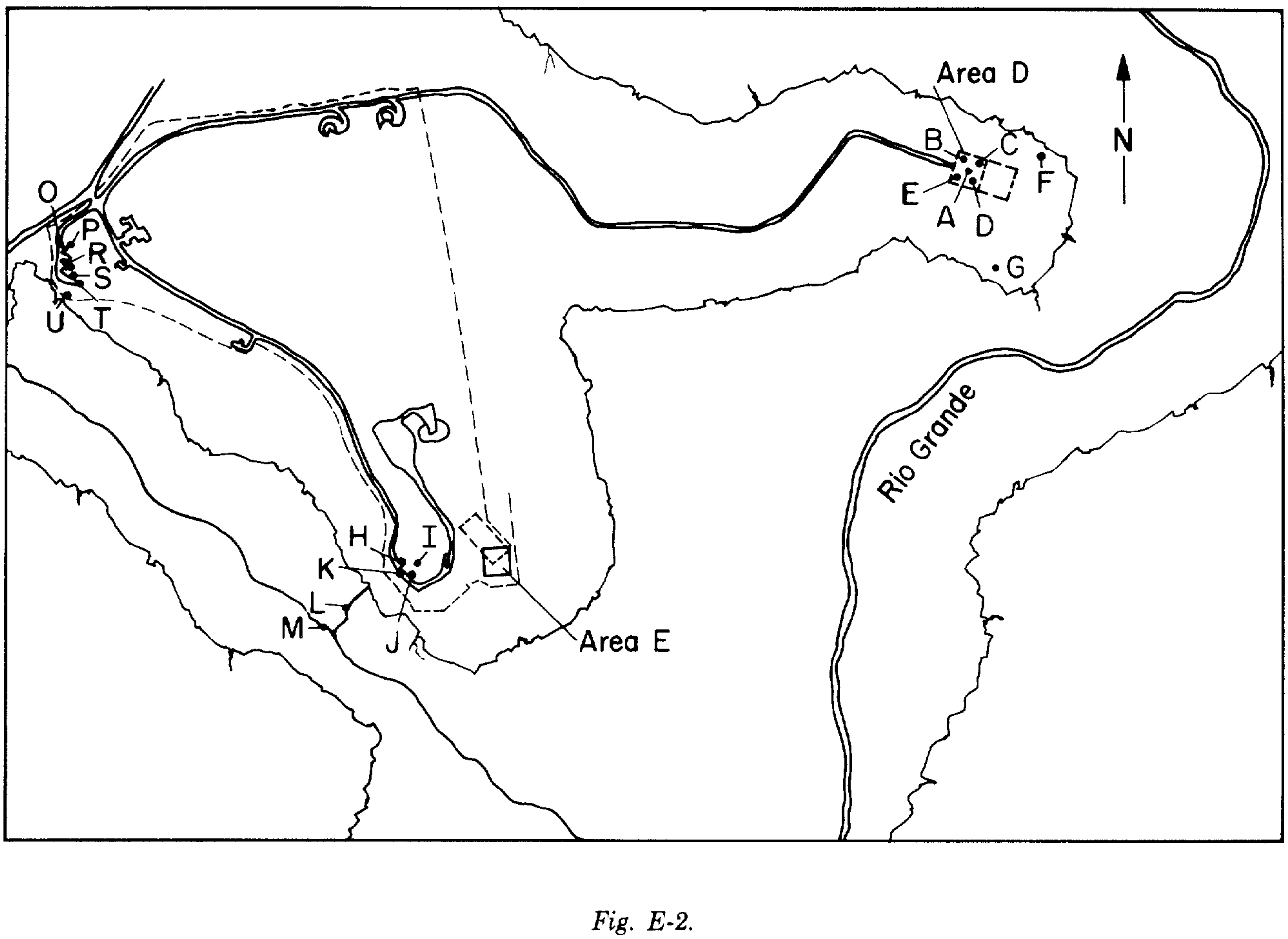


Fig. E-2.
Location of 1952 soil samples H through M near Area E, TA-33.[235]

On April 20, 1954,[242] soil samples were collected for uranium analysis by the fluorophotometric method. "New Hot Point" on Fig. E-3 probably includes Area E. Sample 7 and Sample 15 (each 25 ml samples) had values of 35 mcgs/sample and 22.7 mcgs/sample, respectively.

A preliminary survey of local wind conditions with primary emphasis on terrain effects under relatively light wind conditions was reported May 2, 1955.[238] Area E is referred to as Burial Area 7.

"This area is located on the west rim of a canyon oriented generally north-south and opening to the south... Dominant flow in Burial Area during the major part of the afternoon will be from the south-southwest. These conditions will be fairly persistent and a high degree of confidence could be placed in continuation of an observed direction of flow."[238]

In 1962[239] it was observed that

"At the time of...inspection, the area was enclosed with a three-strand barbed wire fence, with six signs on the fence indicating that the area is contaminated. The gate was open and the area is

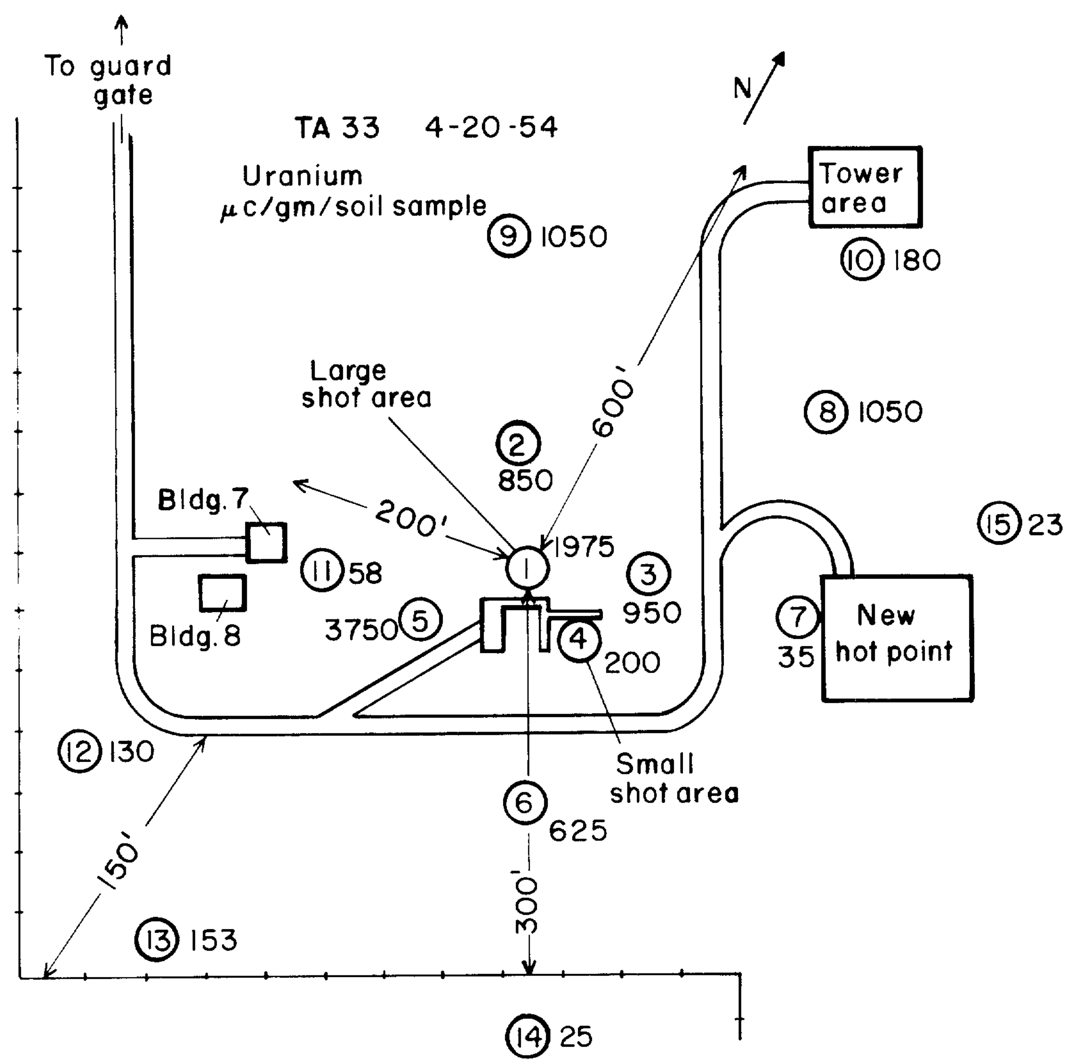


Fig. E-3.
Location of 1954 soil samples 1 through 14 near Area E, TA-33.[242]

becoming a junk yard. [It was suggested] *(1) The gate should be repaired and kept locked. (2) New signs should be placed on each side. The signs should read 'contaminated area — do not enter' and should use the radiation symbol and radiation colors. (3) The open pit on the south side of the area* [Pit 2] *is full and should be covered with at least two feet of dirt. (4) The material in the area should be monitored and if not needed it should be sent to the contaminated waste disposal area on Mesita del Buey. If the material is of value it should be sent to decontamination...and (5) The wooden building just outside the gate should be cleaned out and monitored."*[239]

A 1963 USGS report stated *"The fill probably should be compacted and mounded to minimize erosion and ponding of water around the pits."*[30]

AREA F

I. GENERAL INFORMATION

Area F is located on Two-Mile Mesa Road 2.1 km (1.3 miles) east of the intersection of Two-Mile Mesa Road and West Road (see Fig. F-1). It is north of Two-Mile Mesa Road within LASL coordinates N.35+00 and N.30+00, and E.12+50 and E.7+50. The boundaries of Area F are not strictly defined. There are two burial sites. The small one, closest to the road, has coordinates (beginning with the northeast corner and moving in a clockwise direction) of N.31+68, E.9+54; N.31+25, E.9+46; N.31+30, E.9+00; and N.31+82, E.9+13. The larger site, to the east and north of the smaller one, has coordinates of N.32+70, E.11+94; N.32+37, E.11+96; N.32+51, E.10+26; and N.32+86, E.10+28. Location by township and range is described as near the center of sec. 20, T. 19 N., R. 6 E. The approximate acreage for Area F is 0.18.[230]

II. GEOLOGY AND HYDROLOGY

Two-Mile Mesa is formed by tributaries of the northern branch of Pajarito Canyon. Area F is centered between the tributary canyons. It is at a distance of approximately 457 m (1500 ft) from either canyon and lies about 24 m (80 ft) above the canyon floors. Soil cover for the smaller site is approximately 0.6 to 0.9 m (2 to 3 ft) thick. For the larger area it is approximately 0.3 to 0.6 m (1 to 2 ft) thick.[30] The surface of the smaller site is level while the surface of the larger pit slopes gently north. Excavations at both sites are in the Tshirege Member of the Bandelier Tuff. A 1963 USGS report[30] notes that there is little indication of erosion over the smaller site; however, sheet erosion is evident near the larger site and a small wash has been cut at the west end of the site. *"Blocky tuff with no apparent joint pattern and a northward slope of less than 5 percent crops out between the fenced area* [larger site] *and the south fork of Two-Mile Canyon a few hundred feet north."*[30]

III. PIT DESCRIPTIONS

A. Background

May 15, 1946,[243] the Director of LASL wrote a memo to division and group leaders concerning a disposal pit at TD-site (see Fig. F-2). TD-site on the memo is crossed out, and Two-Mile Mesa is penciled in. Another penciled note says the pit was completed May 7, 1946.

B. Type of Waste

No reliable information on the waste materials has been found to date. In 1952, J. Bolton, Assistant Director for Engineering, reported *"Dump F contains some alpha contamination but is essentially used for disposal of toxic compounds."*[189] The USGS reported in 1963[30] that there were beta-gamma emitters buried in Area F. In January 1973, D. Meyer of H-1 stated[223] that the burial pits contain a very small burial of equipment contaminated by ^{90}Sr and ^{137}Cs. In March 1974, R. Reider of H-3 said his sources of information indicate that the sites contain no radioactively contaminated material but that the smaller site does contain HE contaminated material and that the larger site may contain HE contaminated material.

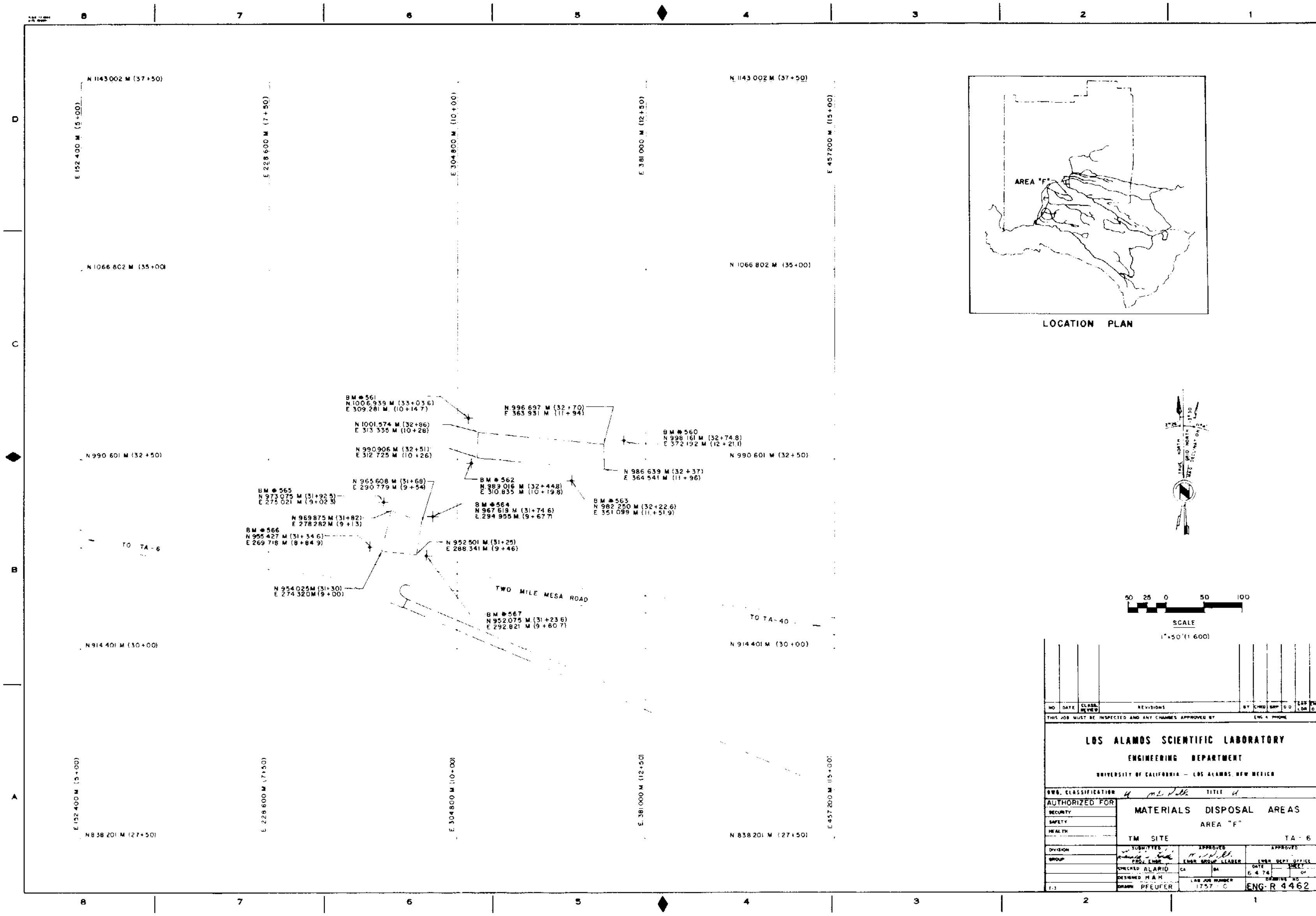


Fig. F-1.
Materials Disposal Area F, TM Site, TA-6.

TA-6-H

May 15, 1946

AREA 'F'

Covered over now located near Concrete bowl

To: Division and Group Leaders

From: N. E. Bradbury

Subject: Disposal Pit at ~~TD Site~~ Two Mile Mesa

Completed May 7, 1946

An obsolete material pit for the disposal of classified objects and shapes has been prepared at TD Site where such material will be made secure by burying. This pit will be open until 1 June. It is urged that divisions and groups "clean house" of obsolete, non-usable, but classified material by the use of this pit.

Division and group leaders desiring to use the pit will notify Security Office, Ext. 541, prior to their delivery of the obsolete classified material. The Security Office will record and locate such material in the pit.

N. E. Bradbury
Director

Called Wilhoyt's office re anchor Ranch Barns & stuff stored out there, also Allen & Newell. Went over & talk to Hightower. Talked to Ken Marple

Fig. F-2.
Memo from N. E. Bradbury to Division and Group Leaders, May 15, 1946.

C. Mode of Disposal

On Engineering Drawing ENG-R-4462, Area F is shown as two distinct sites. The smaller site is considered to have several pits within it. It approximates a square of 13.4 m (44 ft). The larger site is rectangular, approximately 10.7 m (35 ft) by 52.4 m (172 ft). After visiting Area F, the larger site appears to be 9.1 m (30 ft) by 118.3 m (385 ft).

IV. STUDIES AND MONITORING

None known. Area F was described in the 1963 USGS report "Geologic and Hydrologic Environment of Radioactive Waste Disposal Sites at Los Alamos, New Mexico."[30]

AREA G

I. GENERAL INFORMATION

Area G is located on Mesita del Buey approximately 3.2 km (2 mi) southeast of the intersection of the Access Road and Pajarito Road (see Fig. G-1). It is within LASL coordinates* E.290+00 and E.270+00 and E.85+00 and E.70+00. Its location by township and range is S 1/2 sec. 31 T. 19 N., R. 7 E.

II. BACKGROUND

October 18, 1956, a request[72] was made for additional waste disposal area.

"The present waste disposal pit [Pit 6, Area C] *will soon be filled and the excavation of additional pits must be considered. I feel, at this time we should consider the need of such pits for the next ten years and the location be selected on our future needs.*

During the last ten years we have used approximately 30 acres of real estate for our disposal program. In the next ten years our need for solid waste disposal areas is going to increase. In the next year we will have, in addition to our regular daily disposal of laboratory waste, several additional sources of contaminated material; these are O Building, ML Building, and M Building from TA-1. In addition, there will be portions of other structures in TA-1 and the complete acid sewer system from this area.

A reasonable request for the next 10 years would be approximately 40 more acres of real estate. The location of this acreage should be determined as soon as possible, since a new pit will be required by February 1, 1957."[72]

By December 14, 1956, the USGS had completed a survey of Mesita del Buey.[73] They concluded:

"Although the exact location of the pits should be determined after an engineering survey of the area is conducted, there are several basic factors to be considered. First, the Tshirege member is a relatively impermeable rock and percolation from dry waste material due to seepage from precipitation would be negligible. Thus, the extent and depth of this impermeable cap should describe the limits of excavation. Second, as the thickest section of the Tshirege member occurs at the central axis of the mesa, construction for the pits might begin near the axis of the mesa and proceed toward the edge of the mesa to a minimum of 50 ft from the south cliff. By so excavating, the size and number of the joints in the rock can be observed, for the joints tend to become more open near the periphery of the mesa. It was noted in the burial pit near Ten Site [Area C], *however, that joints were filled with clay and silt.*

Considering that the pits are to be established on a long-term basis, it is important that future erosion possibilities be contemplated. The pits should be kept as far as practical from well defined drainage courses such as the ravines that dissect the mesa, mainly along its south side. Furthermore, any natural vegetation on the mesa that feasibly can be preserved will aid in erosion control."[73]

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*LASL coordinates are the original Manhattan Engineering Project grid system.

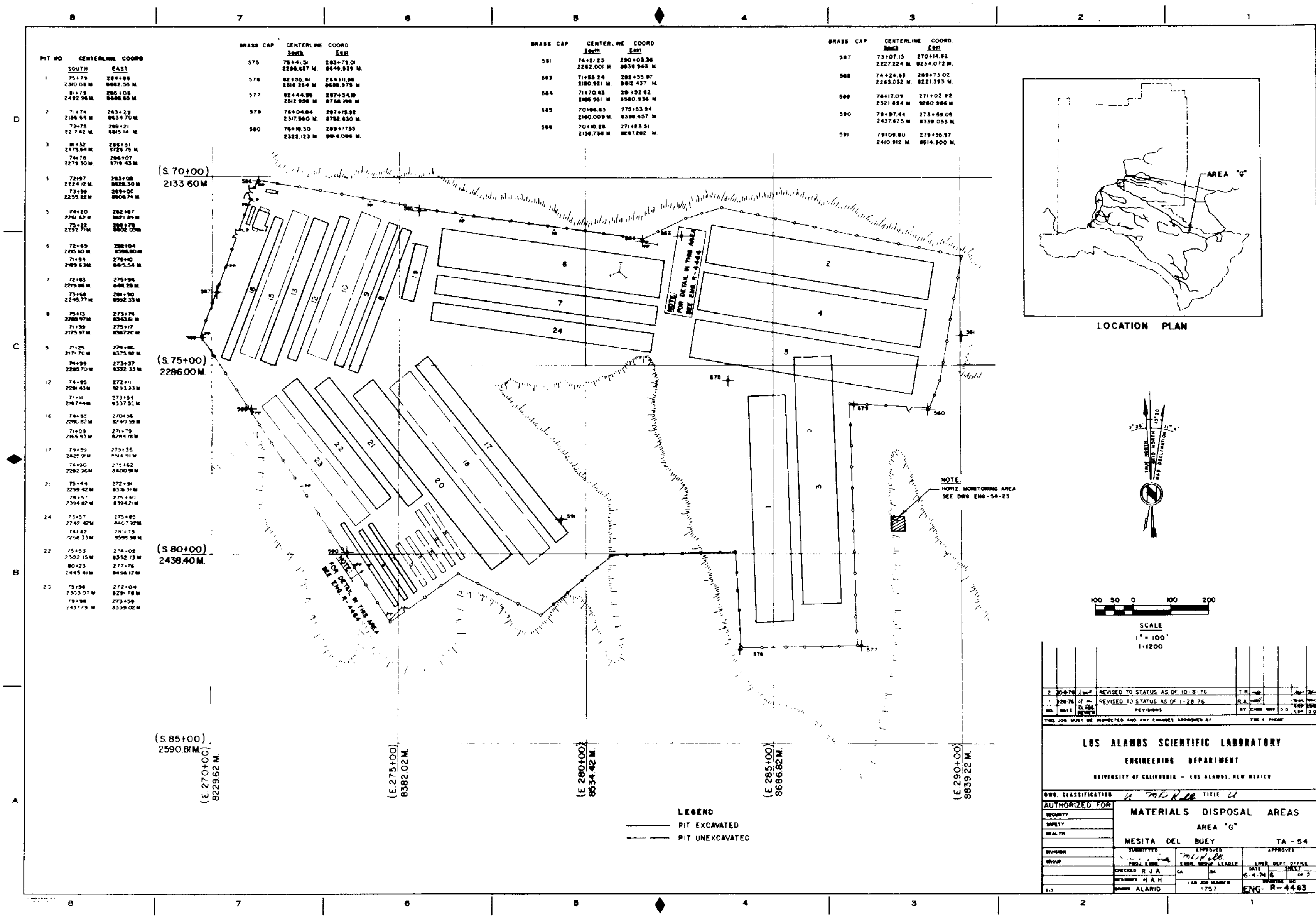


Fig. G-1.
Materials Disposal Area G, Mesita del Buey, TA-54.

The LASL archeologist was directed[74] on February 20, 1957, to request permits to remove ruins 192, 193, 197-A, and 203-B as shown on the Indian Service Map. These ruins were located in the proposed route for the access road and new pit area.

The original acreage of Area G was 5.12. As of July 1976, the acreage was 36.6.

October 7, 1976 land clearing for Phase I of the Area G expansion began.[290]

III. GEOLOGY AND HYDROLOGY

Mesita del Buey is approximately 4.8 km (3 mi) south of the Los Alamos townsite. It is a narrow, southeast trending mesa that is part of the Pajarito Plateau. Bounded by vertical cliffs with steep slopes at their base, the mesa is as narrow as 91.4 m (300 ft), as wide as 402 m (0.25 mi), and approximately 3.2 km (2 mi) long. Mesita del Buey is about 30.5 m (100 ft) above the Pajarito Canyon floor at its western margin and less than 24.4 m (80 ft) at its eastern end.[75] The surface slopes gently to the southeast from an altitude of 2103 m (6900 ft) to 2012 m (6600 ft).[76] Soil cover along the axis is 0.3 to 0.6 m (1 to 2 ft) thick[30] and thins toward Pajarito Canyon on the south and Canada del Buey on the north. Soil erosion is slow because of the small drainage area.[30]

The cliffs expose the Tshirege Member (Griggs, 1964)[4] of the Bandelier Tuff. The Tshirege Member also crops out on the surface of the mesa. At Area G, the Tshirege has an average thickness of 42.2 m (135 ft). Beneath the Tshirege is the Otowi Member (Griggs, 1964) of the Bandelier Tuff which is approximately 36.6 m (120 ft) thick.[77] Beneath the Otowi is the Guaje Member (Griggs, 1964) of the Bandelier Tuff which is approximately 3.4 m (11 ft) thick.[77] The Bandelier Tuff rests on the Basaltic Rocks of Chino Mesa (Griggs, 1964). The basalts exceed 28 m (92 ft) in thickness.[77] The thickness of the underlying Puye Formation (Griggs, 1964) is not known; however, in supply well PM-2, 2.7 km (1.67 mi) west-northwest of Area G (see Fig. G-2), the Puye is 216.4 m (710 ft) thick. PM-2 is completed in the Tesuque Formation (Spiegel and Baldwin, 1963)[3] after penetrating 362.7 m (1190 ft) of that formation[29] (see Table G-1).

"The Tshirege member has been divided into three units by Baltz, et al.,[7] where it outcrops in Mortandad Canyon. The Tshirege at Mesita del Buey was mapped using these units. At Mesita del Buey, as at Mortandad Canyon, Unit 1 has been subdivided into units 1a and 1b, and Unit 2 into 2a and 2b (Fig. G-3). At Mesita del Buey, Unit 3, a nonwelded to moderately welded pumiceous tuff, is absent.

Unit 1: *The lower unit of the Tshirege member consists of two layers, similar in lithology but different in color and welding. The lower layer is designated Unit 1a and the upper, Unit 1b.*

Unit 1a is a light orange to light brown, pumiceous tuff breccia. It contains numerous pumice lumps as much as 6 in. long, with small quartz crystals and rock fragments of latite and rhyolite. The tuff ranges from nonwelded to moderately welded and weathers to a steep slope. In places, a vertical wall with a talus slope at the base has formed. Unit 1a overlies the reworked sediments at the top of the Otowi member. The upper part of the unit is exposed in Canada del Buey along the eastern edge of the mesa (Fig. G-3). In the subsurface at the western part of the mesa, Unit 1a is about 30 ft thick, thinning to less than 10 ft to the east.

Unit 1b is a grayish-brown tuff containing larger quartz crystals but fewer and smaller rock fragments of pumice, latite, and rhyolite. The unit is moderately welded and weathers to a vertical wall or steep talus slope. It is separated from the underlying Unit

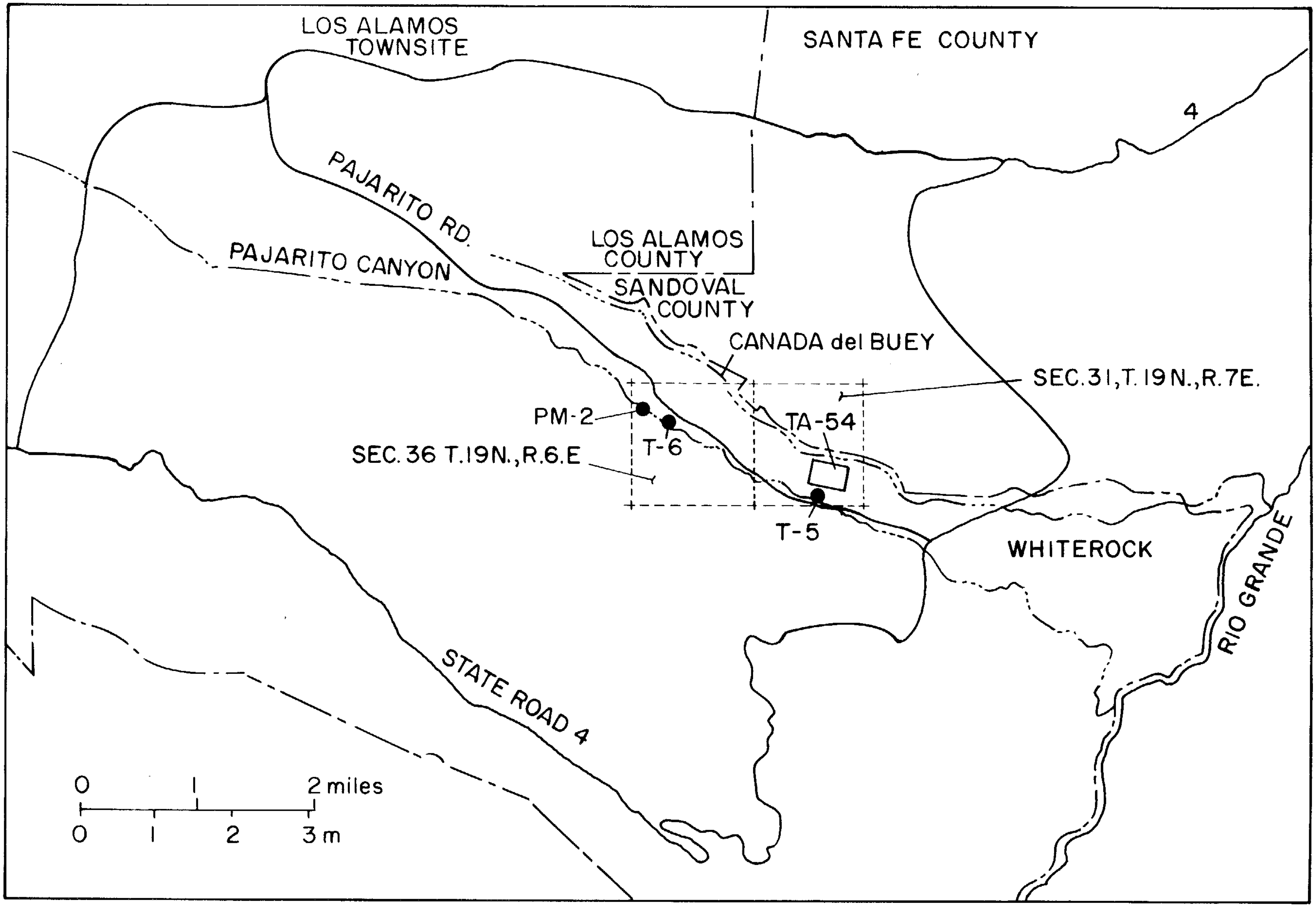


Fig. G-2.
Location map for Well PM-2, and Test Holes T-6 and T-5 in relation to Area G, TA-54.

TABLE G-I

SUPPLY WELL PM-2

USGS Location No. 19.6.36.113 USGS Designation PM-2(Pajarito Mesa-2)
ERDA Coordinates ERDA Designation
Driller Layne-Texas Inc. Address Houston, Texas
Topography Floor of Pajarito Canyon Altitude 6715 ft
Method drilled Hydraulic Rotary Diameter 14 in. Use Public Supply
Drilled depth 2600 ft Completed depth 2300 ft
Date drilled July 1965 Chief Aquifer(s) Puye Conglomerate & Tesuque Formation
Depth to water 823 ft Date July 6, 1965 Transmissibility 40,000 gpd/ft
Specific capacity 24 gpm/ft After 24 hours of pumping at 1200 gpm

Log:

	Thickness	Depth
Alluvium	30-	30
Bandelier Tuff:		
Otowi Member	375-	405
Guaje Member	27-	432
Basaltic rocks of Chino Mesa:		
Unit 3	268-	700
Puye Conglomerate:		
Fanglomerate Member	640-	1340
Totavi Lentil	70-	1410
Tesuque Formation	1190-	2600

Casing Schedule:

Diameter (inches)	Depth (feet)	Remarks
26 ID	0- 504	
14 ID	0-2300	Blank from 0-1004 ft, slotted with 3/32-inch louver openings 1004 to 2300 ft.

Chemical analysis: Constituents in parts per million*

Date July 15, 1965

Ca 8.8 Mg 3.1 Na + K 11 HCO_3 59 CO_3 0 Cl 3.5

F 0.16 NO_3 0.08 Hardness 35 Dissolved solids 158

Specific conductance 68 micromhos, pH 7.6

Radiochemical analysis:

Date July 15, 1965

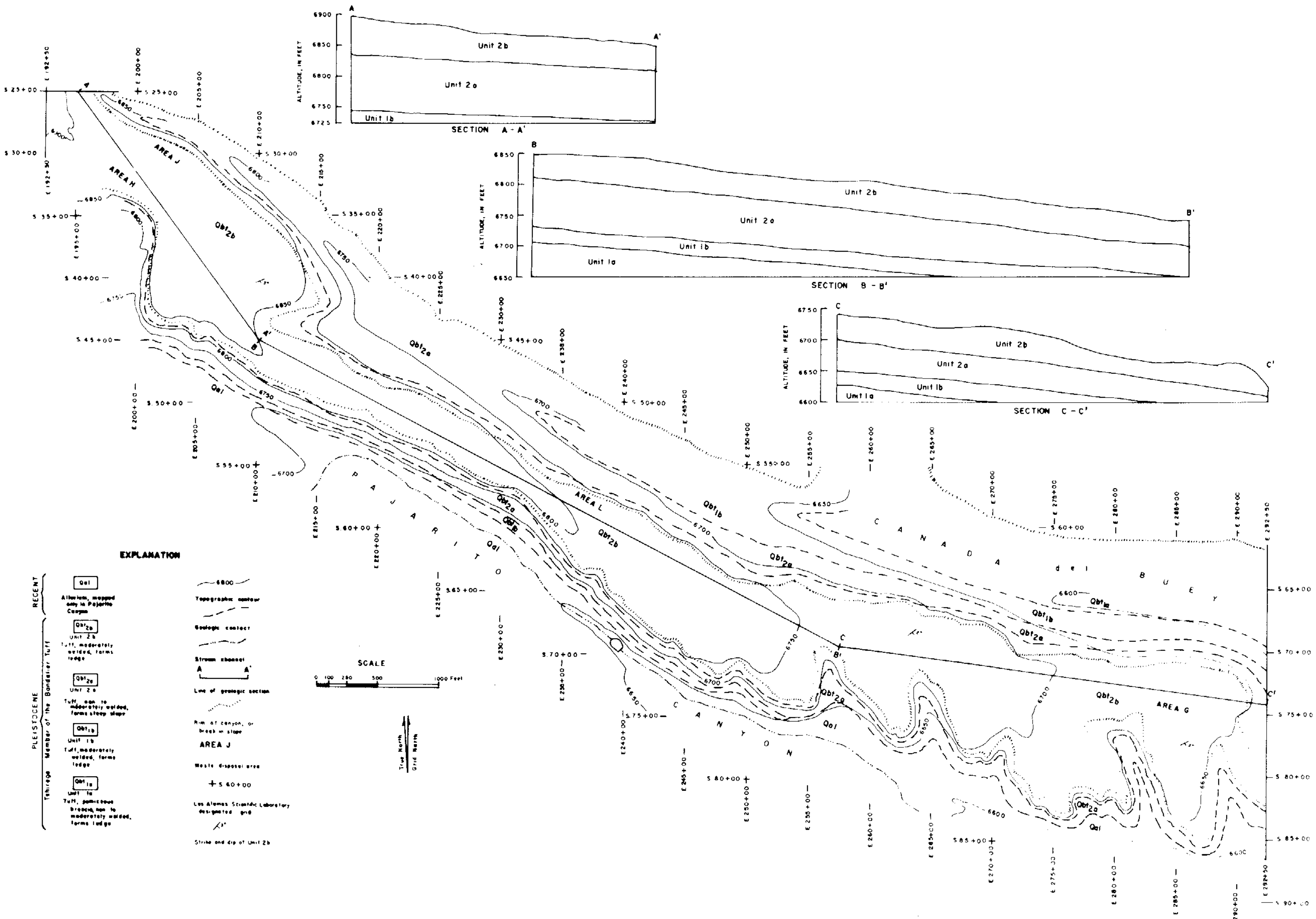
Pu <0.4 d/m/l U <0.5 μg/l Gross β (Gamma) 1.6 d/m/l

Report source of data: J. B. Cooper, W. D. Purtymun, and E. C. John, 1965.

* Analysis by Los Alamos Scientific Laboratory.

Electric logs available

John, Enyart, and Purtymun, 1966[77]



Geology by Wm. D. Purtymun, 1970

Fig. G-3.
Geologic map and sections of Mesita del Buey.

1a by a notch, caused by weathering in a vertical wall, or is recognized as a talus slope lying on the bench formed at the top of Unit 1a. Unit 1b outcrops in lower Canada del Buey east of the mesa. Its thickness averages about 25 ft.

Unit 2: *Unit 2 forms the walls and surface of Mesita del Buey. It consists of several ashflows, divided into lower Unit 2a and upper Unit 2b.*

Unit 2a is a light-gray pumiceous tuff that contains rock fragments of pumice, latite, and rhyolite, with some quartz crystals in a light-gray ash. The pumice fragments are devitrified and dark brown. The rock fragments in the lower part of the unit may be as long as 3 in., but they decrease in size toward the top of the unit. The western part of the unit is a moderately welded tuff that forms a vertical wall along the canyons. Eastward, the welding decreases to a nonwelded unit where it forms a talus slope. There are two ashflows or ashfalls in Unit 2a. The upper part of the unit near the western margin of the mapped area (Fig. G-3) is moderately welded tuff that becomes nonwelded with eastward progression. The nonwelded portion is apparently an ashfall containing numerous pumice fragments and some reworked tuff. Unit 1b is somewhat transitional into Unit 2a, and the contact is recognized by a gradual change in color and by a lithologic change. Unit 2a varies from about 85 ft thick on the west to about 30 ft thick to the east. Most of the thinning occurs in the upper ashfall.

Unit 2b is a light-gray to brown, weathered rhyolite tuff with some pebble-size rock fragments of pumice, latite, and rhyolite, and numerous crystals and crystal fragments of quartz and sanidine. It is a moderately welded to welded tuff that forms the upper walls and surface of the mesa. It forms ledges, benches, and vertical walls around the edge of the mesa. Unit 2b is separated from the underlying Unit 2a by an erosional contact marked by a thin layer of silt, sand, and pumice. Unit 2b is composed of at least two ashflows that cooled as a single unit. The contact between these two flows is not evident where they outcrop, but in pits dug at Area G (Fig. G-3) it is recognized by increased size and number of pumice fragments with an occasional deposit of reworked tuff and pumice. Unit 2b is about 60 ft thick.

The upper ashflows at Mesita del Buey dip 2 to 3 degrees to the southeast. The ashflows of the Bandelier Tuff thin eastward because these younger rocks lie on top of the older basalt. The basalts originated from volcanic centers to the east, and flow was north and west into the area, forming a topographic high before the tuff was laid down...

Joint Systems: *The ashflows of the Bandelier Tuff are broken into a number of blocks by joints formed by shrinkage (tension) as the ashflow cooled. The near vertical attitude of most of these joints and the curved form of some are indicative of formation by cooling. The joints are more numerous in welded than in nonwelded tuffs because the welded tuffs were laid down at higher temperatures.*

The joints are classified as master and minor joints. Master joints are numerous and long, and may pass through one or more ashflows. A single unit may contain several ashflows emplaced at different times, but the joint pattern of the older layer may tend to govern formation of joints in the younger layer as it cools. Also, two or more ashflows may be laid down in rapid succession and cool as a single unit with joints forming in the flows at the same time.

The master joints are vertical or nearly vertical and generally dip 70° from the horizontal. The vertical trend may be straight or slightly curved. The dip is deflected slightly when the joint enters a unit with different density or degree of welding.

Minor joints dip at angles less than 70°. They are more numerous near the tops of ashflows and do not persist as they intersect the master joints.

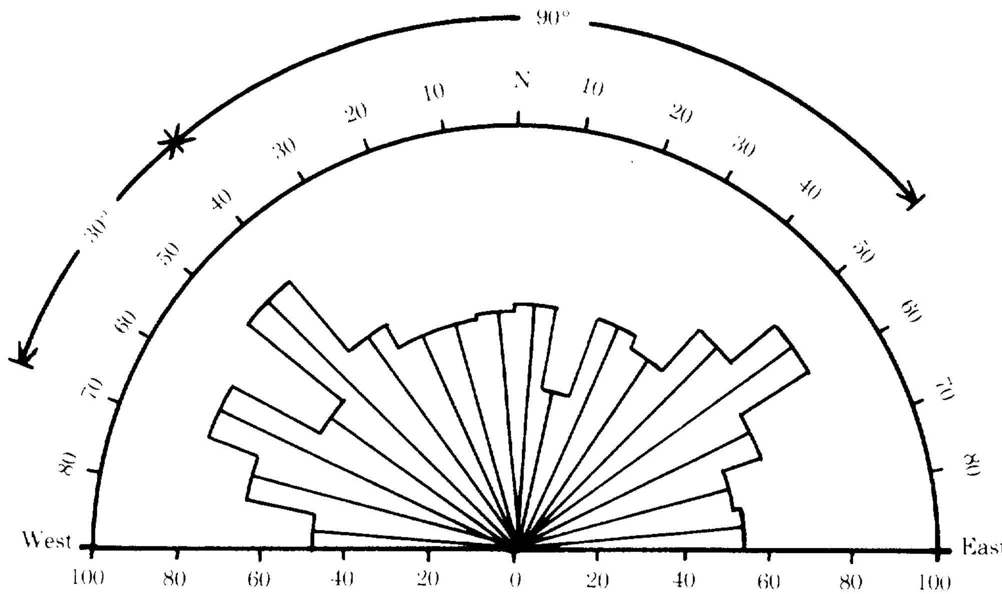
A joint traced vertically through an ashflow may be closed in places and open in others. Locally the opening may be as much as 2 in. wide, but most openings are less than 1/4 in. wide. Joints terminating in the base of the soil zone or in exposed tuff on the mesa surface are filled with light-brown clay which may extend 3 to 4 ft below the surface. Below the brown clay, the joint openings are filled, or the joint faces are plated, with a light-gray clay. The light-gray clay is derived from weathering of the tuff and from minerals leached from the tuff by water and precipitated along joint openings before development of the near-surface brown clay that seals the joint at the surface.

The master joints are tension joints formed by the contraction of the tuff as it cooled. In a cooling, homogeneous, molten liquid, rupture occurs as three vertical fractures intersecting at angles of 120° and radiating out from numerous centers.[(1)] *If the centers are evenly distributed, the fractures bound vertical hexagonal columns. A rose diagram illustrating the orientation of joints formed from a homogeneous molten liquid would show three joint sets (a number of joints with the same characteristic pattern) intersecting at angles of 60°* (Fig. G-4).

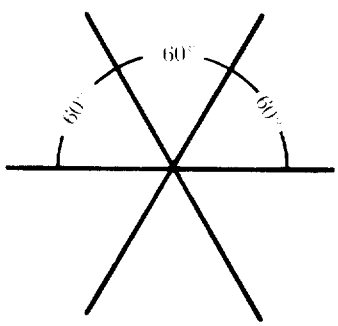
The heterogenous characteristics of the tuff did not allow joint sets to form vertical hexagonal columns. A rose diagram prepared using the orientation of 1078 master joints [492 in area G (Fig. G-3), 296 in Area L, and 290 in Areas J and H] *showed the average of the three joint sets intersecting at angles of 30 and 90° (Fig. G-4). The three joint sets, N 30° W to N 50° W, N 60° W to N 80° W, and N 40°E to N 60°E, comprise 40% of the joints measured for the study.*

The blocks formed by the joints range from a few square feet to as much as 500 ft² at the surface. In the walls of the pits there is about one master joint for every 7 ft of horizontal wall."[76]

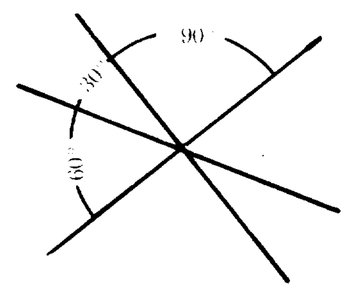
"[(1)]*M. P. Billings, STRUCTURAL GEOLOGY, Prentice-Hall, Inc., New York, 1942."*



Number of joints in each 10-degree sector of Unit 2b.



Ideal joint orientation caused by uniform shrinkage of a homogeneous medium.



Joint orientation of Unit 2b.

Fig. G-4.
Orientation of joints in Unit 2b.

The zone of saturation (water table) lies at unknown depth beneath Area G. It is at a greater depth than 100.6 m (330 ft).* The depth to water at PM-2 [elevation 2046.7 m (6715 ft)] was 250.9 m (823 ft).[77] Water is perched seasonally in the alluvium in Pajarito Canyon.[76]

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*Test well T-5, approximately 402.3 m (1320 ft) south-southwest of the center of Area G, was a dry hole when completed at a depth of 80.2 m (263 ft).[77] The difference in elevation between Pajarito Canyon, where T-5 was drilled, and the surface of the mesa at Area G is approximately 21.3 m (70 ft) (see Table G-II). Therefore, 80.2 + 21.3 ≃ 101.5 m (330 ft). Test well T-6, approximately 2.3 km (1.4 mi) west-northwest of Area G, was a dry hole at a depth of 91.4 m (300 ft) (see Table G-III).

TABLE G-II

TEST WELL T-5

USGS Location No. 19.7.31.433	USGS Designation T-5 (Test well 5)
ERDA Coordinates	ERDA Designation
Driller Jenkins Drilling Co.	Address
Topography floor of Pajarito Canyon	Altitude 6592 ft
Method drilled Cable tool Diameter 24 inches	Use Unused
Drilled depth 263 ft	Completed depth 263 ft
Date drilled March 1950	Chief Aquifer(s) None
Depth to water dry	

Log:

	Thickness	Depth
Alluvium	23-	23
Bandelier Tuff:		
Tshirege Member	17-	40
Otowi Member	120-	160
Guaje Member	11-	171
Basaltic Rock:		
Unit 2	92-	263

Casting Schedule:

Diameter (inches)	Depth (feet)	Remarks
24 OD	0-22	Open hole below 22 feet

Radiochemical analysis:

Report source of data: R. L. Griggs, 1955 and 1964.

Remarks: Drilled for geologic and hydrologic information.

John, Enyart, and Purtymun, 1966[77]

IV. TYPE OF WASTE

Solid radioactive waste disposed of in Area G was logged in LA Notebooks S-1065, S-2141, S-2306, 6905, 7951, 9593, 11363, 11866, 12442, 14909, 14995, 15953, 17335, 17336, 17337, 17338, 17339, 17845, 17900. (See individual pit write-ups for specific designations.)

Until 1971, no attempt to segregate waste by pit was made. Pits received nonroutine and routine radioactive contaminated waste. All pits were initially used for nonroutine waste followed by a mixture of routine and nonroutine waste. Nonroutine contaminated waste included debris from the demolition of TA-1 and Bayo Site, classified materials, TU chips from the shops, and pieces of heavy equipment such

TABLE G-III

TEST WELL T-6

USGS Location No. 19.6.36.141	USGS Designation T-6
ERDA Coordinates	ERDA Designation
Driller Jenkins Drilling Co.	Address
Topography Floor of Pajarito Canyon	Altitude 6705 ft
Method drilled Cable tool	Use Unused
Drilled depth 300 ft	Completed depth 300 ft
Date drilled March 1950	Chief Aquifer(s) None
Depth to water dry	

Log:

	Thickness	Depth
Alluvium	25	25
Bandelier Tuff:		
Tshirege Member	60-	85
Otowi Member	180-	265
Guaje Member	20-	285
Puye Conglomerate:		
Fanglomerate Member	15-	300

Casing Schedule:

Diameter (inches)	Depth (feet)	Remarks
		Open hole

Report source of data: R. L. Griggs, 1955 and 1964.

Remarks: Drilled for geologic and hydrologic information.

John, Enyart, and Purtymun, 1966[29]

as dump trucks. Routine contaminated waste consisted of cardboard boxes 33 cm × 33 cm × 61 cm (13 in. × 13 in. × 24 in.), 5 mil plastic bags 33 cm × 61 cm (13 in. × 24 in.) and 256 cm × 61 cm (40 in. × 24 in.) of material generated in the Chem Labs, and 0.20 m^3 (55 gal.) barrels of sludge from the waste treatment plants at Building 35 DP-West, TA-45 and TA-50.

A December 1970 Radionuclide inventory[78] states:

"The following report is based on all available H-1 records for radioactive waste buried at Los Alamos. From many entries in the H-1 records, the amount and type of radioactive materials are listed as Classified (SECRET/RD). Because of entries such as these, and also other similar ones, this report is an audit of H-1 records and not an investigation of complete facts. Group H-1 records from 1945 through 1960 have almost no information concerning what radioactive material or how much in gram quantities. These records were of the monitoring results of radioactive material or contaminated materials. These records also included volume of waste, location of waste, date of the

burial, signatures of persons involved, and from which group the material originated. Area G has 50 007 lbs [22682.8 kg] *of D-38, 9034 g of U-235, 1084 g of Pu-239, 0.204 g of Pu-238, 0 g of U-233 and less than 10 g of tritium."*[78]

The next radionuclide inventory[79] was published May 1974.

"The records describing the material placed in these pits generally do not contain information on the curie content of the material, but the isotopic composition is generally indicated. Uranium- and plutonium-contaminated wastes are placed in separate pits. Americium-241 is known to be present in the pits, occurring in association with plutonium in drums of sludge generated by liquid treatment facilities.(42) *A reliable estimate can be made of the curie content of the various isotopes using material accountability data.*(43) *Other radioisotopes, such as tritium, are known to be present in the disposal pits in unknown quantities.*(37) *Records on the types and activity of wastes placed in disposal shafts are generally quite good."*[79] (See Tables G-IV and G-V).

"(42)*L. Emility, Los Alamos Scientific Laboratory, internal document (Data on Contamination in Sludge from H-7 sent to Areas C & G), December 1973.*

(43)*V. Bond, Los Alamos Scientific Laboratory, internal document, (Data on Material Removed from Inventory, during years 1952-1972), December 1973.*

(37)*Los Alamos Scientific Laboratory, internal documents (log books of burial operations at Area G)."*

V. MODE OF DISPOSAL

"The U. S. Geological Survey cooperated with the Atomic Energy Commission in the selection of the area [G] *and recommended that disposal pits be no closer than 50 ft to the canyons, be no more than 50 ft deep, and that open joints in the pits be sealed with fine-grained material. The area was selected because it is relatively isolated and probably is large enough for disposal of solid wastes for 10 or more years."*[30] (See Appendix E).

Engineering Drawing ENG-C 18463, (Materials Waste Pits. Standard Specifications. Mesita del Buey, TA-0) dated February 26, 1957, contains the following General Notes:

"1. **Location.** *The location of all pits will be determined and staked by Engineering Department personnel.*

2. **Clearing.** *Clearing of vegetation will be limited to those areas as staked by Engineering Department personnel. Disposal of cleared brush shall be effected by stacking and burning at the site, as agreed upon by AEC forestry authority.*

3. **Cross-sections.** *Cross-sections of the original ground of the pit area will be taken by Engineering Department Survey personnel, upon completion of the clearing, and prior to any excavation. Final cross-sections will be taken upon completion of the excavation, and prior to any burial of materials.*

TABLE G-IV

ESTIMATED RADIONUCLIDE CONTENT OF MATERIALS PLACED IN AREA G AS OF JANUARY 1976[a]

Isotope	Pits (1959-1975)	Disposal Shafts (1965-1975)
^{3}H		91 973
^{22}Na		20
^{60}Co		154
$^{90}Sr-^{90}Y$	2750	284
^{137}Cs		6
^{233}U		5
U[b]	54	<1
^{238}Pu	44	4
^{239}Pu[c]	368	46
^{241}Am	2064	
Fission Products		196
Induced Activity		662

[a]All values in curies, decay corrected

[b]Includes isotopes 234, 235, 236, 238

[c]Weapons Pu mostly (94 wt.% ^{239}Pu, 6 wt.% ^{240}Pu); curie value based upon 0.072 Ci (alpha)/g

(Personal communication from John Warren, H-7)

TABLE G-V

MINOR NUCLIDES IN AREA G DISPOSAL SHAFTS[79]

^{24}Na	^{91}Y	^{144}Ce	^{227}Ac
^{32}P	^{105}Ag	^{147}Pm	^{232}Th
^{51}Cr	^{114}In	^{152}Eu	^{240}Pu
^{57}Co	^{131}I	^{182}Ta	^{242}Pu
^{59}Fe	^{133}Xe	^{191}Au	^{244}Cm
^{65}Zn	^{140}Ba	^{210}Po	^{252}Cf
^{85}Kr			

4. **Stockpiling.** *The location and manner of stockpiling excavated material shall be as directed by Engineering Department personnel.*

5. **Pit Cover.** *The covering of buried materials, with regard to thickness of cover and covering schedule, shall be as directed by the H-Division custodial representative.*

6. **Indian Ruins.** *Permission must be obtained from the Department of the Interior prior to disturbance of any Indian ruins in the area. In the event of the removal of any ruins, they will first be inspected and checked by an authorized archeologist, and disposed of under his direction. The ruins which are to remain undisturbed shall be appropriately marked with 4" by 4" wooden posts, painted white, and extending 4' above ground. The spacing and placement of the posts shall be as determined by the archeologist. Construction equipment shall refrain from crossing any ruins which are to remain in the vicinity.*

7. **Fencing.** *All temporary fencing of pits shall consist of 8' hogwire, mounted on 8" creosoted wood posts set at 10' centers, and three strands of barbed wire on wooden outriggers. Access gates shall be doubled 10' gates, located as directed by Engineering Department personnel. All permanent fencing of pits shall consist of 8' cyclone mesh, mounted on steel posts set at 10' centers, and 3 strands of barbed wire on steel outriggers.*

8. **Signs.** *Installation of warning signs, pit area signs, etc., shall be as directed by H-Division personnel."*[80]

ENG-C 18463 shows a pit in plan view, in longitudinal cross-section, and in cross-section at right angles to the axis of the pit. Pits were to be 182.9 m (600 ft) (maximum where possible) long, and 30.5 m (100 ft) wide. One ramp of the pit was to have a 6:1 slope, and the other ramp was to have a 4:1 slope. The up ramp, a 6:1 slope, covers an approximate horizontal distance of 45.7 m (150 ft); the down ramp, a 4:1 slope, covers an approximate horizontal distance of 30.5 m (100 ft). A 7.6 m- (25 ft-)depth is shown for the pit with a note stating *"actual depth will be determined by conditions encountered in the field."*[80] The walls of the pit were to be cut *"as nearly vertical as excavating equipment will permit."*[80]*

A "typical road cross-section" also appears on ENG-C 18463. It is assumed this cross-section shows construction details for the access road on Mesita del Buey. The road was to be a maximum of 5.5 m (18 ft) wide. It was to have cuts on either side for drainage. From center of cut to center of cut was a distance of 4.9 m (16 ft). The crown (parabolic) of the road was 3.7 m (12 ft) wide covered by 7.6 cm. (3 in.) of gravel.

On July 27, 1965, a new Materials Disposal Areas Standard Pit Specifications came out, Engineering drawing ENG-C 25703. Points 1, 2, 3, 4, 6, 7, and 8 of General Notes remain the same on ENG-C 25703 as those on ENG-C 18463. Changes in the General Notes are as follows:

"5. **Pit Cover.** *The covering of buried materials with regard to thickness of cover and covering schedule, shall be as directed by H-Division and Group ENG-4.*[81] [Point 5 on ENG-C 18463 gave H-Division sole responsibility.]

9. **Contents.** *For information relative to the contents of materials disposal areas, and L.A. notebook information, contact LASL Health Division and/or Group SP-2.*[81]

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*It was never possible to cut vertical walls (personal communication, Charles Daggett, ENG-4).

10. **General.** *For information relative to correspondence, Indian ruin numbers, bench marks, field book information, and other survey data noted on any of these drawings, contact ENG-3 Group Office."*[81]

The only difference in construction detail between ENG-C 25703 and ENG-C 18463 is in the walls of the pit which now show a slope of 1/4 to 1.

Engineering drawing, ENG-C 25700, Materials Disposal Areas FY66, Area G shafts, Mesita del Buey, TA-0, dated July 27, 1965, shows shaft layout and construction details. The following points were made under General Notes.

"1. **Location.** *The location of all shafts will be determined and staked by the LASL Engineering Department. After shafts are bored, survey ties will be made for record purposes.*

2. **Boring Sequence.** *Will be in accordance with stakes, marked to indicate shaft number, diameter and depth as set in the field by ENG-3 personnel.*

3. **Stockpiling.** *The location and manner of stockpiling excavated material will be to the west unless otherwise specified by ENG-4.*

4. **Safety.** *The personnel safety covers must be secured in place over the shafts at all times when drilling is not in progress.*

5. **Boring Instructions.** *Shafts 1 thru 10 inclusive are to be 2 ft in diameter by 30 ft deep.*

6. **Spacing.** *A minimum of 7'6" from center to center is required unless otherwise specified."*[82]

The drawing shows vertical cross-sections of typical shafts. The unlined shaft is 0.6 m (2 ft) in diameter; depth to be specified, or as necessitated by field conditions. The lined shaft is 0.9 m (3 ft) in diameter; depth to be specified, or as necessitated by field conditions. Lined shafts are constructed[83] by centering a 30.5 cm (12 in.) diameter metal tube 0.3 m (1 ft) above the bottom of the shaft. Cement is poured around the metal tube and finished at the top of the shaft so as to promote drainage away from the shaft.

In 1964,

"A change in the method of placement of waste in the pits has been made, at the request of ENG-4 Group. Heretofore, waste has been placed in sections along the floor of the pit and covered when the section (about one-third of the width of the pit floor) was completed. This permitted access into and out of the pit as well as physical separation of the 55 gal drums filled with sludge from combustible boxed material. ENG-4 insists on filling the entire floor of the pit before covering waste material. The term "insist" is used because a work order request to cover exposed trash within Pit #3 was submitted to ENG-4 on 3/5/64 and it is the author's [John Enders, LASL H-7] *opinion that ENG-4 has refused to activate an order until the pit floor is entirely covered with waste material."*[84]

Classified material placed in pits is covered with 3 ft of earth when it arrives.[85] *"As matters now stand, Group H-1 is to notify SP-2 when a covering job is to start so that SP-2 can arrange to deliver classified material to the pit for immediate burial."*[86]

In 1959,[86] a standard operating procedure was submitted *"for approval on the pick up and delivery to the disposal pit of dempster dumpster containers. Another procedure was prepared and submitted for approval on the operation of the two skip type dempster dumpster containers that are used for hauling sludge drums from TA-50 and Building 35, DP West."*[86]

The practice of backing a truck up to the edge of a disposal pit and throwing trash off the rear was abandoned in 1959 when Pit 1 was in use, after a man fell into the pit when the edge crumbled beneath him. However, in 1964, when Pit 4 was in use, the following appeared in a Quarterly Report:[87] *"Because the pit walls began to crumble, it was decided to dump material into the trench from the top of the pit rather than risk being struck by falling rock."*[87]

A change in disposal method of sludge drums was proposed June 9, 1971.[88]

"Assuming these drums may be removed later for transfer to a salt mine, it would be very desirable to stack the drums in the pit. Use of 2" × 12" planking between layers of drums has been proposed. According to Mr. Daggett, ENG-4, a 55-gal drum can withstand the weight of 7 drums on top of it. The planking would further reduce the load of pressure.

The pit is 25' wide, 25' deep, and 400' in length. These dimensions could permit placement of about 12 drums, horizontally, across the pit. The depth of the pit would permit 8 layers of drum (sic) (assuming no dirt cover is to be used). The total number of drums that could be stored in this manner amounts to about 9000. H-7 Group is currently generating about 1000 per year and at this rate the pit could last for about nine years."[89] (Compare the photos in Figs. C-4 and G-5 for the evolution in handling of sludge drums during disposal.)

During the third quarter of 1972 an engineering study[90] to determine feasibility and costs for providing cover for those pits used for long-term storage, Pits 8, 12, and 16, indicated it would be rather expensive to provide covers. *"Other types of covering material are being investigated."*[90]

Compliance with AEC-IAD-0511-21 was begun during the third quarter of 1970.[91]

"1. ^{238}Pu scrap from DP-West is now "stored" in metal drums in Pit 5, Area G.

2 D-38 chips and turnings from the Shops Department are "stored" in metal drums in pit #5, Area G.

3. Tritium contaminated material is being incased in asphalt, where possible, prior to being "stored" in disposal shafts in Area G.

4. Disposal of plutonium contaminated material into disposal shafts is being segregated, where possible, from uranium contaminated material. This requires a larger number of shafts being "in service".

5. Sludge and/or cement paste from H-7's Treatment plants is put into 55-gal metal drums. However, the drums are still being "stored" in disposal pits with other low level wastes."[91]

"More complete compliance with this Directive was achieved during the last quarter of 1971 with the use of Pits #8, #12, and #16. The material placed in these pits is considered to be retrievable.

The decision as to what material should be crated and/or packed into drums is based on estimates made by H-1 using monitoring data and information concerning the use of the equipment and other information to determine the activity/mass category.

It is of interest to note that whenever material must be crated, the disposal cost increases considerably. The current cost of a 4' × 4' × 8' plywood crate is about $75.00 and if a mobile crane is used during off-loading this brings the cost up even higher.

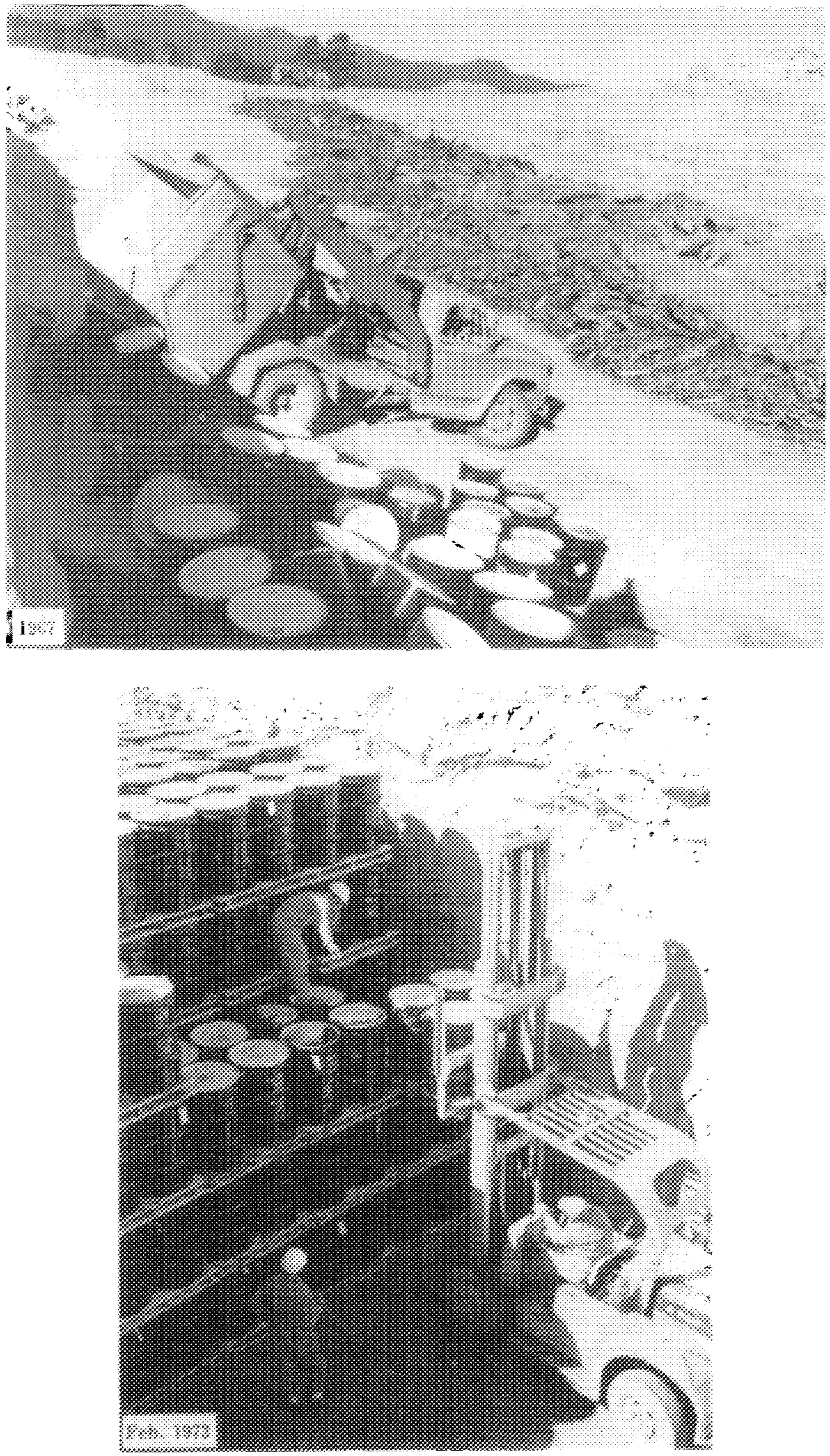


Fig. G-5.
Handling of sludge drums during disposal.

Other procedures that were started in 1970 and continued during 1971 include:

1. *Encasement of tritium contaminated material and disposal into a 6 ft diam shaft.*

2. *Segregation, where possible, of uranium and transuranium material in disposal shafts.*

3. *Use of a 6 ft diameter shaft for contaminated oil disposal.*

4. *Storage of D-38 and ^{238}Pu material in Pit #5.*

The segregation of low-level waste into uranium and plutonium categories has not yet started. This will require additional Dempster Dumpsters for some sites and very close supervision of the loading operations.

Low-level waste is currently packaged into boxes and plastic bags. If there is a requirement to store this material, more durable packaging will be required. Also, currently, scrap material is not usually packaged, and it, too, would require durable containers if it is to be stored for up to twenty years."[92]

During the third quarter of 1967, *"equipment and material was obtained which enabled H-1 to cap disposal shafts with Ready-Mix cement."*[93] The time between the filling of a shaft and capping of a shaft was greatly reduced when H-1 received the capability of capping the shafts themselves.

"The pick up and delivery of contaminated oil to Area G has posed a problem. Some of the containers are 55-gal drums which could weigh more than 300 lbs when full of oil. A study is now underway to decide if hoist equipment might not be used to handle these drums. Information on several designs of hoists is being received now and if such equipment is ordered, present plans call for a 6' diameter shaft to be drilled in the disposal area to receive this oil which would eliminate the fire hazard it poses when placed in the open pits."[94]

The first 1.8 m (6 ft) diameter shaft, Shaft 34, was augered during the fourth quarter of 1969.[95] January 20, 1976[96] it was decided:

"Radioactive contaminated waste oil that has required disposal by burial has until now, been disposed of into 1.8 m diameter by 18 m deep shafts. This practice was initiated many years ago as a result of the potential fire hazard associated with mixing drums of contaminated oil with uncovered combustible waste. At that time the combustible waste was not routinely covered on the day of delivery, and the waste oil was not required to be sorbed prior to disposal as is presently required.... Since the prevention of fire in radioactive waste has been so reduced by the current operational practice, shafts are no longer considered necessary for segregated disposal of radioactive waste oil....

Waste oil contaminated with TRU-radionuclides in amounts >10 nCi/g will continue to be stored retrievably. Waste oil contaminated with tritium will continue to be disposed of with the appropriate packaging into the tritum waste disposal shaft. All other waste oil will, with completion of the filling of the current shaft #60, be disposed of in the appropriate TRU- or U-waste disposal pit."[96]

"A SOP for disposal of small items contaminated with tritium was prepared and approved in April [1970]. Wherever possible, tritium-contaminated material is to be encased in asphalt. Group H-7 now has an asphalt melter and performs the encasement. The encasement procedure was started as a result of studies made by H-7 that indicated asphalt to be a good barrier to tritium."[97]

This SOP was written because of a tritium disposal made to Area G shafts,[95] November 25, 1969. For information on current waste disposal practices, see Appendix F.

PIT 1

Background

Pit 1, Area G was dug in February 1957.[98]

"Considerable work was involved in locating this pit at this site. The access road (approximately 11 150 ft) was constructed after the necessary grubbing and clearing of trees and shrubs was finished. There are several Indian ruins on this mesa; five were excavated and others will be excavated at a later date. A fence and gate were placed around the area where Pit 1 and Pit 3 are located. The excavated dirt for Pit 1 was piled on the Pit 3 site."[99]

Pit 1 was put into use during the second quarter of 1957.[100] It did not, however, begin to receive routine contaminated waste until January 2, 1959.[101] April 18-19, 1961, Pit 1 was retired from use and backfilled to ground level.[102]

Geology and Hydrology

The USGS inspected Pit 1 May 10, 1957.[103]

"Two fissures were noted in the pit, but the distances they run back from the face of the pit wall could not be determined. The fissure in the west wall of the pit is approximately 172 feet north of the southwest corner of the pit and extends into the wall in a northwesterly direction for several feet where the line of view is blocked by loose rock. Whether it extends beyond this point is a matter of conjecture. The fissure in the east wall is approximately 211 feet south of the northeast corner of the pit and extends into the wall in a southeasterly direction for an indeterminable distance."[103]

Type of Waste

Records of waste placed in Pit 1 from January 2, 1959 through May 2, 1961 are found in LA Notebook 9593.[104]

Mode of Disposal

Pit 1 was constructed using Materials Waste Pits Standard Specifications, Engineering Drawing ENG-C 18463. Pit 1 contained a fire pit dug in 1957 in the center of the floor (see Fig. G-6); it was redug during the third quarter of 1958.[105] At the end of 1959[106] chain link fence surrounded the area where Pits 1 through 5 are located. Signs were placed at 15.2 m (50 ft) intervals on the fence. These signs were identical to those on fences around other LASL disposal areas. Numbered signs were also placed on the fence posts along the west side of Pit 1 for use as reference numbers when logging in waste deliveries. Pit 1 is oriented north-south (see Fig. G-1).

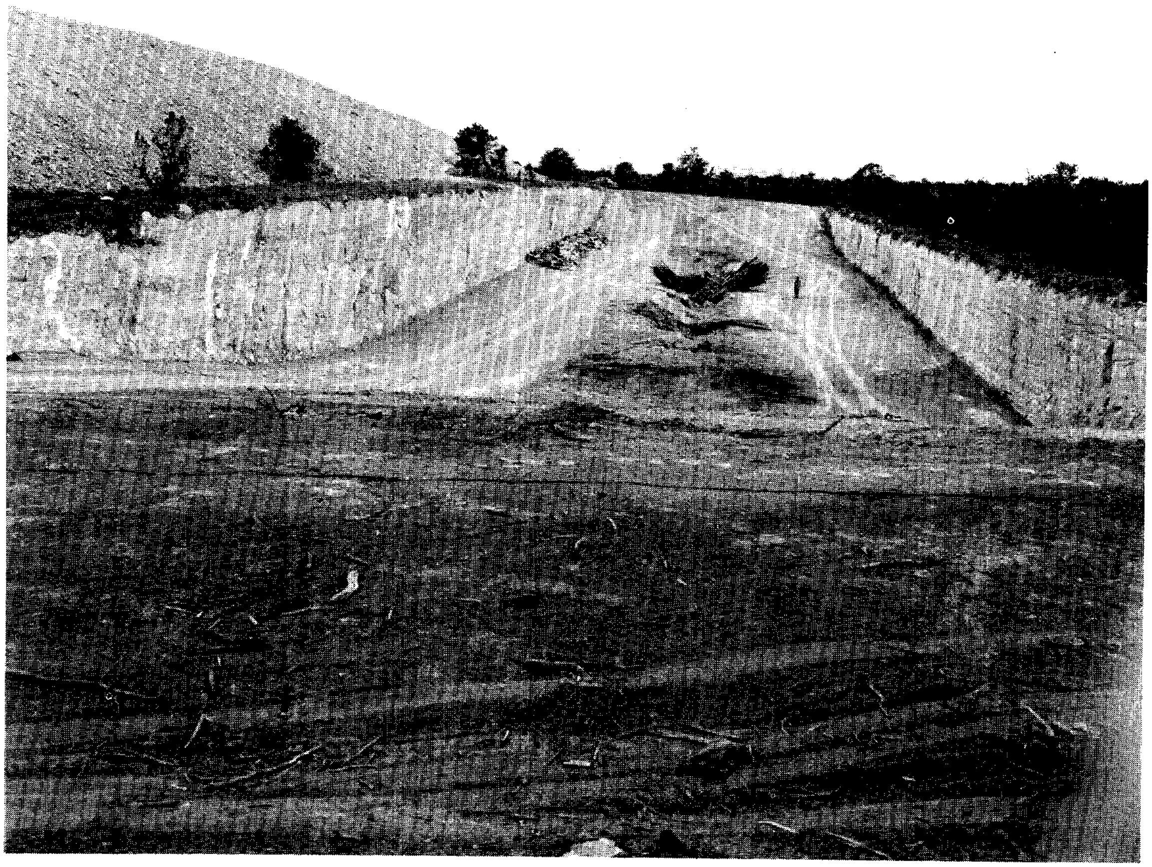


Fig. G-6.
Pit 1, Area G, with fire pit in bottom.

PIT 2

Background

September 4, 1958, a request for a new (in addition to Pit 1) disposal pit was made.

"According to our estimates, Pit 6, Area C, will be full some time in December 1958. If the demolition of J-2 building is not complete by that time, we will have to stop the burning of combustible material in Pit 1, Area G. It would be desirable to schedule the excavation of a new pit in Area G this fall with a completion date of some time early in December."[107]

Pit 2 was started in December 1958 and was completed in February 1959.[101] It was in use by the end of 1959.[106] Pit 2 began receiving routine contaminated waste April 20, 1961.[108] In July 1963, Pit 2 was backfilled to ground level.[109] During the third quarter of 1965 preliminary survey work was completed for 10 disposal wells to be located west of Pit 2.[110] The disposal wells were not constructed.

Geology and Hydrology

"In disposal pit No. 2 the Tshirege consists of two lithologically similar ashflows that have cooled as a single unit. The flows are light-gray to light-pinkish-gray pumicious partially welded rhyolite tuff consisting chiefly of quartz and sanidine crystals in a matrix of fine-grained ash. They also contain some small rhyolite and latite rock fragments and a large amount of devitrified dark-gray pumice fragments.

The top of a pumicious zone marks the contact between two ashflows. The pumice fragments are close together and form a soft lens in the tuff. Intersecting joints near the base of the upper flow above the pumice zone made it possible for large blocks to be dislodged easily. Several such blocks fell into the pit during construction. The soft lens became case-hardened after exposure to weathering a year or more.

The exposed tuff and joints in pit No. 2 were mapped in November 1961 and March 1962 at which times the pit was partly filled with radioactive wastes [Fig. G-7]. *The strike (the direction of the joint in a horizontal plane) was noted to the nearest 10 degrees and the width of the joint openings and type of material filling or plating the joints also was noted.*

The joint frequency averaged about one joint per 7-ft length along the walls of the pit. Three major sets of joints were noted. Twenty-seven percent of the 138 joints mapped were oriented between N. 40° E. and N. 70° E., 19% of the joints were oriented between true north and N. 20° W., and another 19% were oriented between N. 30° W. and N. 50° W. [Fig. G-8].

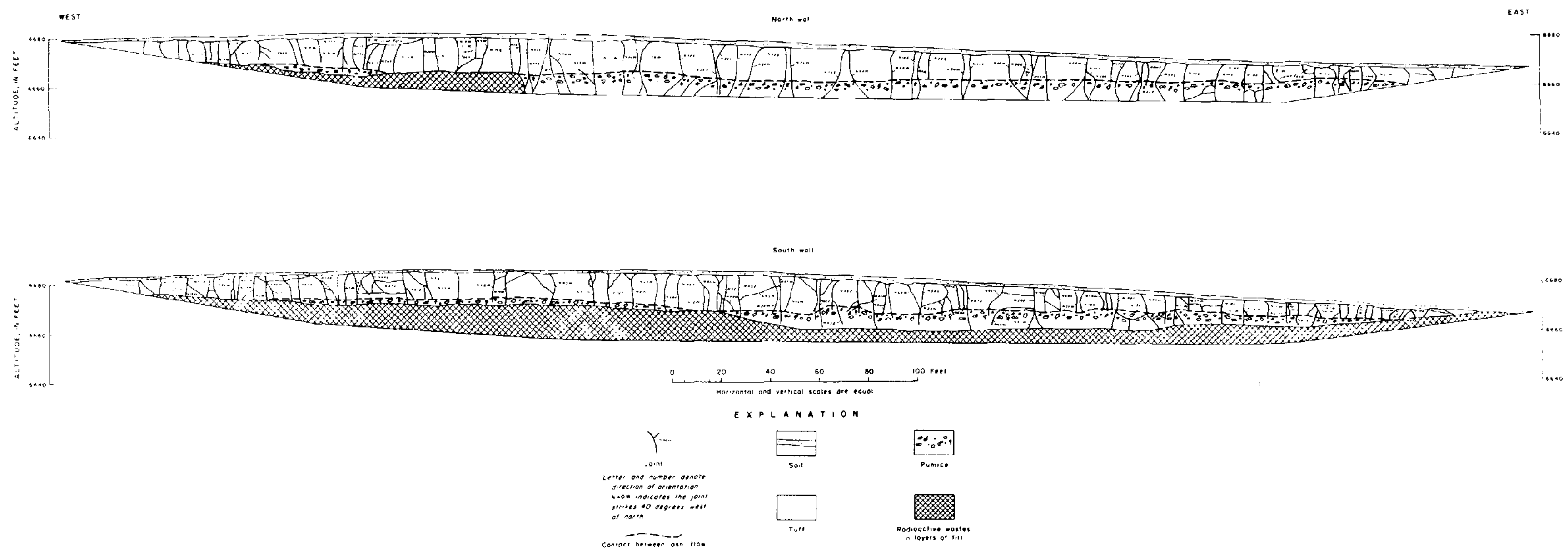
Joints formed by cooling and those formed by tectonic movement are difficult to differentiate in a single small area. The stresses set up in a homogeneous molten liquid as it cools to a solid would form tension joints at angles of 60° (Billings, 1942, p. 123.)[(1)]

The heterogeneous characteristics of the tuff probably did not allow the joint sets to form at intersecting angles of 60°. However, the angles between the N. 40° E. to N. 70° E. and the due North to N. 20° W. sets of joints is about 65° (using an average of the two sets), which is about the angle expected between joint sets formed by cooling [see Fig. G-8]. *Joint systems in the Tshirege Member in an area about 2 miles to the north were assumed to be formed by cooling due to their angles of intersection (Baltz and others, 1962).*[7] *Although some of the jointing may be due to tectonic movement, no displacement along the joints was noted in pit No. 2....*

The dip (the angle of the joint measured from the horizontal) of most of the joints range from 70° to 90°. Joints dipping less than 70° occur immediately beneath the soil and above the pumice zone. The joints are slightly deflected due to the change in density of the pumice and tuff. A single joint may be closed in some places and open in others. Locally the amount of opening is as much as 2 in.; however, the majority of joints are open less than 1/4 in.

Joints in the floor of the unfilled portion of the pit were not visible due to a cover of crushed tuff that resulted from construction of the pit. All joints terminating at the base of the soil zone were filled with a light-brown clay, and 3 to 4 ft below the base of the soil zone most of the joint openings are filled or the joint faces are plated with a light-gray clay. The light-gray clay is derived from weathering of the tuff and from minerals leached from the tuff by water and precipitated along the joint openings by evaporation prior to the development of the soil zone."[75]

"[(1)]*Marland P. Billings, "Structural Geology," Prentice-Hall, Inc., New York (1942)."*



Geology by W. D. Purtymun and Fred E. Busch, 1961 and 1962.

Fig. G-7.
Map of the north and south walls of Pit 2, Area G, showing tuff, pumice, and joint orientation.[75]

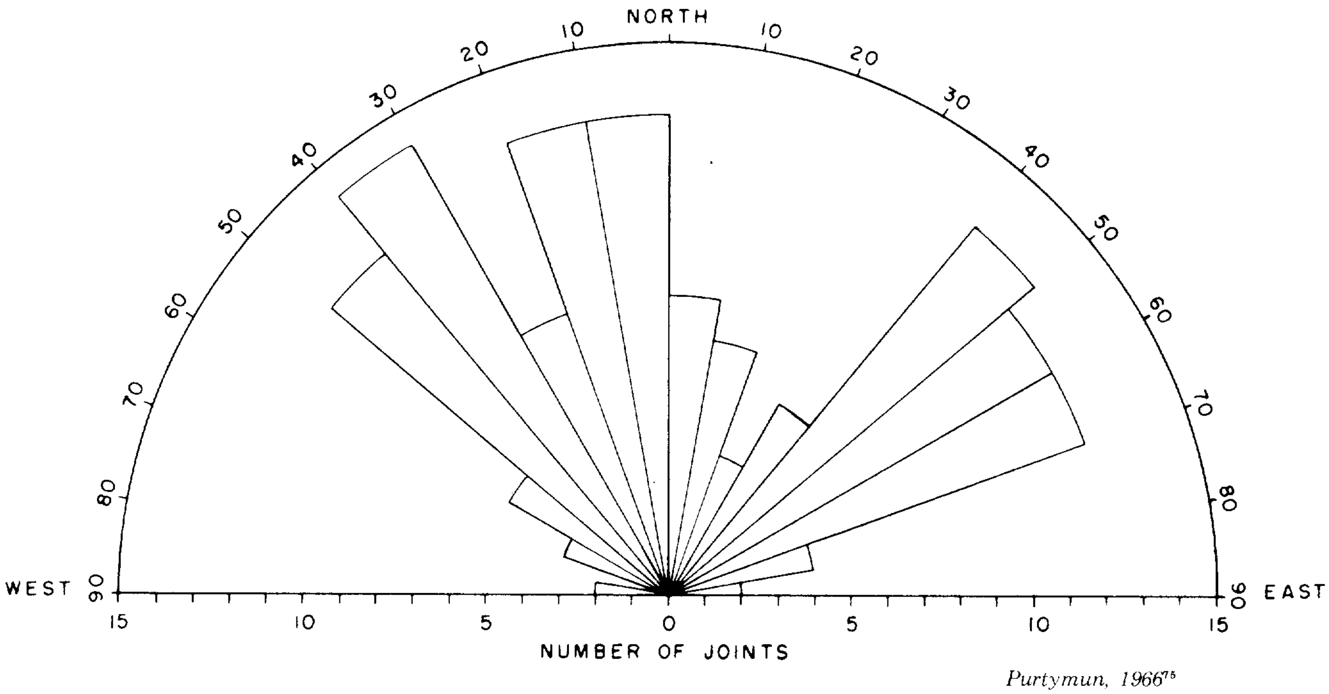


Fig. G-8.
General orientation of joints in the Tshirege Member of the Bandelier Tuff, Area G, Pit No. 2. Each ray represents the number of joints occuring in each 10 degrees.

Type of Waste

Waste for Pit 2 is logged in LA Notebook 11363, May 3, 1961 through January 1, 1963, and in LA Notebook 11866, January 5, 1963 through June 26, 1964.[104]

Mode of Disposal

Pit 2 was constructed using Materials Waste Pits Standard Specifications, Engineering Drawing ENG-C 18463 in an east-west direction (see Fig. G-1).

PIT 3

Background

A request for the excavation of Pit 3 was made during the first quarter of 1962;[111] excavation began December 7, 1962,[108] and was completed in February 1963.[112] Pit 3 began receiving routine contaminated waste on June 20, 1963.[113] During the first quarter of 1966, Pit 3 was filled,[114] with final dirt covering occurring in April 1966.[115]

Geology and Hydrology

Pit 3 was inspected February 6, 1963.[116]

"The soil cover ranges from about 1 to 2 ft thick. The tuff below the soil zone appears to be dry. Investigations in the Los Alamos area have shown that very little water moves into the tuff where the soil cover has not been disturbed.

The lithologic character of the tuff in the pit is the same as that in the tuff in other pits in the area. The zone of soft pumice fragments at a depth of 20-25 ft in Pit 2 was not as well developed as in the new pit; the pumice fragments are smaller and wider spaced in the tuffaceous matrix.

Numerous joints in the tuff are exposed along the walls of the pit. The joints range from open to closed with clay or alteration products. Most of the joints are near vertical and beneath the soil zone are clay filled. In general the joints appear to be the same type that occur in adjacent pits.

The surface of the mesa slopes toward the east and southeast which makes the east rim the low rim of the pit. Fill from excavation of the pit is piled over the soil zone on the east side of the pit to raise the altitude of that rim....

We plan to make a detailed map [the map if made, has not been located (July 1976)] *of the east and west walls of the pit when the weather permits."*[116]

Type of Waste

LA Notebook 11866, January 5, 1963 through June 26, 1964, as well as LA Notebook S-1065, June 26, 1964 through October 20, 1965; and LA Notebook 6905, October 21, 1965 through June 30, 1967, logs waste for Pit 3.[104]

Mode of Disposal

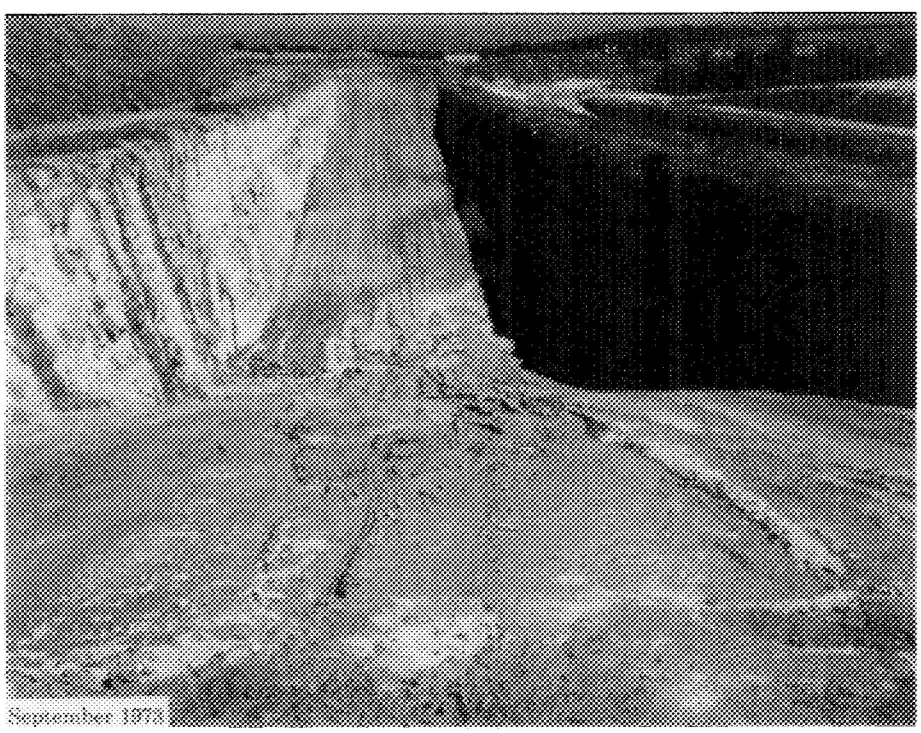
Pit 3 was constructed using Materials Waste Pits Standard Specifications, Engineering Drawing ENG-C 18463. Pit 3 is oriented north-south (see Figs. G-1, G-9).

PIT 4

Background

Pit 4, Area G, was begun May 18, 1964, and finished near July 1, 1964.[117] A trench was cut along the south side of Pit 4 so that debris from TA-1 could be burned.[87] Pit 4 was put into immediate use for this purpose. March 30, 1965, there was a request for a site layout for disposal wells in Area G southeast of Pit 4.[118] *"There is enough space available for about five years usage in this area. This request is based on the assumption that we will close out Area C when the remaining disposal wells are filled."*[118] A site layout of disposal wells southeast of Pit 4 does not appear to have been made. Pit 4 began receiving routine contaminated waste during the first quarter of 1966. During the last quarter of 1967, Pit 4 was filled and covered to ground level.[119,93]

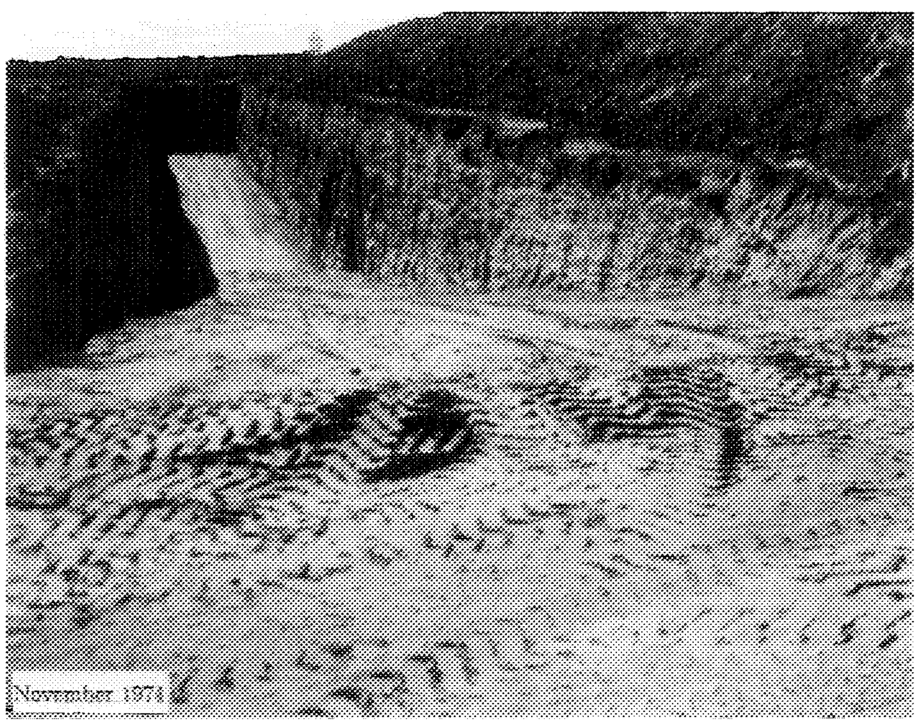
Pit 3, Area G looking south.



Pit 7, Area G looking east.

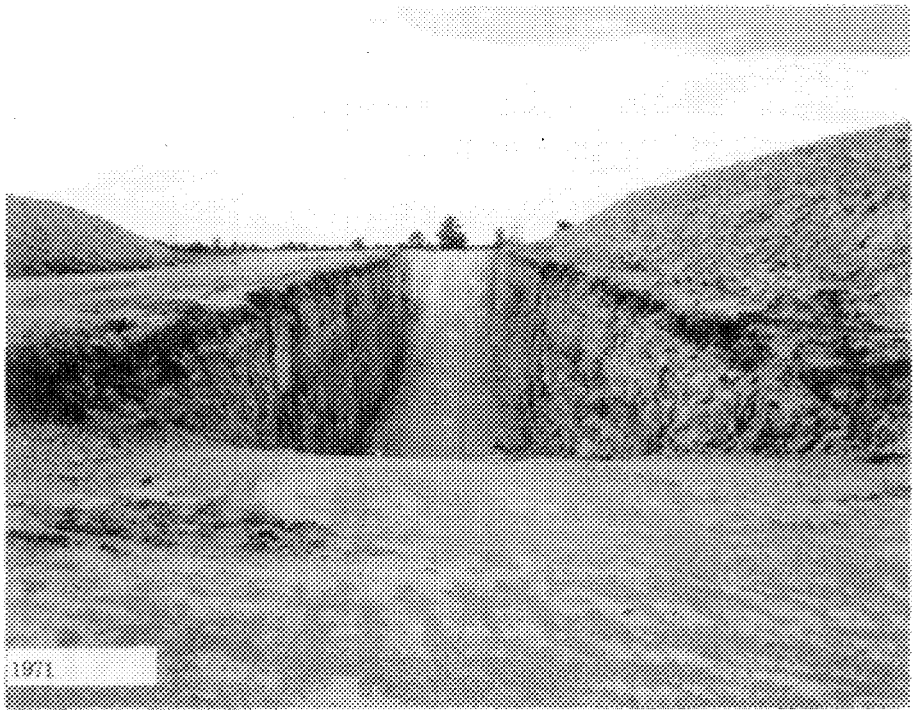
Fig. G-9.
Photographs of Area G pits and trenches.

Pit 8, Area G looking south



Pit 9, Area G looking southward before sumps and asphalt paving put in.

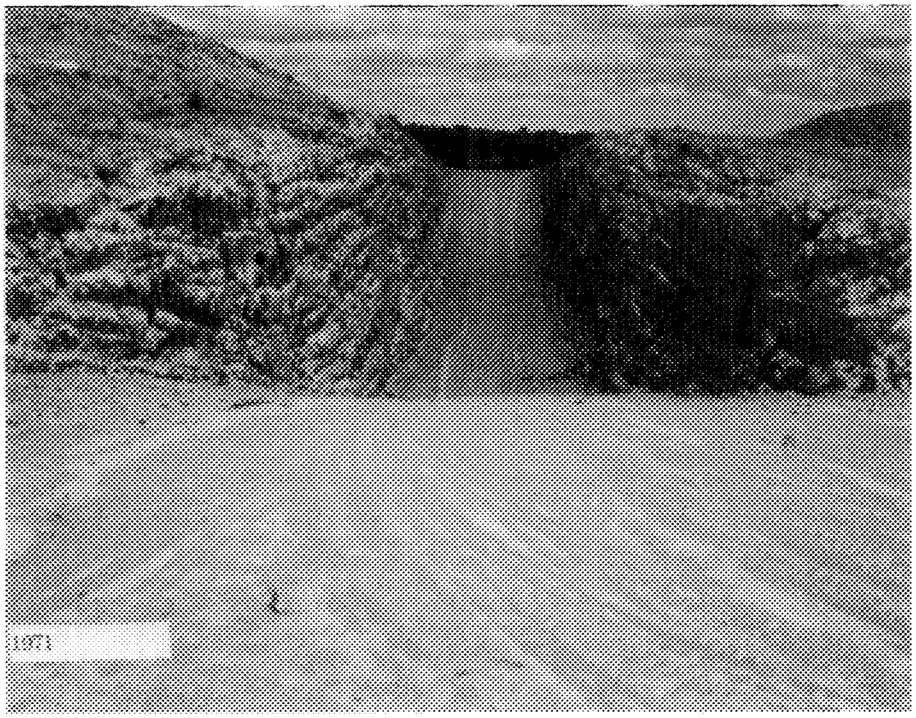
***Fig. G-9** (continued)*



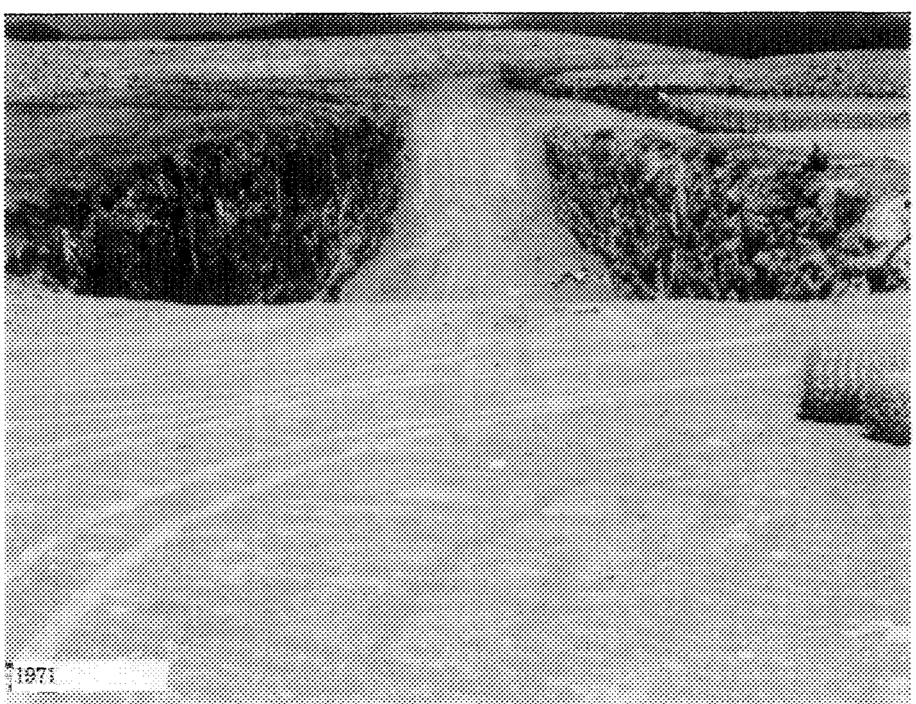
Pit 12, Area G looking south.

Pit 13 looking north

***Fig. G-9** (continued)*



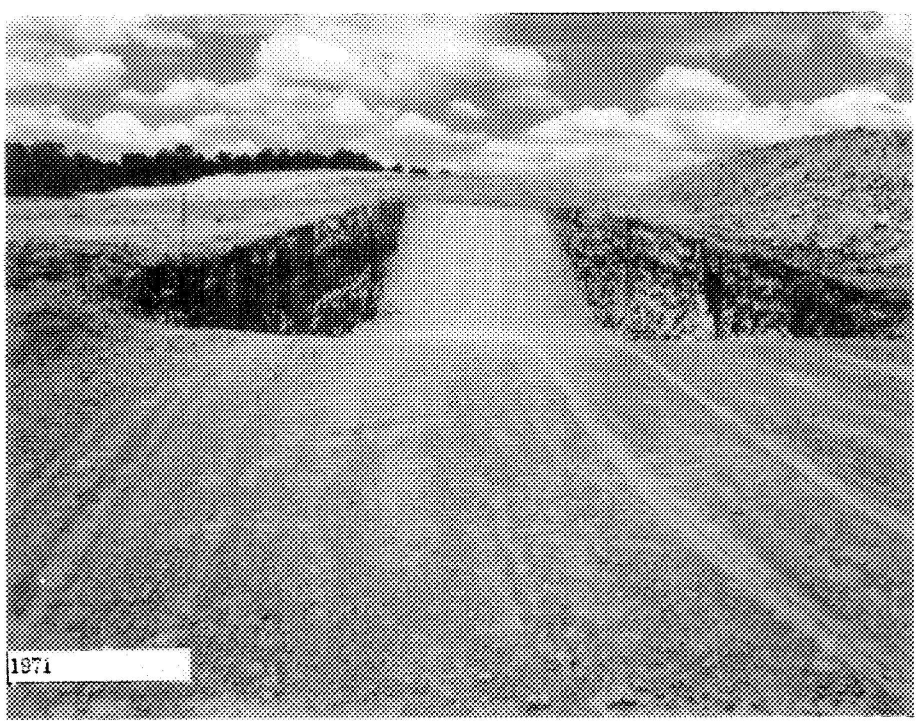
Pit 16, Area G looking north.



Pit 17, Area G looking northwest.

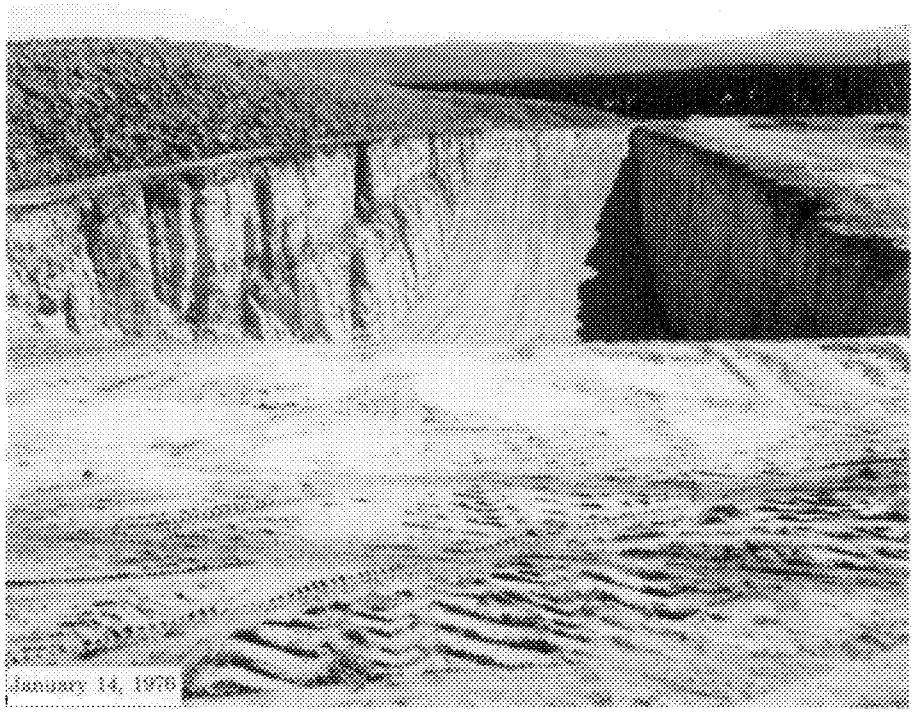
Fig. G-9 (continued)

Pit 20, Area G looking southeast.

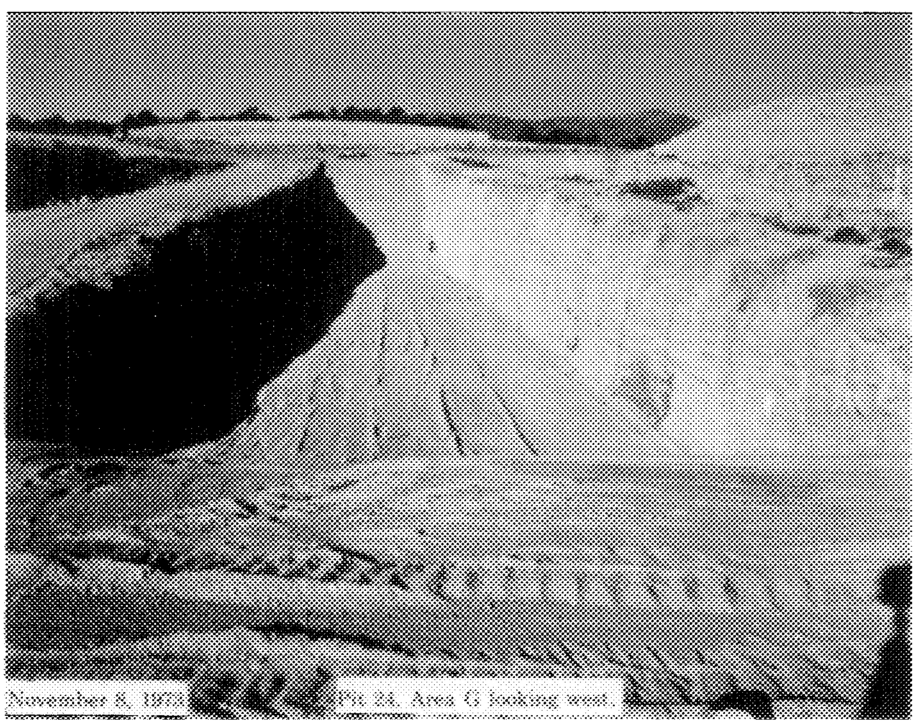


Pit 21,Area G looking northwest.

***Fig. G-9** (continued)*



Pit 22, Area G looking southeast.



Pit 24, Area G looking west.

***Fig. G-9** (continued)*

Caving of holes primarily due to joints in tuff.

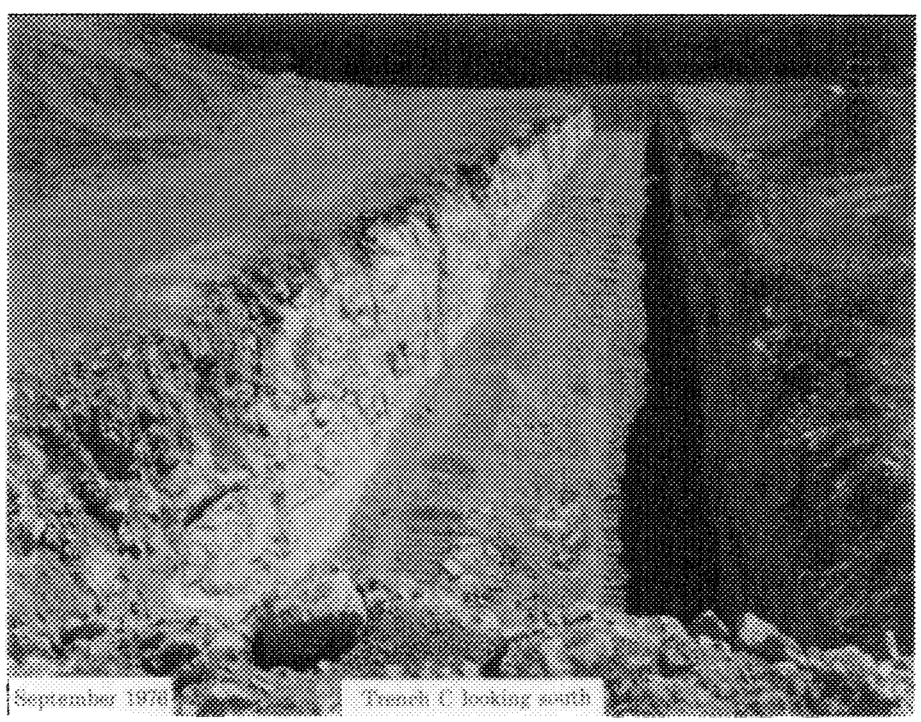


Fig. G-9 (continued)

Geology and Hydrology

August 3, 1974, an inspection was made of Pit 4.

"The pit was excavated on an east southeast-west-northwest axis to an approximate depth of 25 ft with a deeper slot being cut along the south wall where razed building materials could be burned. It was noted that several sections in the north and south walls had caved into the pit along fracture planes of the tuff."[120]

A staff member of the USGS stated he would make a study of the fracture patterns of the tuff and would send a letter outlining his conclusions and recommendations to the Engineering Department. This letter has not been located (July 1976).[104]

Type of Waste

Pit 4 records are found in LA Notebook 6905, October 21, 1965 through June 30, 1967, and LA Notebook 14995, July 3, 1967 through May 5, 1969.[104]

Mode of Disposal

Pit 4 was constructed using Materials Waste Pits Standard Specifications, Engineering Drawing ENG-C 18463. Pit 4 also contained a fire pit, dug along its south wall. Pit 4 is oriented east-west (see Fig. G-1).

PIT 5

Background

A request for a new disposal pit, Pit 5, was made March 31, 1965.

"The radioactive waste disposal pit No. 3, currently in use at Area G, has an estimated life expectancy of six more months. At that time we will need a new pit for disposal of laboratory wastes. We had planned on having additional space in pit No. 4, but it now appears that the materials from DP-West laundry and TA-45 will fill this pit."[121]

The preliminary survey work was completed during the third quarter of 1965;[110] digging was accomplished during the third quarter of 1966.[122] Pit 5 was put into use in the first quarter of 1967.[111] Pit 5 received its final covering by the end of March 1974.[123]

Geology and Hydrology

Pit 5 was inspected December 6, 1966.

"The pit was constructed into two ash flows of the Bandelier Tuff. The contact between the flows is marked by a pumice zone which is well exposed on the north wall of the pit and along the western half of the south wall. The rim of the eastern half of the south wall has been cut and eroded below the contact. The ash flow units are of rhyolite tuff and are the same units as Pits 2 and 4. Both units in this area are of fairly competent rocks that would form a stable cut in the tuff; however, the numerous joints which are near vertical and strike in random directions have caused some large slabs of the tuff to dislodge from the walls of the pit. This is caused by intersection of joints behind the cut face....the pit will not be used until these slabs are scaled from the wall (safety measures have been taken by H-1, as the entrance of the pit is roped off and posted). The joints exposed in the walls of the pit range from closed to open as much as 1 in.; however, the joints immediately below the soil zone are filled with clay or altered material. Any open joints in the floor of the pit are filled with crushed tuff due to traffic of equipment used during construction. No open joints that would require filling were noted.

The soil cover exposed in the walls of the pit ranges from about 0.5 ft to about 3 ft. Along the south wall of the pit from about sections 2+75 to 3+90 ft the upper 8 to 4 ft of the wall consists of fill material as the present pit was cut into the ramp leading into pit No. 3 which is now filled and covered.

The land surface around the pit slopes gently to the southeast from an altitude of 6678 ft at the northwest corner to an altitude of 6658 ft at the southeast corner. The bottom of the inner pit is at an altitude of 6643 which is about 50 ft above the floor of Canada del Buey and Pajarito Canyon."[124]

Type of Waste

Pit 5 records are found in LA Notebook 6905, October 21, 1965 through June 30, 1967, and LA Notebook 14995, July 3, 1967 through May 5, 1969.[104] Pit 5 records can also be found in LA Notebook 15953, April 9, 1969 through April 19, 1972, and in LA Notebook 14909, January 13, 1972 to present.[104]

Mode of Disposal

Pit 5 was the first pit to be constructed under the formalized USGS guidelines (Appendix E) and the new Standard Pit Specifications, Engineering Drawing ENG-C 25703. Pit 5 is 30.6 m (100 ft) wide, 182.9 m (600 ft) long, with a maximum depth of 8.18 m (29 ft). It has an inner pit that is 15.2 m (50 ft) wide, 121.9 m (400 ft) long, with a maximum depth of 1.5 m (5 ft)[124] (see Fig. G-10). In some places Pit 5 is 10.4 m (34 ft) deep. The pit walls slope 1/4 to 1. Pit 5 is oriented east-west (see Fig. G-1).

PIT 6

Background

The request for disposal Pit 6 was made in the first quarter of 1968.[125] The digging of Pit 6 was begun July 1969[126] and it was in use by October 15 of that year. The perimeter fence for Area G was also moved westward at that time to include Pit 6.[95] Pit 6 began receiving routine contaminated waste during the

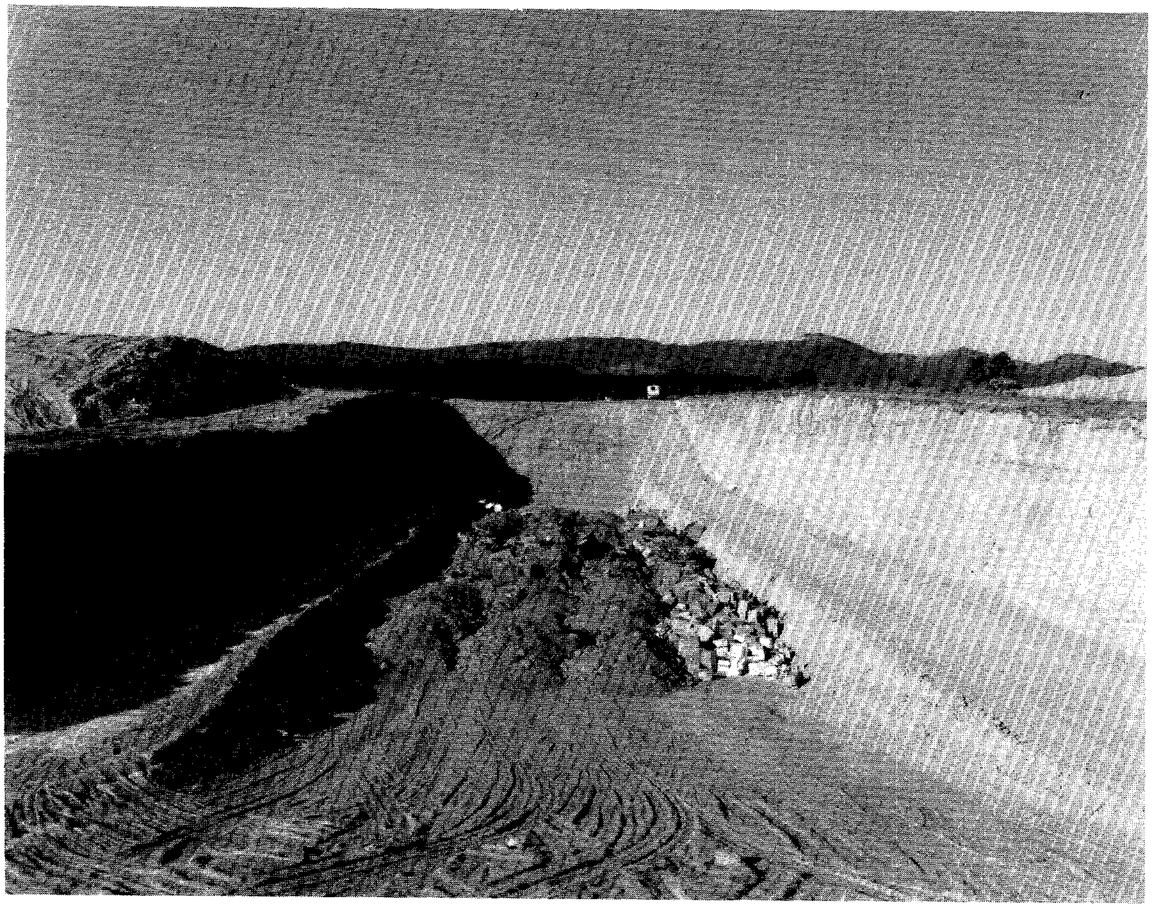


Fig. G-10.
Pit 5, Area G, showing inner pit 15.2 m (50 ft) wide, 121.9 m (400 ft) long with a maximum depth of 1.5 m (5 ft).

first quarter of 1970.[127] It was closed out in August 1972 and the final cover may have been complete in October.[90] On June 12, 1976 "top soil"* from TA-1 was spread over Pit 6.[286]

Geology and Hydrology

An inspection of Pit 6 was made on September 24, and October 9, 1969.

"The soil cover averages about one ft thick around the edges of the pit; however, in some places the soil has been stripped to the top of the tuff. The pit is completed within a single ash flow which is tentatively correlated with Unit 2 at the Meson Facility and at Mortandad Canyon. The tuff is moderately welded, light-gray in color. It is fairly competent though several blocks have fallen from the north and south walls due to intersecting joints within the wall.

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*This soil had traces of Pu-contamination. Group H-8 analyses showed 38 samples with no detectable contamination and 2 samples with 20 pCi/g.[286]

The majority of the joints range from vertical to about 60° from horizontal. The joint frequency averages about one joint per six feet along the pit wall. Orientation of 190 joints showed three major joint sets. Twenty-four percent of the joints were oriented from N. 20° W. to N. 50° W.; 17% were oriented from N. 50° E. to N. 70°E.; 15% were oriented from N. 10° W. to N. 10° E.: the remaining 44% of the joints were of random orientation. Beneath the soil zone joints in the tuff are filled with dark-brown clay derived from weathering of the tuff. The joints in the tuff range from closed to open as much as one in. and are filled or plated with light-gray clay or precipitate which in places contains some organic material from roots."[128]

Type of Waste

LA Notebook 15953, April 9, 1969 through April 19, 1972, and LA Notebook 17335, April 19, 1972 through August 16, 1972, log waste for Pit 6.[104]

Mode of Disposal

Pit 6 was constructed in an east-west direction under Standard Pit Specifications, Engineering Drawing ENG-C 25703. It was the last pit to be constructed with a 30.5 m (100 ft) width (see Fig. G-1).

PIT 7

Background

Excavation of Pit 7 was completed August 3, 1973.[129] Pit 7 was put in use March 28, 1974. It received its last delivery October 8, 1975.[130] Final covering began October 10, 1975[131] and finished March 3, 1976 (personal communication J. Enders, H-7). On June 12, 1976 "topsoil"* from TA-1 was spread over Pit 7.[286]

Geology and Hydrology

A survey of Pit 7 was completed August 27, 1973.

"The pit conforms...to guidelines for pit construction outlined in a memo from the USGS to ENG-3 dated June 30, 1965 [Appendix E]."[132]

"1. The pit is 50 ft from the canyon rim.

2. Maximum depth of the pit is above adjacent canyon floors.

3. The long dimension of the pit is parallel to surface topographic contours.

4. There are numerous joints and fractures in the walls of the pit. Joint frequency is about 1 joint per 6 ft of wall in the pit. This is about the same frequency as found in other pits in the area. Most of the joints are vertical or near vertical — the lowest angle is not less than 60° from a horizontal plane.

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*This soil had traces of Pu-contamination. Group H-8 analyses showed 38 samples with no detectable contamination and 2 samples with 20 pCi/g.[286]

Forty-two percent of the joints are root-filled. None of the joints stands open greater than 1 in. Some joints appear to be filled with soil even to a depth of 25-30 ft.

Pit 7 is dug in Unit 2b of the Tshirege member of the Bandelier Tuff."[133]

Joint data were collected for Pit 7 August 23, 24, and 27, 1973 (see Fig. G-11).

Type of Waste

As of July 1974, Pit 7 replaced Pit 17 for low-level transuranic waste. Records of waste placed in Pit 7 from March 28, 1974 to October 8, 1975 are found in LA Notebook 17339.

Mode of Disposal

Pit 7 is 15.2 m (50 ft) wide and 182.9 m (600 ft) long, with a maximum depth of approximately 9.1 m (30 ft). It is oriented east-west (see Figs. G-1, G-9).

PITS 8, 12, 16, 17, AND 21

Background

Five disposal pits (8, 12, 16, 17, and 21) were requested in the first quarter of 1971.[134] They were begun at the end of April[135] and completed during the second quarter of 1971.[136] The perimeter fence for Area G was moved west to inclose these pits during this quarter.[137] Pits 8, 12, and 16 were in use at the end of 1971.[92] Pit 17 received its first waste August 2, 1972, and Pit 21 received its first waste August 16, 1972.

Pit 8 received its final cover of dirt May 27, 1974; Pit 17, filled March 1, 1974, received its final covering by the end of March. Pit 21, filled December 16, 1974, received its final covering in December; Pit 16, backfilled to ground level August 1975, received a covering of top soil December, 1975 and Pit 12 received backfill to above ground level during the week of December 22-26, 1975.[123,130,131]

Geology and Hydrology

On July 20, 1971, a survey was made of Pits 8, 12, 16, 17, and 21.

"(1) The pits inspected were 50 ft from the canyon rim (2) Maximum depths of the pits were above adjacent canyon floors (3) Generally the pits were laid out with long dimension parallel to surface topographic contours. Pit 21, the long dimension is at right angles to the contours... (4) There are numerous joints and fractures in the walls of the pits. Joint frequency is about 1 joint per 6 ft of wall in the pits. This is about the same joint frequency as found in other pits in the area. Most of the joints are vertical ranging from 70 to 90° from a horizontal plane.

Pits 8, 12, 16, and 21 cut through two ashflows in Unit 2. The contact is characterized by increase in size of pumice fragments and thin layers of reworked sediments. Pit 17 is within the lower ashflow. It was noted that in several of the pits that (sic) the thin sediments in the contact were offset several inches along near vertical joints cutting both ashflows. The offset is probably caused by compaction of the lower flows..."[138]

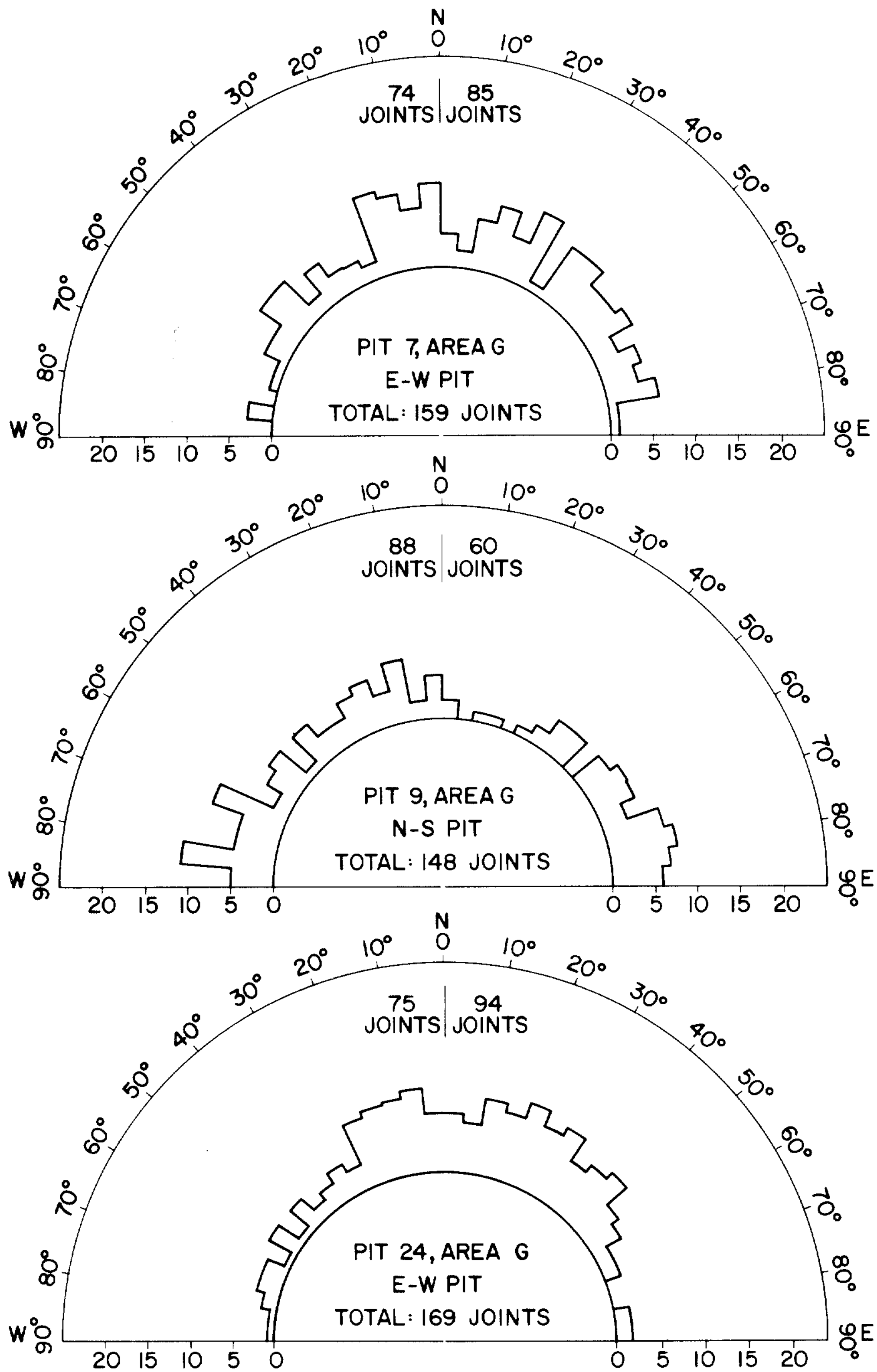


Fig. G-11.
Rose diagrams of joints in Pits 7, 9 and 24, Area G.

Type of Waste

Records of waste in Pit 8 are found in LA Notebook 17339, October 4, 1971 to March 27, 1974. LA Notebook 17338 logs waste in Pit 12 from October 6, 1971 to November 24, 1975. Pit 16 waste records are found in LA Notebook 17337 from October 15, 1971 to August 16, 1974 and in LA Notebook 17900 from August 27, 1974 to July 9, 1975.[287] LA Notebook 17336 logs waste in Pit 17 from August 2, 1972 to March 1, 1974. LA Notebook 17845 logs waste from August 16, 1972 to August 28, 1974, and LA Notebook 17900 logs waste from August 30, 1974 to December 16, 1974 for Pit 21.[104,131]

In 1970 compliance with AEC-IAD-0511-21 was initiated.[91] Following a decision made during the third quarter of 1971[137] Pit 8 was put into use for storage of 210 ℓ (55 gal) barrels of sludge from the H-7 waste treatment plants; Pit 12 was put in use for storage of plutonium-contaminated material estimated to exceed 10 nCi/g; Pit 16 was put in use for crates and drums containing uranium-contaminated material; Pit 17 would be put in use for low-level (<10nCi/g) TRU waste delivered by Dempster Dumpsters; and Pit 21 would be put in use for low-level uranium-contaminated material delivered by Dempster Dumpster. Later Pit 8 received not only sludge drums but also "nonretrievable" TRU waste.[123] Plutonium-contaminated material stored in Pit 12 was transferred to Pit 9 when that pit was completed. Pit 12 (1975) was used for nonretrievable waste.

Sites generating transuranic waste placed in Pit 17 are: TA-3, SM-29, Wings 2, 3, 4, 5, 7, and 9; TA-3, SM-184, OHL Bldg.; TA-43, HRL-1, HRL Bldg; TA-48, 1, E. Side and S.W. Side; TA-48, 8, N.W. Side; TA-50, 1, S.E. Side; TA-35, Bldg. 2, 10-Site; TA-33, 86; TA-3, SM-30; TA-41, Bldg. 4, W-Site; TA-21, 2-3, S. Side; TA-21, 3-4, N. Side; TA-21, 150; TA-21, 257; and TA-21, 2, N. Side.[139]

Sites generating uranium waste placed in Pit 21 are: TA-3, SM-102; TA-3, SM-66, Docks 1, 3, 4, and 5 and W. Side; TA-3, SM-35, Press Bldg.; TA-3, SM-40, TA-21, 152-155; TA-21, 3-4, S. Side; TA-46, Bldg. 31; TA-18, Kivas 1, 2, and 3 and Bldg. 129; TA-2, Bldg. 1, Omega; TA-15, R-184; and TA-18, Bldg. 70.[139]

Mode of Disposal

Dimensions of Pits 8, 12, 16, 17, and 21 differ from Standard Pit Specifications, ENG-C 25703. Pits 8, 12, and 16 are 7.6 m (25 ft) wide, 121.9 m (400 ft) long, and 7.6 m (25 ft) deep. Pit 8 walls slope approximately 1 on 8; Pit 12 walls are almost vertical; and Pit 16 walls slope approximately 1 on 10. Pit 17 is 15.2 m (50 ft) wide, 182.9 m (600 ft) long, and 7.6 m (25 ft) deep. Pit 21 is 15.2 m (50 ft) wide, 121.9 m (400 ft) long, and 7.6 m (25 ft) deep. Pit 17 walls slope approximately 1 on 6; Pit 21 walls slope approximately 1 on 12.[140] Pits 8, 12, and 16 are oriented northeast-southwest; and Pits 17 and 21 are oriented northwest-southeast (see Figs. G-1, G-9).

PIT 9

Background

Construction of Pit 9 was requested February 4, 1974.[123] Construction began in June 1974 and Pit 9 was put into use November 25, 1974. Covering for its first cell began December 20, 1974 and was complete July 11, 1975.[141] Stacking of waste in Cell 2 began in mid-December 1974.[141]

Geology and Hydrology

November 18, 1974, joint data were collected for Pit 9 (see Fig. G-11).

Type of Waste

Retrievable transuranic wastes, i.e., waste materials which contain 10 nCi/g ^{239}Pu, or ^{233}U, or 100 nCi/g ^{238}Pu, are stored in Pit 9. LA Notebook S-2141 records waste stored in Pit 9 from November 25, 1974 to present (July 1976).[287]

Mode of Disposal

Pit 9 is 9.1 m (30 ft) wide, 121.9 m (400 ft) long, with an average depth of 6.2 m (20 ft). The south end of Pit 9 has a slope of 1 to 2.[142] Pit 9 is oriented northeast-southwest (see Figs G-1, G-9).

The bottom of the pit is graded and asphalt paved and curbed to promote drainage away from the wastes. Any moisture moving on the asphalt surface drains into two 1.8 m (6 ft) diameter, 3.05 m (10 ft) deep asphalt-lined sumps at the northwest corner of the pit where it is sampled for contamination and, if necessary, is removed to the liquid waste treatment plant.

Waste materials, specially packaged in 210 ℓ (55 gal) drums with 10 mil plastic liners or in fiberglass-coated crates are stacked within the curbing to a height of 1 m (3 ft) below the ground surface for a pit length of 17 m. The waste stack is then covered with 12 mil nylon-reinforced plastic sheeting followed by plywood on the top and a 1 m (3 ft) layer of crushed tuff. The 1 m (3 ft) of crushed tuff between waste stacks provides a firebreak.

PIT 13

Background

Excavation of Pit 13 began August 2, 1976 and was completed August 26, 1976.

Geology and Hydrology

"The field survey of Pit #13 was completed on October 28, 1976. Pit #13 meets all geologic criteria mentioned in detail below and is approved for use.

The long axis of the pit strikes parallel to topographic contours (about N 70 E). It is a minimum of 40 m from the canyon rim and the bottom is at least 20 m above adjacent canyon floors.

The pit is excavated in two flows of Unit 2B of the Tshirege Member of the Bandelier Tuff. As in Pits #20 and #22, a 2 cm-thick reworked layer separates the two flows in some areas. In other areas, the contact is marked by a zone of less-dense welding in the bottom of the upper flow. On the west wall of the pit, the contact intersects the south ramp at 12.2 m and the north ramp at 104 m north of the south end. On the east wall, it intersects the north ramp at 23 m and the south ramp at 106.4 m south of the north end.

In comparison to Pit #22, there are less fractures in the walls of this pit. The density of occurrence of major fractures is 1 every 2.71 m. Two-thirds of the fractures dip 80° or more. Sixty percent of the fractures are weathered or have roots to the bottom of the pit. No fracture was open more than 4 cm. One fracture is an apparent normal fault with apparent vertical displacement of only 5 cm.

Photographs (Neg. No. 7612383-7612429) and descriptions of major fractures in Pit #13 are in the files of H-8..."[291]

Type of Waste

Uranium, fission products, and induced activity wastes are disposed of in Pit 13. The first waste delivery was November 4, 1976. LA Notebook 17900 records waste disposals to Pit 13.

Mode of Disposal

Pit 13 is 12.8 m (42 ft) wide, 121.9 m (400 ft) long with a maximum depth of 8.5 m (28 ft). The pit is oriented northeast-southwest (see Figs. G-1, G-9).

PIT 19

Background

April 6, 1971, a request for a decontamination pit at Area G was made[89] because:

"Due to the rupture of a drum while attempting to recover a pump in Pit 6, Area G, TA-54, three Zia trucks and three dumpsters were contaminated. Attempts were made to clean these items at TA-50... We are requesting that a decon pit... be excavated... Since we will not be able to complete the decontamination on the highly contaminated vehicles until such time as we can obtain this facility, we feel it is urgent that this be done immediately."[89]

The decontamination pit was dug April 7-8, 1971.[134]
The following was discussed in March 1975:[143]

"Group H-5 presently is planning to carry out research on "Cancer Suspect Agents". The work will be done in a room in the CMR Building in a "hot" area; consequently, although no radioactive materials are directly involved, the solid waste generated will be considered as radioactive and will require burial at Area G, TA-54.

A major uncertainty at this time, however, is that retrieval and subsequent treatment of this solid waste may be required in the future. The volume of waste will be small; only about one 4 yd³ Dumpster every 2-3 months. Because of this slight possibility for retrieval, it is proposed that this waste be disposed of in the small "decontamination" pit now at Area G. Required usage of such a pit is very remote and other pits in the area always could be used if needed. Based on the size of the "decontamination" pit (30′ × 120′ × 12′) and anticipated waste volume, the pit should be usable for about 2-3 years. This is more than sufficient for the presently planned work."[143]

The Decontamination Pit became Pit 19. It received its first waste under its new use definition November 21, 1975.[131]

Geology and Hydrology

No specific information available.

Type of Waste

Some alpha contamination is present in the bottom surface of Pit 19.[143]
Waste from research on "Cancer Suspect Agents" done by Group H-5 in the basement of Wing Four, SM-29 is logged in LA Notebook 17339 from November 21, 1975 to present (July 1976).[130,131,143,288]

Mode of Disposal

The decontamination pit is approximately 9.1 cm (30 ft) wide, 45.7 m (150 ft) long, and 3.7 m (12 ft) deep. It is oriented northeast-southwest (see Fig. G-1).

Because waste placed in Pit 19 might need to be retrieved in the future, "...*a plastic layer was placed in the bottom of the pit and about 6 inches of crushed tuff was placed on top of the plastic*"[130] so that the waste would not be contaminated by the pit.[143]

PIT 20

Background

Excavation of Pit 20 began June 10, 1975[130] and finished August 6, 1975. It was put into use November 26, 1975.[131]

Geology and Hydrology

Joint data[144] were collected for Pit 20 at the end of summer 1975.

Type of Waste

Pit 20 replaced Pit 7 for low-level (<10n Ci/g) transuranic waste. Records of waste placed in Pit 20 from November 26, 1975 to present (July 1976) are in LA Notebook 17338.[131] Most of the waste in the first 5 layers is dirt from a TA-1 clean-up operation.[130]

Mode of Disposal

Pit 20 is 21.3 m (70 ft) wide and 182.9 m (600 ft) long, with a maximum depth of approximately 12.2 m (40 ft). It is oriented northwest-southeast (see Figs. G-1, G-9).

PIT 22

Background

Work began on Pit 22 December 22, 1975.[130] Excavation was completed January 8, 1976.

Geology and Hydrology

"The field survey of Pit #22 was completed on August 11, 1976.

The long axis of the pit strikes parallel to topographic contours (approximately N37W). The edge of the pit is a minimum of 30.5 m from the canyon rim and the bottom is at least 20 m above adjacent canyon floors.

The pit is excavated in two flows of Unit 2B of the Tshirege Member of the Bandelier Tuff. In some locations, a 2 cm-thick reworked layer separates the two flows. In other locations, the contact is marked by a zone of less dense welding in the bottom of the upper flow....

On the southwest wall, the contact intersects the northwest ramp of the pit 17.7 m southeast of the northwest end (near Fracture #13 on the photos) and intersects the southeast ramp 116 m southeast of the northwest end (at Fracture 58). On the northeast wall, the contact intersects the northwest ramp of the pit 18.6 m southeast of the northwest end (1.6 m southeast of Fracture #64); it intersects the southeast ramp 113.4 m southeast of the northwest end (3 m southeast of Fracture #101).

Fractures are numerous in the walls of the pits. A major fracture is one that has a fairly constant strike and which intersects the pit wall from top to bottom. The density of occurrence of major fractures is 1 every 2.4 m. Seventy percent of the fractures dip 80° or more. At least thirteen percent show some signs of weathering and fourteen percent have roots to the bottom (9 m below the surface in some locations). No fracture was open more than 3 cm.

Fractures 52, 53 and 55 are apparent normal faults. (The northwest side has moved down relative to the southeast side). The apparent vertical displacement is 7 cm on Fractures 52 and 53 and 9 cm on 55.

Photographs (CN76-1067 to 1084) and descriptions of major fractures in Pit #22 are in the files of H-8..."[289]

Type of Waste

Pit 22 will be used for low-level transuranic waste. Eight sections of filter plenum were placed in the pit September 20, 1976.[288]

Mode of Disposal

Pit 22 is 15.2 m (50 ft) wide and 121.9 m (400 ft) long with a maximum depth of approximately 10.7 m (35 ft). It is oriented northwest-southeast (see Figs. G-1, G-9).

PIT 24

Background

Excavation of Pit 24 was completed September 14, 1973.[129] Radioactive waste container fire tests (Memo H8-WM-350, December 5, 1974) began in Pit 24, on December 12, 1974. Pit 24 began receiving wastes July 3, 1975.[131] Final backfill of Pit 24 was begun October 1976.[290]

Geology and Hydrology

Joint data were collected for Pit 24 November 21, and December 4 and 10, 1973, and June 24, 25 and 27, 1975 (see Fig. G-11).

Type of Waste

Pit 24 replaced Pit 21 for low-level uranium waste. Waste records for Pit 24 from July 3, 1975 to November 2, 1976 are in LA Notebook 17900.[131,287] Pit 24 received uranium, tritium, mixed fission products, and mixed activation products wastes.[287]

Mode of Disposal

Pit 24 is 15.2 m (50 ft) wide and 182.9 m (600 ft) long, with a maximum depth of approximately 7.6 m (25 ft). It is oriented east-west (see Figs. G-1, G-9).

DISPOSAL SHAFTS

Background

Another request for disposal shaft layout was made May 5, 1965;[145] two previous ones do not appear to have been acted upon.[146,118]

"We estimate that the disposal wells in Area C of the contaminated waste disposal area will be full by the end of this year. The general opinion seems to be that when these wells are full we should close out Area C and move all of our contaminated waste disposal operations out to the Mesita del Buey area [Area G].

Will you please prepare a layout for disposal wells in Area G, using the same spacing as we had in Area C."[145]

Preliminary survey work for location of 10 disposal shafts west of Pit 2 was completed during the third quarter of 1965.[110] By the end of 1965 the 10 disposal shafts were dug.[147] Shafts 1, 2, 3, and 11 were put into use in the first quarter of 1967.[111] (See Table G-VI.)

Geology and Hydrology

Some of the 1.8 m (6 ft) diameter shafts at Area G have been inspected by means of a bosun's chair. Structural defects caused by fracturing prevented ingress of Shaft 39 (personal communication, W. D. Purtymun, H-8)

March 4, 1975 Shafts 51 through 57 and 67 through 69, which are 0.6 m (2 ft) diameter shafts were entered and fracture data were collected.[158]

Type of Waste

LA Notebook 12442 logs waste which went into disposal shafts in Area G from April 21, 1966 to February 24, 1976 and LA Notebook S-2306 logs waste from March 3, 1976 to present (December 1976).[286] See Appendix G for a listing of the contents of the 97 shafts in Area G.

Mode of Disposal

Shafts 1 through 10, 24 through 33, 40 through 49, 51 through 57, 67 through 69, and 71 through 90 are 0.6 m (2 ft) diameter, 7.6 m (25 ft) deep, unlined shafts. Shafts 11, 12, 13, 58, and 61 through 66 are 0.9 m (3 ft) diameter, 7.6 m (25 ft) deep, unlined shafts. Shafts 35 through 38 are 0.9 m (3 ft) diameter, 12.2 m (40 ft) deep, unlined shafts. Shafts 91 through 95 are 0.9 m (3 ft) diameter, 15.2 m (50 ft) deep unlined shafts. Shafts 14 through 23 are 0.3 m (1 ft) diameter, 7.6 m (25 ft) deep, cement-lined shafts. Shafts 34, 39, 50, 59, 60, 70 and 150 are 1.8 m (6 ft) diameter, 18.3 m (60 ft) deep shafts; Shaft 96 is a 1.8 m (6 ft) diameter, 15.2 m (50 ft) deep shaft. While open all 1.8 m (6 ft) diameter shafts are covered with steel shaft covers which are 2.4 m (8 ft) high, 1.8 m (6 ft) diameter cylinders with lids. Construction details are given on Engineering Drawing ENG-R 3638. The shaft cover projects above ground level about 0.9 m (3 ft). Figure G-12 shows location and typical shaft construction.

TABLE G-VI

HISTORY OF DISPOSAL SHAFTS AT AREA G, TA-54*

Shaft No.	Date Augered	Date of First Delivery	Date of Last Delivery	Date Sealed
1	4th quarter, 1965[147]	4-21-66	1-20-67	8- 8-67
2	4th quarter, 1965[147]	4-21-66	6-13-67	8- 8-67
3	4th quarter, 1965[147]	4-21-66	11- 9-67	10- 2-68[148]
4	4th quarter, 1965[147]	4- 5-67	1- 2-68	10- 2-68
5	4th quarter, 1965[147]	6- 7-67	1-26-68	3-27-68[149]
6	4th quarter, 1965[147]	6- 7-67	3- 7-68	3-27-68
7	4th quarter, 1965[147]	6- 7-67	9-19-68	10- 2-68
8	4th quarter, 1965[147]	4-22-68	1-15-69	4-11-69[150]
9	4th quarter, 1965[147]	6-17-68	4- 9-69	4-11-69
10	4th quarter, 1965	2-26-69	8-25-69	11-25-69
11	July, 1966[151,152]	1-30-67	11-11-69	11-25-69
12	July, 1966[151,152]	7-29-66	3-19-70	6- 9-70
13	July, 1966[151,152]	9-23-66	5-25-70	6-10-70
14	July, 1966[151,152]	9-21-67	9-10-69	before 11-10-72
15	July, 1966[151,152]	11-25-69	6-16-70	before 11-10-72
16	July, 1966[151,152]	11-25-69	11-25-69	11-25-69
17	July, 1966[151,152]	3-30-70	12- 2-74	3-23-76
18	July, 1966[151,152]	7-13-70	3- 2-73	3-23-76
19	July, 1966[151,152]	10-21-71	4-26-74	3-23-76
20	July, 1966[151,152]	5-29-74	6-12-75	3-23-76
21	July, 1966[151,152]			open
22	July, 1966[151,152]			open
23	July, 1966[151,152]			open
24	3rd quarter, 1968[94]	9- 3-69	12- 8-70	5- 7-71
25	3rd quarter, 1968[94]	9-29-69	2-16-71	5- 7-71
26	3rd quarter, 1968[94]	12-10-69	6-23-70	5- 7-71
27	3rd quarter, 1968[94]	5- 6-70	8-25-70	5- 7-71
28	3rd quarter, 1968[94]	6-23-70	7-21-70	5- 7-71
29	3rd quarter, 1968[94]	7- 9-70	1-20-71	5- 7-71
30	3rd quarter, 1968[94]	7-28-70	2-26-71	5- 7-71
31	3rd quarter, 1968[94]	9-24-70	2-16-71	5- 7-71
32	3rd quarter, 1968[94]	5-27-70	10-18-71	before 11-10-72
33	3rd quarter, 1968[94]	10-26-70	3-15-71	5- 7-71
34	10-6-69[95,153]	2- 3-70	4-19-72	8- -72
35	May, 1970[97,153]	9- 7-71	1-13-72	before 11-10-72
36	May, 1970[97,153]	6- 9-70	6- 9-70	open
37	May, 1970[97,153]	6- 9-70	6- 9-70	open
38	May, 1970[97,153]	6- 9-70	6- 9-70	open
39	3rd quarter, 1970[154]	8-11-70	10-26-73	11-27-73

TABLE G-VI (Continued)

Shaft No.	Date Augered	Date of First Delivery	Date of Last Delivery	Date Sealed
40	June 9, 1970[97]	3- 5-71	5- 6-71	5- 7-71
41	June 9, 1970[97]	3-12-71	8-31-72	before 11-10-72
42	June 9, 1970[97]	3-16-72	10-25-72	before 11-10-72
43	June 9, 1970[97]	7- 1-71	8- 3-72	before 11-10-72
44	June 9, 1970[97]	8-25-71	8- 3-72	before 11-10-72
45	June 9, 1970[97]	9- 7-71	8-17-72	before 11-10-72
46	June 9, 1970[97]	4- 4-72	8-29-72	before 11-10-72
47	June 9, 1970[97]	4- 6-72	7-13-72	before 11-10-72
48	June 9, 1970[97]	6-19-72	10- 5-72	before 11-10-72
49	June 9, 1970[97]	6-15-72	9-28-72	before 11-10-72
50	May, 1974[155]	6-13-74	4-15-76[286]	6-10-76
51	12-31-74	2-27-75[141]	10- 2-75	6-10-76
52	12-31-74	9- 8-75[141]	6-17-76[286]	7-12-76
53	12-31-74	11-20-75[141]	4- 2-76[286]	6-10-76
54	12-31-74	6-16-76[286]		open
55	12-31-74			open
56	12-31-74			open
57	12-31-74			open
58	2nd quarter, 1972[156]	7-21-72	9-18-73	11-21-73
59	Jan.-Feb. 1973[157]	2-14-73	5-30-74	4th quarter, '74
60	2nd quarter, 1972[156]	12-11-72	2-16-74	3-24-75
61	2nd quarter, 1972[156]	6-25-73	2- 8-74	5-17-74
62	2-20-73[157,153]	4- 8-74	2-20-76	3-23-76
63	2-20-73[157,153]	1-19-76	1-19-76	3-23-76
64	2-20-73[157,153]			open
65	2-20-73[157,153]			open
66	2-20-74[157,153]	4-30-76	6-29-76	8-31-76
67	12-31-74			open
68	12-31-74			open
69	12-31-74			open
70	12-31-74	1-10-75	2-20-76	3-23-76
71	9- 2-76			
72	before 11-10-72	3- 1-72	3- 1-73	11-21-73
73	before 11-10-72	1-19-73	3- 8-73	11-21-73
74	3- 2-73[153]	3- 8-73	5-30-73	11-21-73
75	3- 2-73[153]	5-31-73	10-12-73	11-21-73
76	3- 2-73[153]	10-26-73	4- 4-74	5-17-74
77	3- 2-73[153]	1-10-74	5- 2-74	6-25-74
78	3- 2-73[153]	6-12-74	3- 6-75	3-24-75
79	3- 2-73[153]	10- 8-74	12-16-75	3-23-76
80	3- 2-73[153]	6- 6-75[141]	2-17-76	7-12-76

TABLE G-VI (Continued)

Shaft No.	Date Augered	Date of First Delivery	Date of Last Delivery	Date Sealed
81	3- 2-73[153]	5-15-75[141]	5-13-75	7-12-76
82	9- 2-76			
83	9- 2-76			
84	9- 2-76			
85	9- 2-76			
86	9- 2-76			
87	9- 2-76			
88	9- 2-76			
89	9- 2-76			
90	9- 2-76			
91	9- 2-76			
92	9- 2-76			
93	9- 2-76			
94	9- 2-76			
95	9- 2-76			
96	9- 2-76			
150	5- 3-76	5-13-76[286]		open

*Data (unless referenced) are from LA Notebook 12442.

TRENCHES A & B

Background

Trench A and Trench B of the ^{238}Pu storage facility were begun January 7, 1974, and finished March 21-22, 1974.[123] Placement of drums in Trench A began March 4, 1974. Trench A was filled on October 29, 1974 and covered by the second week of November 1974. (Personal communication, J. Warren, H-7). Trench B was put into use March 25, 1974.[141] Excavation of Trench C began September 1976 and was completed September 10, 1976. Mounding over Trenches A and B was completed September 30, 1976.

Geology and Hydrology

No specific information available.

Type of Waste

Waste records for Trench A and Trench B are found in LA Notebook 17335 from March 4, 1974 to present (December 1976).[287] Waste consists of heat source ^{238}Pu (80% ^{238}Pu, 16% ^{239}Pu, 3% ^{240}Pu, and 1% other). For reasons such as the following, this waste was placed in casks in the trenches instead of in Pit

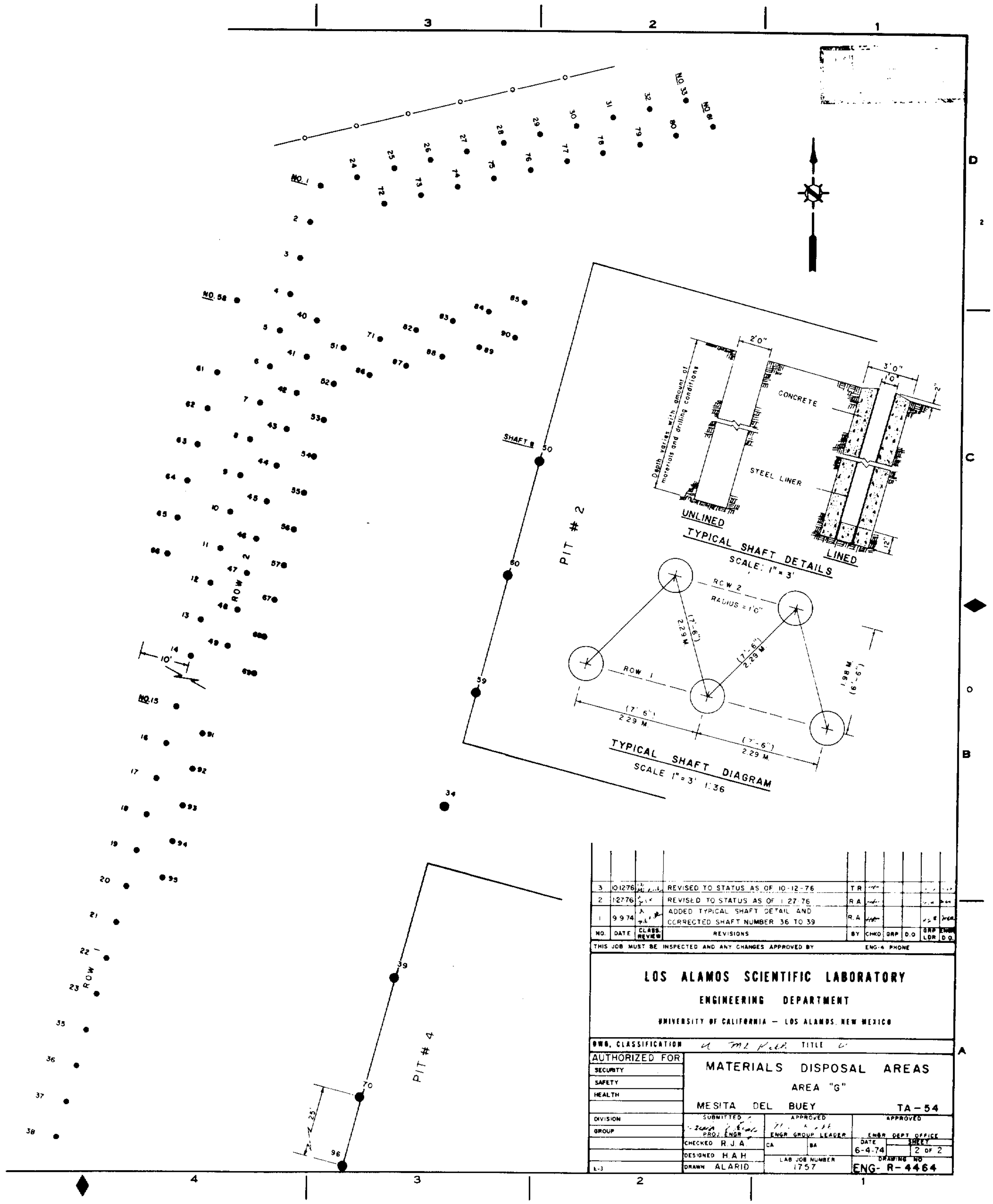


Fig. G-12.
Map of shaft field, Area G, TA-54.

9: (1) nuclear heating, (2) radiolytic gas formation, (3) radiation emitted from wastes. In the future, other retrievable waste besides heat source ^{238}Pu might be placed in the casks for similar reasons. There is an average of 18 g ^{238}Pu/cask. The maximum amount any cask may contain is 40 g ^{238}Pu.

Mode of Disposal

Trenches A and B are 4.0 m (13 ft) wide and 1.8 m (6 ft) deep. Trench C is 4.0 m (13 ft) wide and 2.4 m (8 ft) deep. Trench A is 80.9 m (262.5 ft) long, and Trenches B and C are 66.7 m (?18.75 ft) long. Two rows of 0.9 m (3 ft) diameter, 0.6 m (2 ft) deep holes[123] were augered on 1.2 m (4 ft) centers in the floors of Trenches A and B. The rows were on 1.0 m (3.2 ft) centers (see Fig. G-13). Into each hole was placed a concrete cask (Fig. G-14) which holds two 115 ℓ (30 gal) metal drums.[123] No holes were augered in the bottom of Trench C.[292] The trenches are oriented northwest-southeast (see Fig. G-9).

There are 20 numbered casks to an "array." Each array is backfilled with crushed tuff up to the rims of the casks. After placement of wastes in the casks the lids are sealed with asphalt material. When each array is filled, corrugated "Q-Decking" is placed on top of the lids of the casks to create an air space between the top of the casks and the overlying 1 m (3 ft) of crushed tuff which fills the trench. Each array is separated from the next array by 1.5 m (5 ft) of crushed tuff.

Trench A contains 120 casks in 6 arrays. Trenches B and C contain 100 casks in 5 arrays. In a trench each cask has a location number and, on a red plastic tag, an identification number. The drums placed in the casks carry identification numbers which are recorded on numbered radioactive solid waste disposal sheets. On the radioactive solid waste disposal sheets, trench letters appear under the pit column (See Table G-VII).

VI. STUDIES AND MONITORING

In March 1950 the USGS drilled two test wells, T-5 and T-6, in the floor of Pajarito Canyon south of Mesita del Buey for geologic and hydrologic information[77] (see Fig. G-2). Test well T-5 (SW 1/4 SE 1/4 sec. 31, T. 19 N., R. 7 E.)[159] was approximately 472.4 m (1550 ft) south-southwest of the center of Area G. It was an 80.2 m (263 ft) hole with a diameter of 61 cm (24 in.). No water was encountered (see Table G-II). Test well T-6 (SW 1/4 NE 1/4 sec. 36, T. 19 N., R. 6 E.)[159] was approximately 2.3 km (1.4 miles) west-northwest of Area G. It was a 91.4 m (300 ft) hole. No water was encountered (see Table G-III).

December 7, 1956, J. E Weir, Jr. and J. H. Abrahams, Jr. of the USGS made a geologic investigation of Mesita del Buey at the request of the AEC.[73] The purpose of the investigation was to determine if Mesita del Buey was a suitable burial site for radioactive wastes.

"Mesita del Buey is capped with the welded tuff (upper) member of the Bandelier Tuff, which may be subdivided into several distinct layers. The top layer of the mesa-capping is about 85 ft thick near the road junction and a maximum of about 50 ft thick near the Tshirege ruins. The layer beneath this, a pumiceous tuff, is about 30 ft thick toward the west end and thins to about 10 ft thick toward the east end of the proposed burial area. The upper few feet of the basal unit of the Tshirege member crops out in Pajarito Canyon and Canada del Buey, and was noted to be agglomeratic and moderately pumiceous. Information from the logs of the two test holes drilled in Pajarito Canyon show that layers of welded tuff occur in the subsurface of the basal unit. This lower unit of basically welded tuff is 60 to 100 ft thick under the area studied.

The two basal members of Bandelier Tuff are more pumiceous and permeable than the Tshirege member and underlie the top member. The Puye Conglomerate underlying the Bandelier Tuff is encountered in drilling about 200 ft beneath the base of the Tshirege member toward the west end of the proposed burial pit area. A basalt bed occurs about 130 ft beneath the base of the Tshirege member toward the east end of the proposed burial pits. The Puye Conglomerate is a water-laid

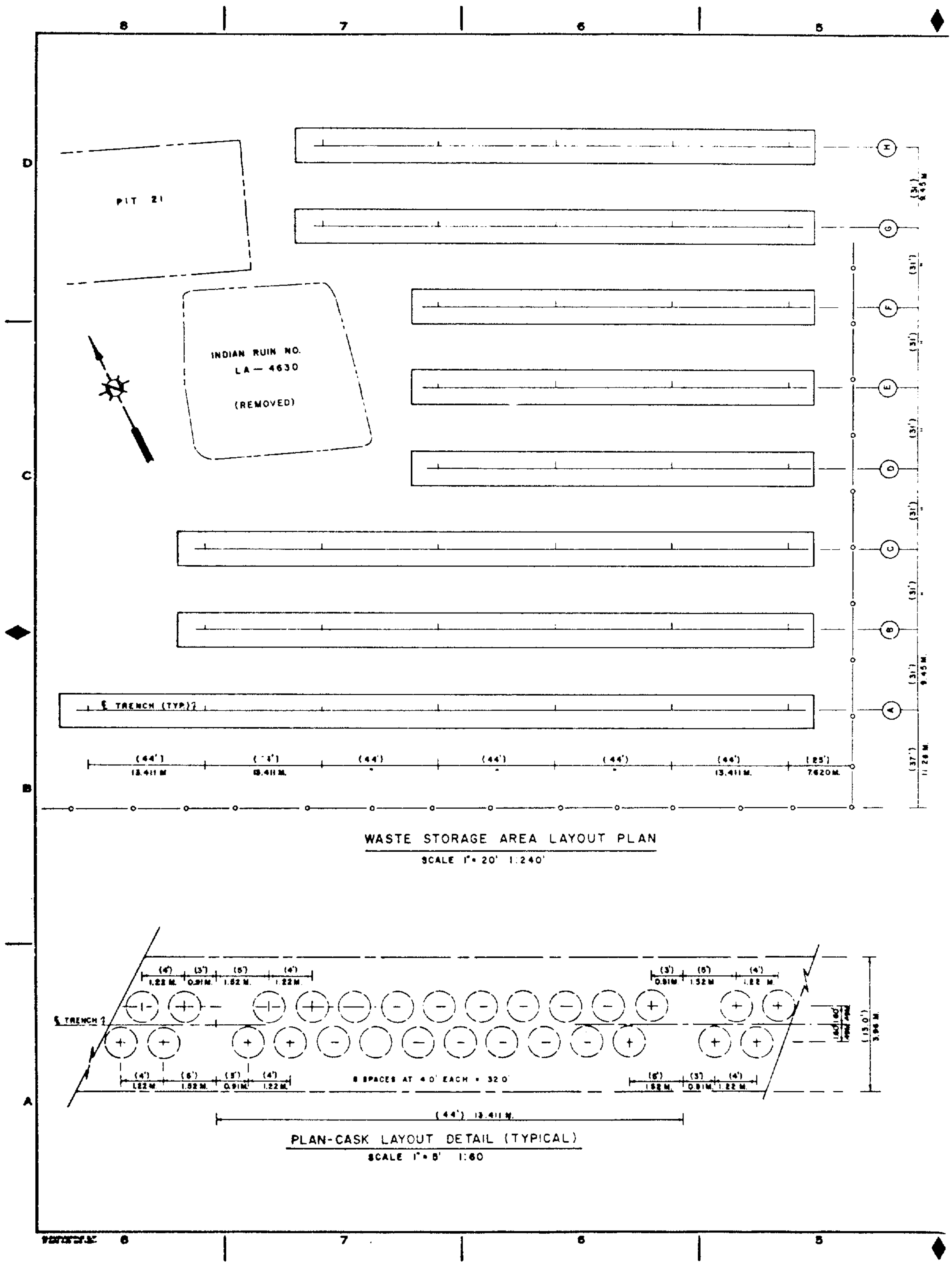


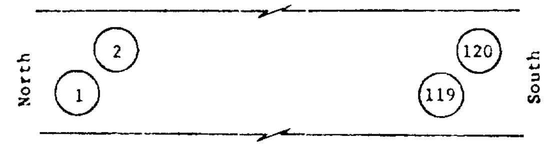
Fig. G-13.
Map of trenches, Area G, TA-54.

TABLE G-VII

DRUM AND CASK LOCATION FOR TRENCHES A, B, AND C

LA Notebook 17335

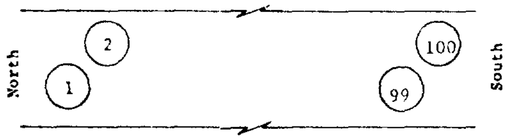
Trench A



Date	Cask Number	Array	Drum[a,b] Number	Red I.D. Tag Number
3/4/74	120	A-6	11 & 16	751
	119	A-6	5 & 21	752
	118	A-6	15 & 20	753
	117	A-6	4C & 10C	754
	116	A-6	19C & 13C	755
	115	A-6	14 & 7	756
	114	A-6	9 & 8	757
	113	A-6	12 & 18	758
	112	A-6	3 & 6	759
	111	A-6	1C & 2C	760
	110	A-6	31 & 63	761
	109	A-6	52 & 26	762
	108	A-6	60 & 61	763
	107	A-6	29 & 59	764
	106	A-6	24 & 58	765
	105	A-6	28 & 36	766
	104	A-6	27 & 25	767
	103	A-6	32 & 35	768
	102	A-6	30 & 23	769
	101	A-6	40 & 22	770
	100	A-5	38 & 46	771
	99	A-5	42 & 50	772
	98	A-5	43 & 48	773
	97	A-5	37 & 41	774
	96	A-5	39 & 44	775
	95	A-5	57 & 47	776
	94	A-5	54 & 49	777
	93	A-5	53 & 56	778
	92	A-5	51 & 55	779
3/6/74	91	A-5	83 & 52	780
	90	A-5	82 & 79	781
	89	A-5	81 & 75	782
	88	A-5	78 & 77C	783
	87	A-5	80 & 76	784
	86	A-5	73 & 74	785
	85	A-5	72 & 65	786
	84	A-5	70 & 69	787
	83	A-5	71 & 68C	788
	82	A-5	67 & 64	789
	81	A-5	66 & 95	790
	80	A-4	92 & 96	791
	79	A-4	90 & 94	792
	78	A-4	87 & 93	793
	77	A-4	91 & 84	794
	76	A-4	86 & 89	795
3/8/74	75	A-4	115 & 88	796
	74	A-4	114 & 105	797
	73	A-4	113 & 104	798
	72	A-4	100 & 112	799
	71	A-4	110 & 111	800
	70	A-4	99C & 108C	801
3/18/74	18	A-1	197 & 198	853
3/25/74	17	A-1	199 & 217	854
	16	A-1	214C & 17C	855
	15	A-1	216 & 213	856
10/29/74	14	A-1	241 & 242	860
	13	A-1	243 & 244	861
	12	A-1	237 & 238	862
	11	A-1	239 & 240	863
	10	A-1	234 & 235	864

Date	Cask Number	Array	Drum[a,b] Number	Red I.D. Tag Number
3/8/74	69	A-4	102 & 107	802
	68	A-4	103 & 109	803
	67	A-4	106 & 45	804
	66	A-4	98C & 97C	805
	65	A-4	101C & 128C	806
	64	A-4	132 & 129	807
	63	A-4	131 & 134	808
	62	A-4	130 & 133	809
	61	A-4	127 & 126	810
	60	A-3	125 & 119	811
	59	A-3	124C & 123C	812
	58	A-3	117C & 122C	813
	57	A-3	118C & 116C	814
5/13/74	56	A-3	156 & 152	815
	55	A-3	120C & 121	816
	54	A-3	150 & 153	817
	53	A-3	151C & 149C	818
	52	A-3	145 & 147	819
	51	A-3	143 & 144	820
	50	A-3	141 & 146	821
	49	A-3	148C & 140C	822
	48	A-3	138 & 142	823
	47	A-3	136 & 139	824
	46	A-3	135 & 137	825
	45	A-3	173 & 171C	826
	44	A-3	174 & 172	827
	43	A-3	167 & 169	828
	42	A-3	163 & 168	829
	41	A-3	170 & 166	830
	40	A-2	165 & 164C	831
	39	A-2	159C & 161C	832
	38	A-2	160 & 162	833
	37	A-2	157 & 155	834
	36	A-2	158 & 154	835
3/18/74	35	A-2	193 & 194	836
	34	A-2	188 & 184	837
	33	A-2	189 & 185	838
	32	A-2	190 & 186	839
	31	A-2	191 & 187	840
	30	A-2	196 & 195	841
	29	A-2	179 & 180	842
	28	A-2	178 & 181	843
	27	A-2	177 & 176	844
	26	A-2	175 & 183	845
	25	A-2	211 & 85	846
	24	A-2	210 & 209	847
	23	A-2	208 & 207	848
	22	A-2	205 & 206	849
	21	A-2	201 & 202	850
	20	A-1	200 & 203	851
	19	A-1	204 & 212C	852
10/29/74	9	A-1	236C & 222C	865
	8	A-1	230 & 231	866
	7	A-1	226 & 229	867
	6	A-1	225 & 233	868
	5	A-1	227 & 232	869
	4	A-1	221 & 223	870
	3	A-1	228 & 224	871
3/25/74	2	A-1	215[a] & 219	857
	1	A-1	218 & 182[a]	858

Trench B



Date	Cask Number	Array	Drum[a,b] Number	Red I.D. Tag Number
3/25/74	1	B-1		
	2	B-1		
	3	B-1		
	4	B-1		
	5	B-1		
4/29/76	6	B-1	BFB344 & 364	1969
	7	B-1	BFB345 & 352	1968
	8	B-1	BFB355 & 362	1967
	9	B-1	BFB343 & 348	1966
	10	B-1	BFB353 & 358	1965
	11	B-1	BFB361 & 351	1964
	12	B-1	BFB356 & 365	1963
	13	B-1	BFB342 & 350	1962
	14	B-1	BFB360 & 366	1961
	15	B-1	BFB359 & 349	1960
	16	B-1	BFB357 & 367	1959
	17	B-1	BFB347 & 346	1958
	18	B-1	BFB368 & 369	1957
	19	B-1	BFB354 & 363	1956
	20	B-1	BFB370 & 371	1955
	21	B-2	BFB372 & 373	1954
9/29/76	22	B-2	BFB374 & 375	1949
9/8/76	23	B-2	9 & 8	1984
	24	B-2	7 & 15	1983
	25	B-2	14 & 13	1982
	26	B-2	24 & 22	1981
	27	B-2	12 & 23	1980
	28	B-2	10 & 11	1978
	29	B-2	29 & 28	1979
	30	B-2	5 & 25	1977
	31	B-2	26 & [illegible]	1976
	32	B-2	4 & 6	1975
	33	B-2	20 & 21	1972
	34	B-2	& 19	1974
	35	B-2	17 & 16	1973
	36	B-2	2 & 18	1971
	37	B-2	1 & 3	1970
6/30/76	38	B-2	320 & 340	1929
	39	B-2	327 & 335	1928
	40	B-2	330 & 332	1927
	41	B-3	323 & 333	1926
	42	B-3	334 & 338	1925
	43	B-3	322 & 324	1924
	44	B-3	337 & 328	1923
	45	B-3	325 & 341	959
	46	B-3	321 & 314	958
	47	B-3	319 & 326	957
	48	B-3	315 & 317	956
	49	B-3	336 & 339	955
	50	B-3	316 & 309	954
	51	B-3	310 & 311	950
	52	B-3	329 & 313	951
	53	B-3	312 & 331	953
5/27/76	54	B-3	25 & 318	969
	55	B-3	18 & 24	966
	56	B-3	17 & 19	965
	57	B-3	14 & 16	964
	58	B-3	22 & 23	963
	59	B-3	15 & 21	960
	60	B-3	13 & 20	929
	61	B-4	11 & 12	928
	62	B-4	9 & 10	927
	63	B-4	7 & 8	926
	64	B-4	2 & 6	925
	65	B-4		
12/2/75	66	B-4	275C & 280C	999
	67	B-4		
	68	B-4	278C & 279	998
	69	B-4	282C & 285C	997
	70	B-4	284C & 300	996
	71	B-4	276C & 283C	995
	72	B-4	308 & 277	994
	73	B-4	306 & 286	993
	74	B-4	297 & 305	992
12/2/75	75	B-4	307 & 299	991
	76	B-4	289 & 288	990
	77	B-4	294 & 287	989
	78	B-4	292 & 302	988
	79	B-4	304C & 293	987
	80	B-4	303 & 281C	986
3/25/74	81	B-5	220 & 192[a]	859
12/2/75	82	B-5	295 & 301C	985
	83	B-5	298 & 296	984
	84	B-5	290 & 291	983
6/12/75	85	B-5	247 & 260	886
	86	B-5	248 & 255	885
	87	B-5	251 & 246	884
6/12/75	88	B-5	249 & 250	883
	89	B-5	254 & 253	882
	90	B-5	256 & 252	881
	91	B-5	258 & 257	880
	92	B-5	259 & 245C	872
	93	B-5	262 & 261	873
	94	B-5	264 & 263C	874
	95	B-5	267 & 268	875
	96	B-5	265 & 266C	876
	97	B-5	272[b] & 273	877
	98	B-5	270[b] & 271	878
6/12/75	99	B-5	274 & 269	879
6/3/75	100	B-5		732

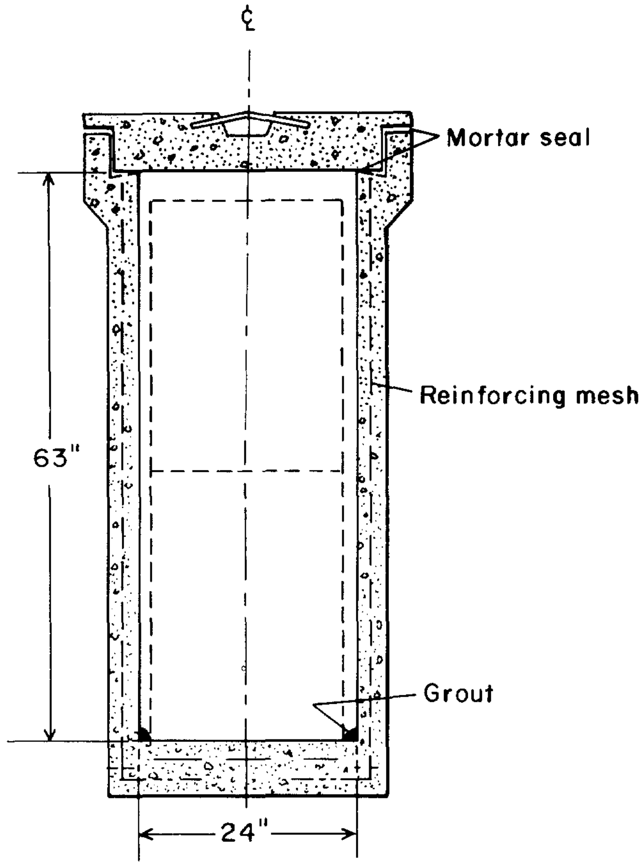


Fig. G-14.
Construction details of storage casks for Area G trenches.

deposit and has a relatively high permeability, but the basalt bed, which interfingers with the Puye, is impervious except for large joints and fractures. The 300-ft hole drilled into the upper part of the Puye Conglomerate in Pajarito Canyon is dry and the main saturated zone of the ground water is thus more than 210 ft beneath the base of the welded tuff (Tshirege) at this point.

Although the exact location of the pits should be determined after an engineering survey of the area is conducted, there are several basic factors to be considered. First, the Tshirege member is a relatively impermeable rock and percolation from dry waste material due to seepage from precipitation would be negligible. Thus, the extent and depth of this impermeable cap should describe the limits of excavation. Second, as the thickest section of the Tshirege member occurs at the central axis of the mesa, construction for the pits might begin near the axis of the mesa and proceed toward the edge of the mesa to a cliff. By so excavating, the size and number of the joints in the rock can be observed, for the joints tend to become more open near the periphery of the mesa. It was noted in the burial pit near Ten Site, however, that joints were filled with clay and silt.

Considering that the pits are to be established on a long-term basis, it is important that future erosion possibilities be contemplated. The pits should be kept as far as practical from well defined drainage courses such as the ravines that dissect the mesa, mainly along its south side. Furthermore, any natural vegetation on the mesa that feasibly can be preserved will aid in erosion control."[73]

Some of the points in the 1956 Letter Report concerning location and construction of pits were formalized June 30, 1965, in a set of guidelines for construction, burial of wastes, and surface seal of pits (see Appendix E). A suggestion by Dr. C. V. Theis, appended to the Guidelines, stated:

"It may be necessary to have periodic inspections of the sealed and finished pits to determine any unusual settling or gullying. It is thought that the times of inspection for instability and indications of adjustment of the surface to a natural condition will be shortly after the season of highest rainfall. It may be necessary to have biannual inspections."[132]

The USGS began its series of inspections of newly dug pits with Pit 1 on May 10, 1957.

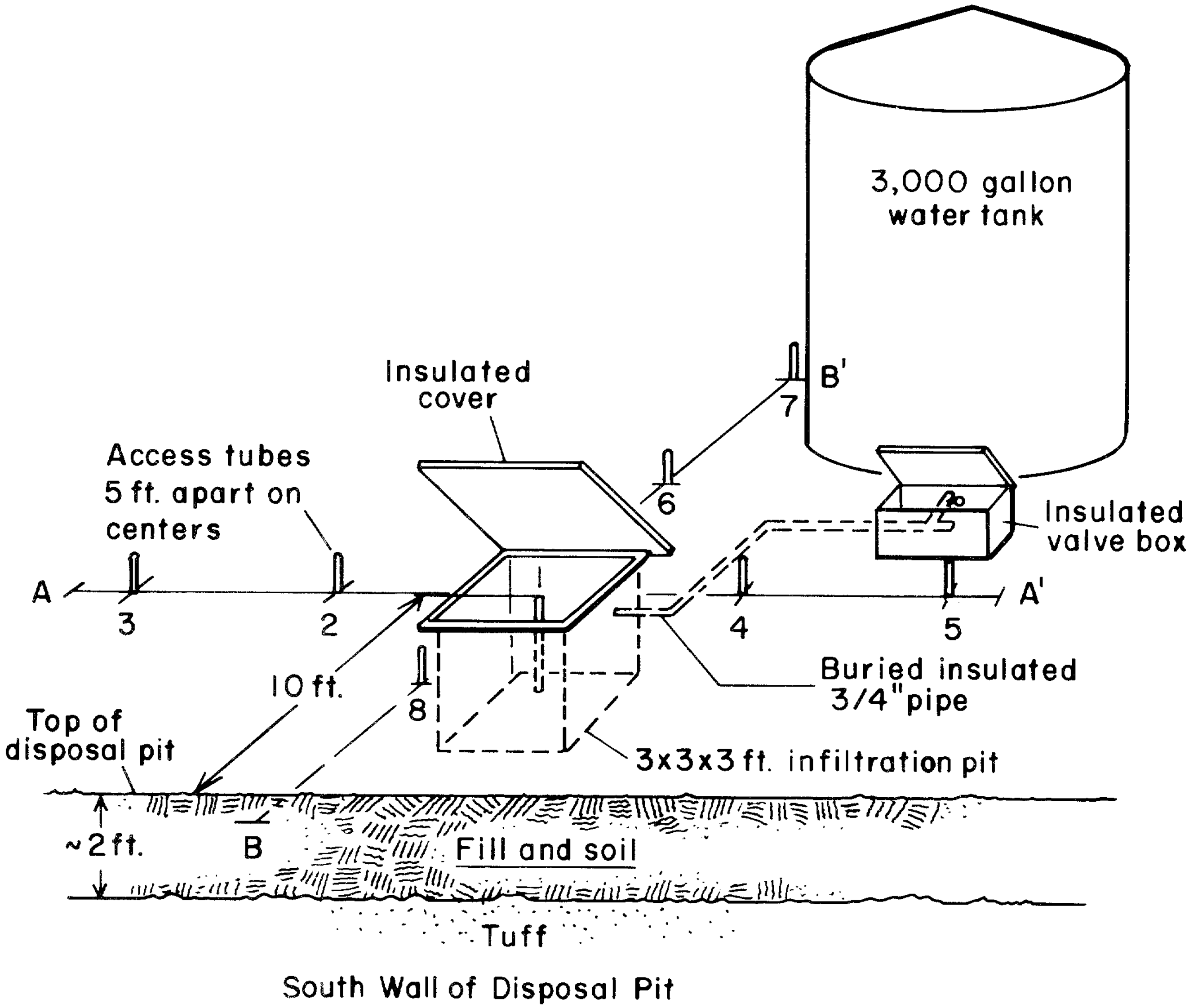
"Mr. Abrahams [USGS] *expressed an opinion that the fissures are probably blocked a short distance back from the pit wall, but as an added precaution against possibly contaminating deep water bearing stratas through connected cracks in the tuff formation it is recommended that your office notify Health Division that no wastes be placed closer than five feet of the pit wall adjacent to the fissures, thus permitting the earth fill to close up and seal the fissures."*[103]

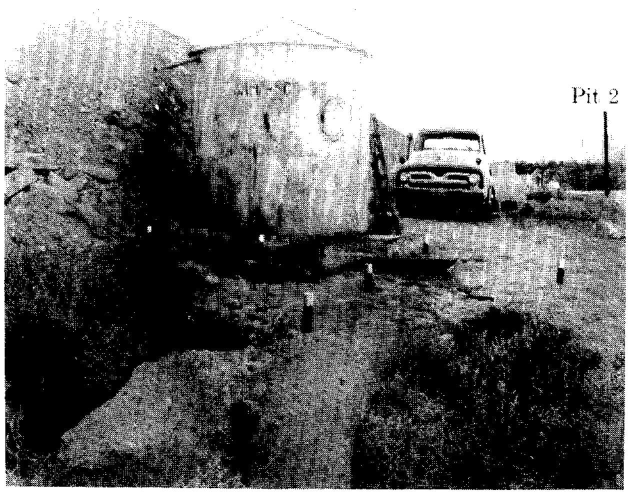
A USGS study to *"investigate movement of water and nuclides during continuous infiltration"*[160] began the second quarter of 1959.[99]

"The USGS has a water saturation experiment station located on the south edge of Pit 2, at about the middle of the pit. Should they start to use radioactive material in their work the west gate [located at the west end of Pit 2] *would have to be locked."*[86]

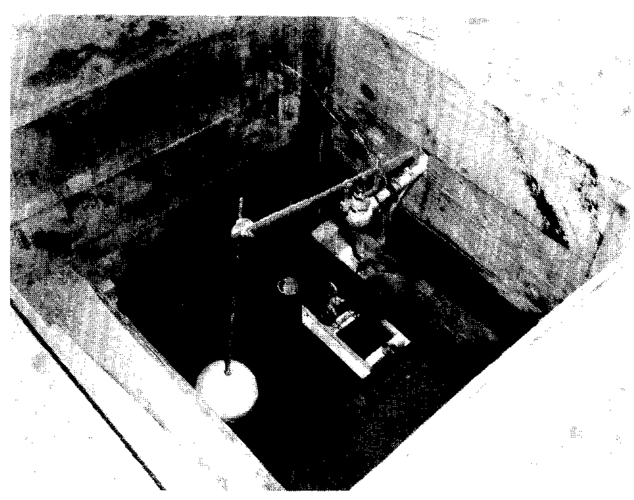
"An infiltration pit, access tubes, and a water-storage tank were installed near the edge of the vertical wall of the disposal pit [Fig. G-15]. *The center of the infiltration pit was 10 ft south of the south edge of the waste disposal pit. The upper 2 ft of the infiltration pit was shored with wood planks within the soil and fill material, and the lower 1 ft was dug into the unweathered tuff. Water entered the pit through a 3/4-in. pipe connected to a valve box adjacent to a 3000-gal storage tank. A float valve in the infiltration pit maintained a constant head of water of about 3/4 ft. Eight holes 40 ft deep lined with plastic tubing were installed in and near the infiltration pit* [Fig. G-15].

Periodic measurements of water losses from the storage tank were made to determine the volume of water moving to the infiltration pit.





Looking west 1959-1961 infiltration experiment on south rim, Pit 2, Area G.



"Tipping Bucket" assembly as shown installed in infiltration pit on south rim of Pit 2, Area G.

Fig. G-15.
1959-1961 infiltration experiment at Pit 2, Area G, TA-54. Abrahams, 1963.[160]

The infiltration experiment started when water was put into the pit October 8, 1959. Between December 29, 1959 and January 6, 1960 the water line froze and the pit dried up. The infiltration phase of the experiment was suspended until April 20, 1960 and then restarted. About December 9, 1960 the water line froze again and the infiltration phase of the experiment was stopped, but moisture measurements were made in access tubes for several months to observe drainage patterns.

Photographic evidence that water moved into the tuff from the infiltration pit was a wet patch [Fig. G-16] *that developed on the wall of the disposal pit 10 ft north. Evaporation from the wall discharged water that would have moved deeper in the tuff."*[160]

The rate of infiltration of water for the 1959 study decreased from about 3.05 cm/h (0.75 gph/ft^2 [gallons per hour per square foot]) to about 0.81 cm/h (0.2 gph/ft^2). For the 1960 study the rate of infiltration decreased from about 2.7 cm/h (0.68 gph/ft^2) to about 0.41 cm/h (0.1 gph/ft^2) (Fig. G-17).

"Significant seasonal changes in the log curve of the rate of infiltration for the 1960 study occur during the months of April and September. The steeper parts of the curve show a relatively rapid decrease in the rate of infiltration with time during the months in which the average temperature is less than about 50°. The flatter part of the curve shows the rate of infiltration during months in which the average temperature is above 50°. In these months the rate of infiltration decreased from about 0.4 gph/ft^2 to about 0.2 gph/ft^2. The range of the temperature of the water in the pit, from near freezing during the winter to about 80° in the summer, was enough to cause seasonal differences in the rate of infiltration into the tuff due to changes in viscosity (Horton, 1940, p. 417).[1] *In addition, seasonal temperature variances in the tuff beneath the infiltration pit may have been sufficient to cause some small differences in the rate of percolation.*

The flatter part of the log curve of infiltration includes the time of the growing season at Los Alamos, and it is possible that evapotranspiration of tumbleweed on the soil and fill pad consumed a small amount of water moving from the pit. However, when most of the plants were removed no measurable effect on the rate of infiltration took place. Several plants growing with their tap roots along the side of access tubes were kept in place. The moisture content of the upper 2 ft of material [Table G-VIII] *was reduced at access tubes 2 and 3 where the tumbleweeds were growing; the moisture content increased after the plants were removed September 1. The moisture content at all the other tubes remained high throughout the growing season.*

No evidence was found that water moved through the soil and fill pad and evaporated from the surface in quantities sufficient to affect the rate of infiltration in the pit. The moisture content of the upper foot of the soil ranged between 5 and 10% by volume, which generally is too low to transmit much water. The sandy material tends to form a barrier that reduces evaporation (Willis, 1960, p. 241).[2]

The rate of infiltration (5 to 10 gpd/ft^2) during the summer months was within or somewhat above the range of permeability determined from cores in the laboratory. The field permeability (rate of percolation) in the zone of aeration cannot be directly compared to the saturated permeability (laboratory measurement) because water in the infiltration pit not only moved downward but also

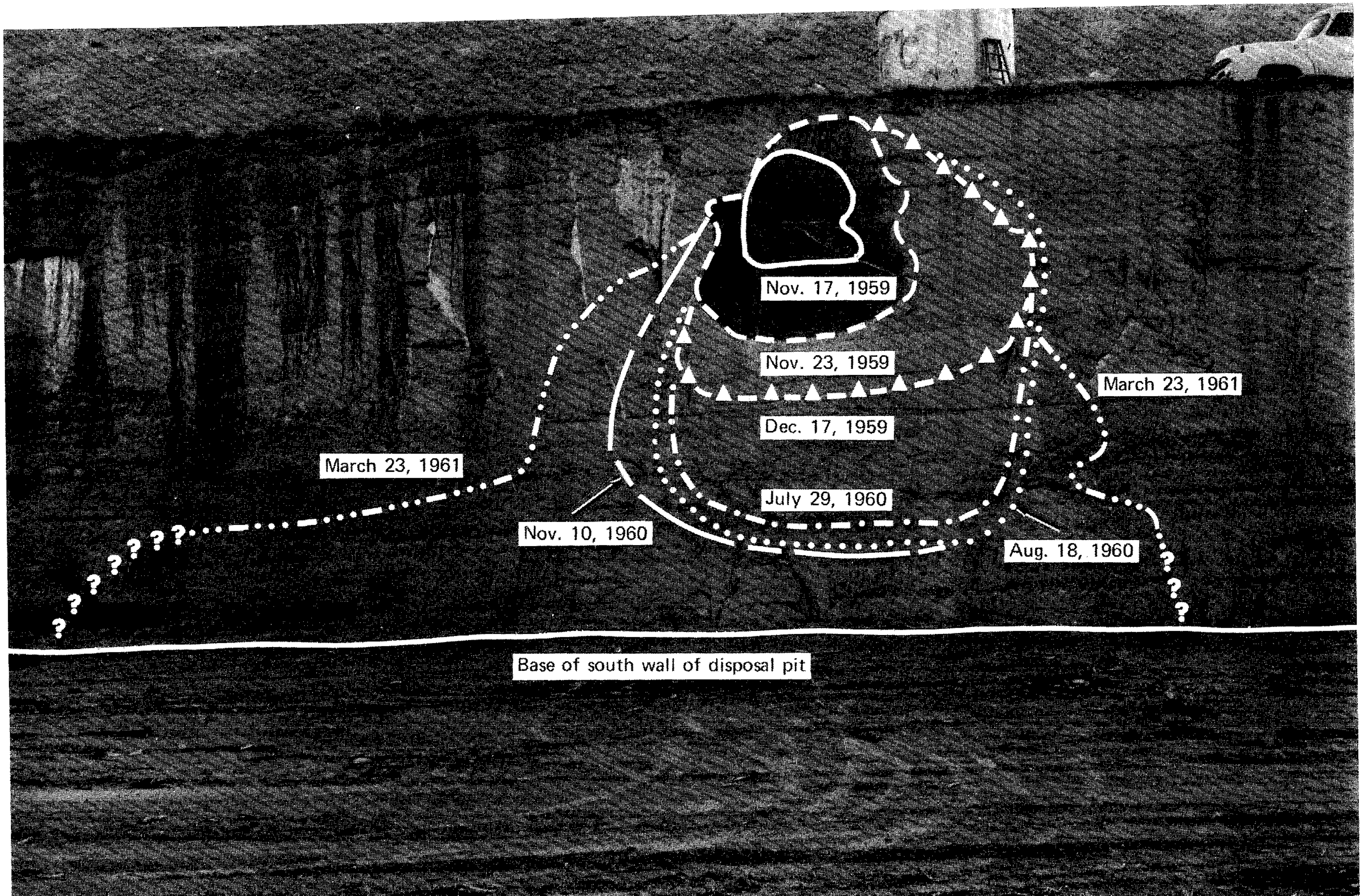


Fig. G-16.
Wetted areas on south wall of Pit 2, Area G, resulting from seepage from the infiltration pit 3 m (10 ft) back of the wall. Abrahams, 1963.[160]

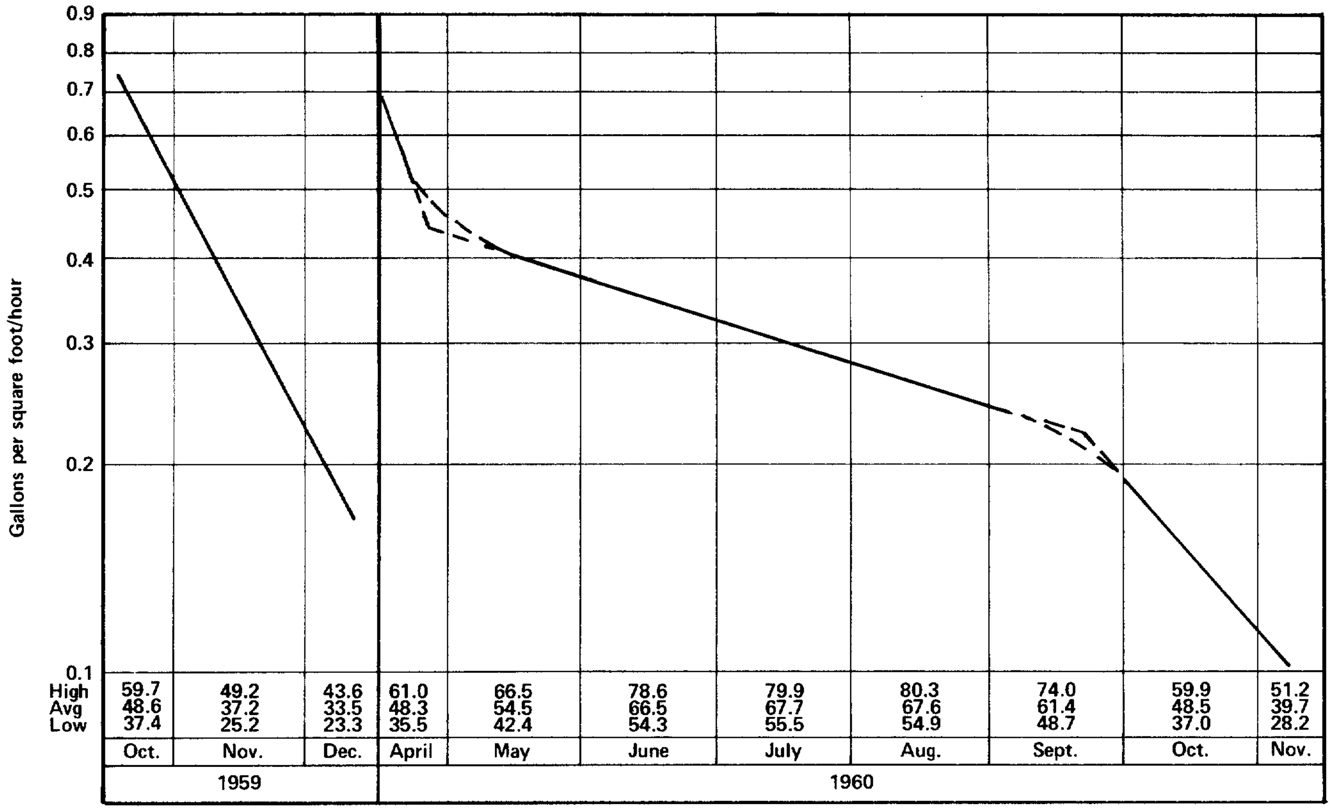


Fig. G-17.
Infiltration rate during 1959-1960 at Pit 2, Area G. Abrahams, 1963.[160]

TABLE G-VIII

EFFECTS OF TRANSPIRATION BY TUMBLEWEED PLANTS
ON THE MOISTURE CONTENT OF TUFF AT PIT 2, AREA G

Hole No.	Remarks	1960 (Moisture content in percent by volume) May 18	June 2	July 1	July 29	Sept. 1	Dec. 6
3	Tumbleweed at side of access tube	22.5	16.5	12.5	8	6	20
2	Tumbleweed at side of access tube	27.5	27.5	28.5	19	14	21
4	No tumbleweed nearby	26	26	27.5	25.5	24	26
6	No tumbleweed nearby	27.5	29	27.5	27	27.5	29
8	Tumbleweed removed from near access tube	20	19.5	19	19.5	15	18

Abrahams, 1963[160]

moved laterally as much as 8.5 ft from the edge of the infiltration pit. Thus, the rate of percolation, particularly from a small source of water located in a layered medium, is substantially less than the saturated permeability, because the water is subject to forces not involved in saturated flow.

The wetting front moving into the unsaturated tuff was sharpest in the early part of the 1959 study, but it became thicker and more diffuse as infiltration continued [Fig. G-18, profile I]. *Energy barriers at the front retard the movement until the moisture content behind the front is raised to a maximum or optimum value (Bodman and Colman, 1944, p. 117-118).*[3] *The thickness of the zone of transmission, the area between the unwetted tuff and the maximum moisture content attained during the vertical movement, probably was a function of layering in the tuff. The average rate of movement of the part of the front containing a moisture content of 25 to 28% by volume was about 2 ft during the next 11 days, and about 1/10 ft per day during the next 56 days, with additional movement in the lower moisture range to a total depth of about 18 ft. The rate of movement of the front in 1960 was higher* [Fig. G-18, profile II] *than in 1959 probably because the rock was wetted and fewer energy barriers existed to reduce the rate of movement and less water was needed to reach field capacity.*

The moisture content of 25 to 28% apparently was the maximum attained away from the pit [Fig. G-18, profiles II and III] *at Site 5* [Area G]. *This moisture content is several percent above field capacity but is considerably less than saturation. The maximum moisture content 1 ft beneath the infiltration pit was about 40%, which is 6 to 7% less than the estimated effective porosity. The 6 to 7% probably represents the large pore spaces from which water drained into the underlying material, although it may also represent entrapped air. However, entrapped air should not be a problem in this study because of the large volume of porous medium involved and the probability that entrapped air beneath the infiltrating water would escape and not be surrounded or compressed (Free and Palmer, 1940, p. 395.)*[4]

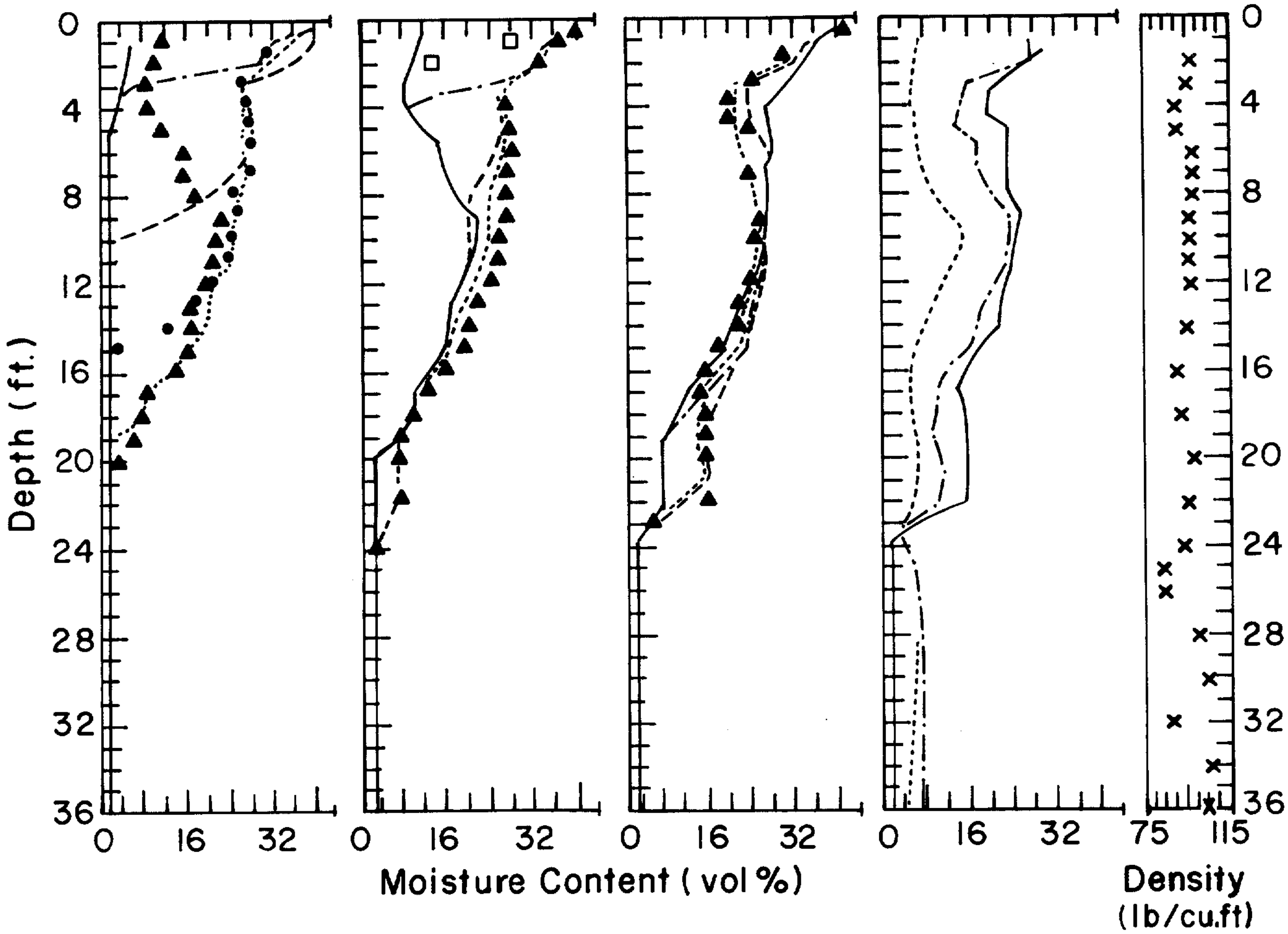
The moisture content of the tuff decreased steadily above an apparent density change at about 25 ft beneath the infiltration pit to a range of 5 to 16% after about 9 1/2 months drainage [Fig. G-18, profile IV]. *The moisture content below the apparent density change slowly increased during drainage and after about 2 months reached a moisture content of about 8%. The 8% saturation extended below the bottom of the access tube."* [160]

"[1]*R. E. Horton, An Approach Toward a Physical Interpretation of Infiltration-capacity."* **Soil Sci. Soc. America Proc.,** *v.* 5, *pp. 399-417, 1940.*

[2]*Willis, W. O., "Evaporation from Layered Soils in the Presence of a Water Table."* **Soil Sci. Soc. America Proc.,** *v. 24, No. 4, pp. 239-243, 1960.*

[3]*Bodman, G. B., and Coleman, E. A., "Moisture and Energy Conditions During Downward Entry of Water into Soils."* **Soil Sci. Soc. America**, *v. 8, pp. 116-122, 1944.*

[4]*Free, G. R., and Palmer, V. J., "Interrelationship of Infiltration Air Movement, and Pore-size Distribution in Graded Silica Sand."* **Soil Sci. Soc. America Proc.**, *v. 5, pp. 390-399, 1941."*



Profile I

Moisture content at start of infiltration test on Oct. 8, 1959.

Moisture content on Oct. 9, 1959.

Moisture content on Oct. 21, 1959. Pit was dry--infiltration was restarted.

Moisture content on Nov. 25, 1959.

Moisture content on Dec. 29, 1959.

Moisture content on Apr. 20, 1960.

Profile II

Moisture content on Apr. 20, 1960, at start of infiltration test.

Moisture content on Apr. 20, 1960, 2 hours after start of infiltration.

Moisture content on Apr. 21, 1960, 1 day after start of infiltration.

Moisture content on Apr. 29, 1960, 9 days after start of infiltration.

Moisture content on May 5, 1960, 15 days after start of infiltration.

Moisture content on May 18, 1960, 28 days after start of infiltration.

Profile III

Moisture content on May 18, 1960, 28 days after start of infiltration on Apr. 20, 1960.

Moisture content on June 2, 1960, 42 days after start of infiltration.

Moisture content on July 28, 1960, 99 days after start of infiltration.

Moisture content on Oct. 7, 1960, 170 days after start of infiltration.

Moisture content on Dec. 6, 1960, 230 days after start of infiltration.

Profile IV

Moisture content on Dec. 6, 1960, 230 days after start of infiltration.

Moisture content on Mar. 1, 1961, 60 days after cessation of infiltration and start of drainage on Jan. 1, 1961.

Moisture content on Oct. 12, 1961, 286 days after start of drainage.

Fig. G-18.
Moisture content and density of tuff in Access Tube 1 at Pit 2, Area G. Abrahams, 1963.[160]

For the 1960 study, isohydral lines of moisture content along an east-west and a north-south section are shown in Fig. G-19 for the beginning of the study, April 20, 1960, and for the end of the study, December 6, 1960. Density gradients in the tuff are reflected in the east-west sections and evaporation from the wall of Pit 2 is reflected in the north-south sections.

"Water was retained in the tuff to near field capacity between the depths of 8 to 14 ft beneath the bottom of the pit approximately 3 1/2 months after the infiltration phase of the experiment was suspended in January 1960."[160]

The slight bunching of the 10, 15, and 20% isohydral lines to the east in Fig. G-19 may indicate movement down dip in the tuff or density changes at access tubes 4 and 5.[160]

"The lower moisture content at the upper part of holes 2 and 3 was due to evapotranspiration by the tumbleweeds growing there."[160]

"Moisture measurements, made on December 6 after 230 days of infiltration, [Fig. G-19b] *show a decrease in the moisture content of the tuff from that of previous measurements. Although the rate of evaporation from the disposal pit wall decreased steadily during the fall, because of the decreasing temperature, the rate of infiltration probably also decreased because of the greater viscosity of the water. The rate of infiltration at the near-freezing temperatures in the pit in December was probably only about half that during the middle of summer (Mavis and Wilsey, 1936, p. 17).*[(1)] *Water in the pit probably froze during extremely cold nights late in November and early in December before the permanent freeze, thus completely stopping infiltration for periods of several hours. The rate of percolation exceeded the rate of infiltration from the pit when the water was near freezing.*

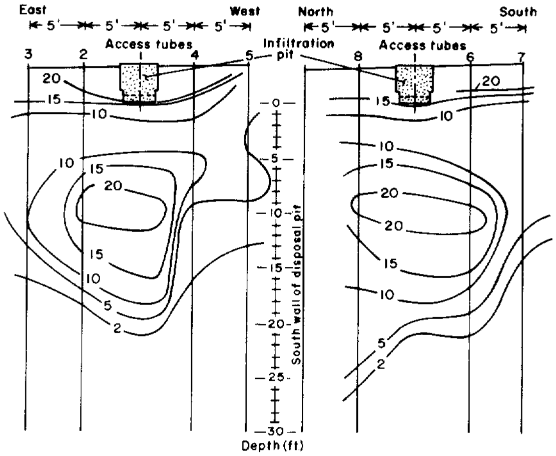
On March 1, 1961, after about 3 months of drainage [Fig. G-19c] *the isohydral lines assumed about the same positions and shapes as of April 20, 1960, except in the lower moisture range directly beneath the infiltration pit where a low moisture content column 3 or 4 ft in diameter formed below a depth of about 30 ft.*

A total of about 11 100 gal of water moved through the infiltration pit during the 230 days of the study, most of which infiltrated during the summer months. A water budget cannot be calculated, however, because of the unknown quantities lost by evaporation."[160]

"[(1)]*F. T. Mavis and E. F. Wilsey, 'A Study of the Permeability of Sand.' Bull. 7, University of Iowa, studies in Engineering, Iowa City, Iowa, 1936."*

The exposed tuff and joints in Pit 2 were mapped by the USGS in November 1961 and March 1962 when the pit was partly filled with radioactive wastes [Fig. G-7].

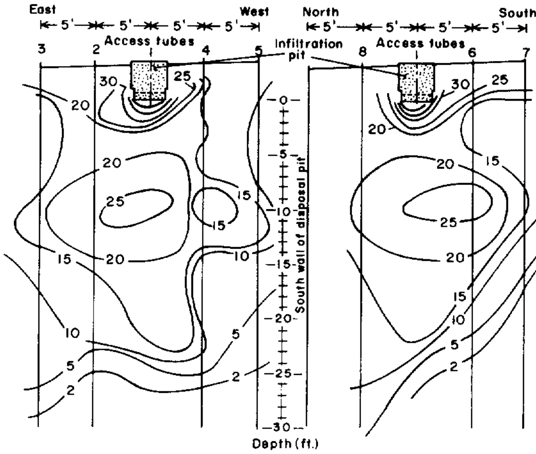
"The orientation of the major joint sets (intersecting at angles of 30° to 90°) and random orientation of the remaining joints are such that layout of a pit to avoid the intersection of joints in the walls is impossible. Pits should be laid out to make the best utilization of the area available.... The bulk of the tuff beneath the soil is quite dry. The moisture content was about 8% by volume in the tuff at a depth of 2 ft beneath the soil zone in a shallow hole [may be one of the holes drilled for the 1959-1961 infiltration study] *drilled near Pit 2. Eight feet below the soil zone the moisture content decreased to less than 4% and between 8 and 4-ft it was 4% or less."*[75]



19a

Isohydral lines of moisture content of the tuff, in percent by volume, along an east-west section at Pit 2, Area G on Apr. 20, 1960, after about 3-1/2 months of drainage.

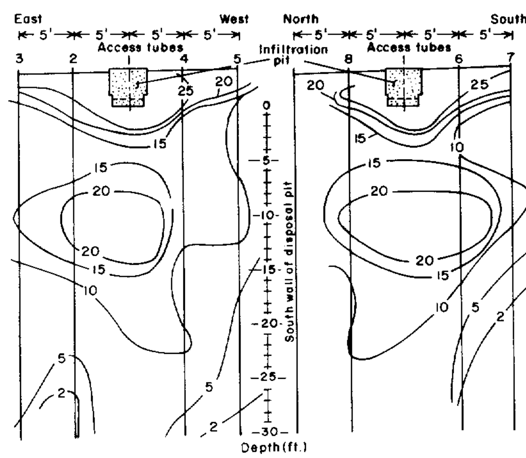
Isohydral lines of moisture content of the tuff, in percent by volume, along a north-south section at Pit 2, Area G on Apr. 20, 1960, after about 3-1/2 months of drainage.



19b

Isohydral lines of moisture content of the tuff, in percent by volume, along an east-west section at Pit 2, Area G on Dec. 6, 1960, after 230 days of infiltration.

Isohydral lines of moisture content of the tuff, in percent by volume, along a north-south section at Pit 2, Area G on Dec. 6, 1960, after 230 days of infiltration.



19c

Isohydral lines of moisture content of the tuff, in percent by volume, along an east-west section at Pit 2, Area G on Mar. 1, 1961, after about 3 months of drainage.

Isohydral lines of moisture content of the tuff, in percent by volume, along a north-south section at Pit 2, Area G on Mar. 1, 1961, after about 3 months of drainage.

Fig. G-19.

Isohydral lines of moisture content of the tuff, in percent by volume for the 1959-1961 infiltration experiment. Abrahams, 1963.[180]

Area G was briefly described in the 1963 USGS report, **Geologic and Hydrologic Environment of Radioactive Waste Disposal Sites at Los Alamos, New Mexico.**[30]

A brief inspection of Pit 3 was made February 5, 1963. It was recommended that:

"Filling of the pit with waste material should be completed below the soil zone as heavy precipitation may cause erosion of the artificial east rim and expose some of the wastes or allow water to move radioactive contaminants out of the pit on to the surface of the mesa."[116]

And a comment made that:

"There should be little danger of water moving radioactive contamination from the waste material in the pit into the adjacent canyons, if the pit, when filled, is sealed with a material which would restrict infiltration of precipitation.

Little is known of the hydrologic characteristics of the crushed tuff that now is used to seal over waste disposal pits. A field study utilizing the neutron-neutron scattering moisture probes and the access tubes installed in a disposal pit that is filled and sealed is planned in the future to determine the depth of infiltration into the seal material from precipitation and the loss of moisture by evaporation."[116]

"Pit 2, Area G, was backfilled to ground level in July [1963]. *The USGS had installed moisture tubes in this pit and 20 ft extension tubes had to be put on by H-1 in order to bring the ends to the ground level* [Fig. G-20]."[109] *"The distribution of moisture in the seal material indicated little if any water from precipitation moves to a depth greater than 4 ft before it is returned to the atmosphere by evaporation."*[116]

In 1964 a review[161] of geologic data, collected in previous Pajarito Plateau studies by the USGS, was made to pick a site for a new Los Alamos municipal supply well in Pajarito Canyon south of Mesita del Buey. No additional field studies were done in the preparation of the report. A site approximately 2.69 km (1.67 miles) west-northwest of Area G (NE 1/4 SW 1/4 NW 1/4 sec. 36, T. 19 N., R. 6 E.) was recommended (Fig. G-2).[159] *"The depth of the pilot hole at the proposed well site should be at least 2600 ft to determine the geologic and hydrologic conditions in this area of no deep test holes."*[159]

July 1965[77] supply well PM-2 (Pajarito Mesa-2) was drilled by hydraulic rotary to a depth of 793 m (2600 ft). Water was encountered at a depth of 251 m (823 ft) (see Table G-I).

After inspecting Pit 4, Area G, August 3, 1964, the USGS

"was inclined to think there was a possibility that by changing the axis of future pits, to parallel the major line of fracturing, that the tendency of the banks to cave could be reduced.

... the fissures in the rock [do not] *present any threat to the water bearing stratas below by infiltration of precipitation through the pits. ...the backfill material effectively seals the pits and furthermore, the penetration of any moisture into the backfill is dispersed by evaporation into the atmosphere."*[120]

Fig. G-20.
Measuring moisture levels in Pit 2, Area G with a neutron depth moisture gage.

The January 1966 USGS report, **Geology and Hydrology of Area "G" Mesita del Buey, Los Alamos County, New Mexico**, states:

"Water moving through the soil to the tuff probably moves more readily into the tuff than into the joints filled with brown clay because the tuff is more permeable than the clay. Movement of water in the tuff is slow. Flatlying to near-vertical open joints probably will perch water and impede the downward movement of water in the tuff, because the water is held in tension in the small pore spaces of the tuff.

... large amounts of water (more than available from precipitation) would be required to move contaminants from the pits to the main groundwater body because of the large thickness of dry sediment between the land surface and the water table 850 to 900 ft below the surface of the mesa or through open joints into the adjacent canyons."[75]

In the February 1966 USGS report, **Hydrology of Waste Disposal Systems, Los Alamos, New Mexico, 1949 through 1961,**[41] there is a very brief description of Area G.

Pit 5, Area G was inspected December 6, 1966.[124] The letter report concluded:

"The disposal pit is suitable for disposal of solid or package wastes as it meets the guidelines for pit construction set forth in a conference between ENG-3, H-1, H-6, and H-7 of the Los Alamos Scientific Laboratory and the US Geological Survey held at Los Alamos on June 23, 1965. The guidelines are summarized in a letter [see Appendix E] *to Mr. Ted Russo, ENG-3, dated June 30, 1965, from F. C. Koopman, US Geological Survey."*[124]

September 24 and October 9, 1969, Pit 6 was inspected.

"Orientation of the joints and joint openings are about the same as in the tuff exposed in other pits in the area and should pose no problems in disposal of wastes.

The pit is suitable for the disposal of solid or package wastes as it meets the guidelines for pit construction as summarized in [the USGS 1965 letter, Appendix E]. *For future reference we have on file a series of photographs showing the walls of the pit."*[128]

The following is from the section on Soil and Tuff Moisture, in **Geology and Hydrology of Mesita del Buey**, November 1970.

"Where the soil cover has been disturbed, as in the disposal areas, the moisture content of the tuff indicates that precipitation may have infiltrated to a depth of 10 ft. The moisture ranges from 2 to 8% by weight, decreasing with depth. Below 10 ft the moisture content ranges from 0.5 to 2% by weight, showing that the moisture is redistributed by diffusion.

Tests of infiltration of precipitation in the tuff used to cover the waste in pits showed that moisture from a single storm may reach a depth of 6 ft, but in the weeks after the storm it is returned to the atmosphere by evaporation.

Open joints in the ashflow may allow precipitation to move into the tuff. The joints are now filled to a depth of 3 to 4 ft with clay that acts as a seal and prevents precipitation from infiltrating the tuff."[76]

From the section, Main Aquifer:

"The rate of water movement computed from aquifer tests of supply wells is estimated to be 1 ft/day.[(1)] *From Mesita del Buey to the Rio Grande is about 4 1/2 miles, so we estimate that any water will take over 60 years to move from beneath the mesa to the river."*[76]

"[(1)]*C. V. Theis and C. S. Conover, "Pumping Test in the Los Alamos Canyon Well Field near Los Alamos, NM." U.S. Geological Survey Water Supply Paper 1619-I, 1962."*

The section on Erosion Rates of Tuff states:

"Vital to the containment of wastes buried at Mesita del Buey is the rate at which the tuff encompassing the wastes erodes. Some of the wastes contain radionuclides with a very long half-life.

There is no practical method to determine the erosion rate of the tuff during the short time that the mesa has been used for waste disposal. Erosion rates can be approximated by relating the age of the tuff to its past erosion. Erosion rates based on these assumptions are conservative because the tuff probably eroded faster initially than at present. The area is more stable since the stream channels in Canada del Buey and Pajarito Canyon have cut to a temporary base level on the resistant basalt.

Radiometric dating indicates that the tuff was emplaced about 1.1 million years ago.[(1)] *The thickness of Unit 3 tuff eroded from the surface of the mesa at Area G is estimated to be about 80 ft on the basis of geologic sections on the plateau where this unit is preserved. Its erosion rate for the past 1.1 million years is about* 7.2×10^{-5} *ft/year. Vertical downcutting in the canyons has been estimated at* 1.9×10^{-4} *ft/year in Canada del Buey and* 1.6×10^{-4} *ft/year in Pajarito Canyon. Wilden and Criley*[(1)] *estimated the vertical downcutting in major canyons to be 5 to* 8×10^{-4} *ft/year. At Area G, horizontal erosion at the top of the mesa is estimated to be about* 4.5×10^{-4} *ft/year.*

Wastes are buried in the natural confines of the tuff to a level 2 ft below the mesa surface and then covered and mounded over with 6 to 8 ft of tuff. Considering the vertical erosion of 2 ft of tuff on the mesa top at a rate of 7.2×10^{-5} *ft/year, it would take 27 000 years for the mesa top to erode to the top of the wastes.*

The edges of the pits are 50 ft or more from the edge of the mesa. Considering the horizontal erosion of 60 ft of tuff at a rate of 4.5×10^{-4} *ft/year it would take more than 110 000 years for the tuff to erode far enough to expose the wastes in the pits."*[76]

"(1) R. Wilden and E. Criley, "Geology of Los Alamos." In, "Geologic Studies and Material Properties Investigations of Mesita de Los Alamos," Los Alamos Scientific Laboratory report LA-3728, 1963."

The following is from the Waste Disposal Areas section:

"The pits and most of the shafts extend into Unit 2b, and the deeper (64 ft) shafts extend through Unit 2b into the top of Unit 2a of the Tshirege Member of the Bandelier Tuff."[76]

The section on Waste Disposal and the Geohydrologic Environment states:

"Total containment of contaminants is of paramount importance in the disposal of wastes at Mesita del Buey. Initial containment is accomplished with the burial of wastes in pits or shafts. After burial, the major means of transport of contaminants to the environment would be in the hydrologic cycle.

Transport of contamination by surface runoff on the mesa seems unlikely because the wastes are buried.

Little if any water from precipitation or surface runoff infiltrates through the seal material overlying wastes in filled pits. There is not enough water to leach the contaminants from the wastes and move them into the tuff. The bottoms of the pits are underlain by about 590 ft of tuff along the western part of the mesa and about 240 ft of tuff along the eastern edge. The hydrologic characteristics and conditions of the soil, seal material, and tuff indicate no recharge to the stream-connected aquifers or main aquifer through the surface soil, buried wastes, or underlying tuff at Mesita del Buey.

The natural moisture content of the unsaturated tuff is in the range in which moisture is redistributed by diffusion. Contaminants may be transported by diffusion if gases or volatile fluids are placed in shafts or pits. Diffusion may take place through the tuff where there are large amounts of pore space, through open joints, or along contacts between ashflows.

Vertical and horizontal erosion rates of the tuff surrounding the waste in pits or shafts indicate that under present climatic conditions the estimated life of the pits will be about 27 000 years. Routine maintenance to control erosion of the seal material will extend this life."[76]

A safety analysis[156] of Pits 8, 12, 16, 17, and 21 was made June 21, 1971. The following remarks were made:

"The design slope of the pits was 1 on 6, but in many cases the actual slope was greater. A more desirable slope would have been 1 on 4.

The volcanic tuff in this area is a poorly welded Unit 2b tuff, greatly resembling the Unit 3 tuff on Mesita de Los Alamos. Fracturing is extensive and the possibility of cave-ins does exist."[140]

The July 20, 1971, survey[138] of Pits 8, 12, 16, 17, and 21 was made to see if the pits conformed to the guidelines for pit construction as outlined in the memo from F. C. Koopman, USGS, to S. E. Russo, ENG-3, dated June 30, 1965 (see Appendix E). In summary:
Contrary to the guidelines, the long dimension of Pit 21 is at right angles to topographic contour lines.

"When the pit is filled, a greater thickness of seal material should be used to cover the wastes to prevent erosion from forming gullies down the long dimension.

The only joint that will need attention is in Pit 17 about 265 ft from the NW corner on the SW wall. The joint opening strikes 75° to 80° NW and is open 2 to 5 inches, and extends 4 to about 12 ft below the rim of the pit. Joint opening is near vertical. The opening can be filled and plugged when wastes in the pit are laid up to the level."[138]

Vertical displacement along vertical joints was observed in several of the pits.[138]

"This is general information and does not effect (sic) the use of the pits for disposal of wastes."[138]

"Recent rains have produced small amounts of runoff which have entered the ramp on the NW ends of Pits 8 and 17. Runoff should be diverted from the pits. Pit 7 will probably experience some sheet wash runoff into the pit along the SW wall. In the future tuff excavated from the pits should be piled up gradient from the pit to prevent runoff along the walls.

Unless noted, the pit construction meets the suggested guidelines as presented in the letter of June 30, 1965.

As per conversation with W. D. Purtymun on July 20, 1971, photographs [see Fig. G-9] *of the walls and bottoms of the pits should be obtained for the record prior to the disposal of any wastes in the pits."*[138]

Pit 7 was inspected from an ecological viewpoint[162] on August 21, 1973, and the following comments made:

"1. Several joints in the tuff are of great interest from the standpoints of

A. Lateral movement of radioactive materials that may be released by container failure;

B. Vertical movement of radioactive materials by soils dynamics, particularly from the standpoint of whether the joints contain clay or other materials; and

C. The joints are prime sites of root channeling by the vegetation that occupies the site now (especially trees and shrubs) and will be part of the future picture, unless vegetation control is a management tool.

2. Assuming that Pit 7 is representative of the situation in Pit 8, which contains the leaking 55-gal drums of TRU sludge awaiting a decision [decision to bury made in January 1974] *as to treatment, there are several studies of radioactive waste mobilization that may be undertaken if the decision is made to bury the 1600 drums in their present condition. We would like to be kept advised of plans for disposition of the drums in Pit 8, with enough advance notice that we can properly design the studies.*

3. I would appreciate whatever information exists about the various pits in G Area and in the other waste disposal areas on the following points:

A. Date of excavation and finished depth

B. Type and amount of radioactive materials buried

C. Depth of fill over material

D. Date the pit was finally covered.

This information will enable us to reconstruct plant succession in various areas and under various conditions. I realized this is a large order and much of the information may be mere estimates; however, we need the best information that exists to design future studies and to make recommendations for your immediate use.

4. Pit 7 appears to be as 'ecologically acceptable' as can be expected under the circumstances of waste disposal; but it exhibits several areas of concern where we presently have great need of more information."[162]

Observations from the August 27, 1973, geological survey[133] of Pit 7 are:

"There is no indication care has been taken to see no run-off from precipitation on the mesa enters the pit while it is being filled.

Since there is heavy equipment in the area something should be done to improve the surface drainage from Pit 8. There appears to be some surface runoff into the pit from the north end causing some ponding at times underneath the barrels. To a lesser degree the same condition exists for Pit 12."[133]

February 9, 1973, the H-1 Group Leader wrote:

"As you may have noticed during flights on Ross Aviation between Los Alamos and Albuquerque, our waste pits at TA-54 remind one of strip mining. The visual impact on the environment has been rather drastic. Please estimate how much it would cost to level, seed, and water some type of vegetation cover on the areas outlined in ink on the attached photo."[163] [see Fig. G-21].

March 28, 1974, a program was started by H-8, Solid Waste Management, "to establish needed improvements in **erosion control** and **soil fixation**"[164] for the approximate 12 acres of Area G where Pits 1 through 5 are located.

"It is recognized that much of the early work may be experimental in nature, testing different possible concepts or techniques.

To establish an initial program plan we request that in the next few weeks you take a close look at the designated area and formulate possible courses of action that can be tried or tested. It would be appreciated if these proposals could be submitted to the Waste Management Section by April 26. Shortly thereafter, if necessary, a meeting of all interested parties will be called to discuss and select the initial work to be done."[164]

June 4, 1974, H-8 Ecology replied:

"In response to your Memo H8-WM-151 of 28 March 1974, we have mobilized a variety of talent to address the above topic. On May 8, ... the US Forest Service in Santa Fe visited the Areas G and C environs to determine what the situation looked like so that knowledgeable recommendations [could be made]. *On 28-29 May Dr. Elmer Remmenga of Colorado State University was brought to consult on the project. As a result of these inputs, we now plan to proceed as follows:*

1. ...Area G soil samples [were taken] *for analysis of nutrients, as a basis for fertilizer recommendations;*

2. [The US Forest Service] *is immediately furnishing information on vendors of rangeland drills, grass seeds, and fertilizers; upon receipt of the soils analyses ...*[a] *USFS rehabilitation and revegetation specialist will be brought in to make firm recommendations;*

3. We believe that watering facilities....will be highly desirable if not imperative to achieve any sort of success in the revegetation effort; perhaps you have some estimates from ENG concerning this;

4. We propose to do some very small scale flower pot experiments immediately upon which to base extrapolation to the Area G situation; and

5. We anticipate reconstructing a scheme of natural vegetation succession on disturbed LASL waste pits according to information furnished by you in Memo H8-WM-173, [Subj: History of Pits 1-6 in Area G, dated April 11, 1974] *and data that we will be requesting in the future."*[165]

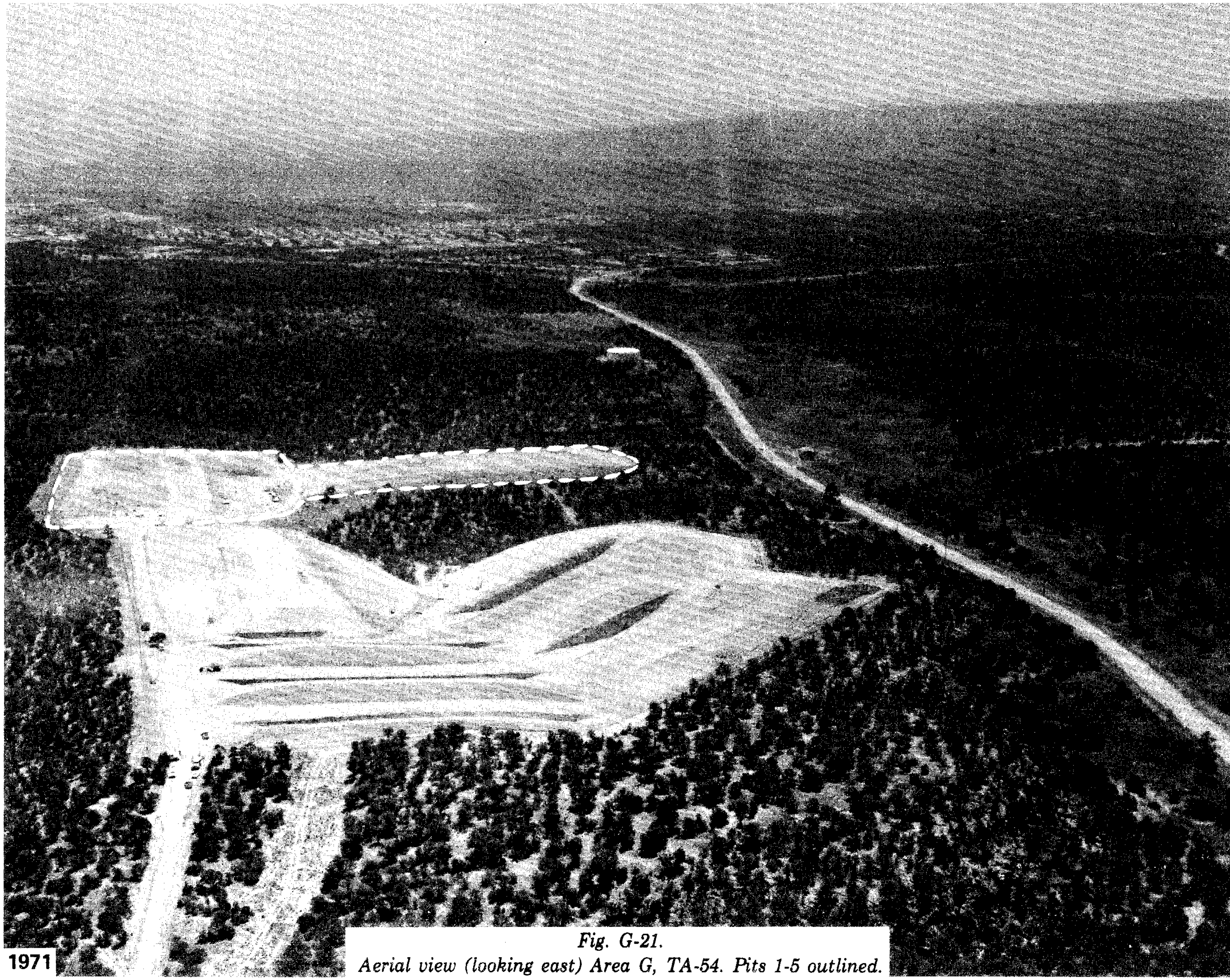


Fig. G-21.
Aerial view (looking east) Area G, TA-54. Pits 1-5 outlined.

After a particularly dry August and early September, two heavy rains fell at Area G, September 10-11, 1973.[166] Rain 1, 12 p.m. to 9:30 a.m. September 10, produced 1.83 cm (0.72 in.) of precipitation at Area G; Rain 2, 6:30 p.m. September 10 to 4:00 a.m. September 11, produced 3.81 cm (1.5 in.) of precipitation at Area G.[166]

Following Rain 1, ponding occurred in Pit 8 only. Moisture continued to run into the pit throughout the day (September 10). This moisture seemed to be moving along the soil-tuff interface to the intersection of this interface with the north ramp of Pit 8 and then down the ramp into the pit.[166]

Following Rain 2, ponding occurred in the Decontamination Pit (Pit 19) and Pits 7, 8, 12, and 17. Water did not pond in Pits 16 and 21. Direct rainfall into the pits plus runoff down a ramp (the north ramp for the Decontamination Pit (Pit 19) and Pits 8, 12, and 17 and the west ramp for Pit 7) created the ponds. Very little water ran over and down the walls of the pits; and most of this water did not reach the bottom of the pits. Depth of ponding in the pits ranged from a fraction of an inch to 24.1 cm (9.5 in.) (see Fig. G-22a). Where water was ponded against the walls of a pit, it moved up the walls (in the tuff) by capillary action. Of particular interest is the movement of precipitation through the soil into intersecting joints which in Fig. G-22b channeled water to an opening on the south wall of Pit 7.[166]

An attempt to correlate observed disappearance of moisture with estimated rates of evaporation in Pit 7 had mixed success. The formula used by H-8 gave the best correlation between observation and estimation during the time water was ponded. It demonstrated that the disappearance of ponding was primarily due to penetration of moisture instead of evaporation of moisture.[166]

The augering of four holes in Pit 7 was completed September 20, 1973.[166] For all holes, samples of cuttings taken at 1.52 m (5 ft) intervals were analyzed for moisture content. Hole 1, 44.5 m (146 ft) from the west end of the pit along the south wall, was 35.7 m (117 ft) deep. Holes 2 and 3, 68.3 m (224 ft) and 107.6 m (353 ft), respectively, from the west end of the pit along the north wall, and Hole 4, 78 m (256 ft) from the west end of the pit along the south wall, were 15.24 m (50 ft) deep. Only Hole 4 was in the area where water ponded in Pit 7. In the first 1.52 m (5 ft), Hole 4 showed approximately 5 times the amount of moisture than in the first 1.52 m (5 ft) of Holes 1, 2, and 3.[166]

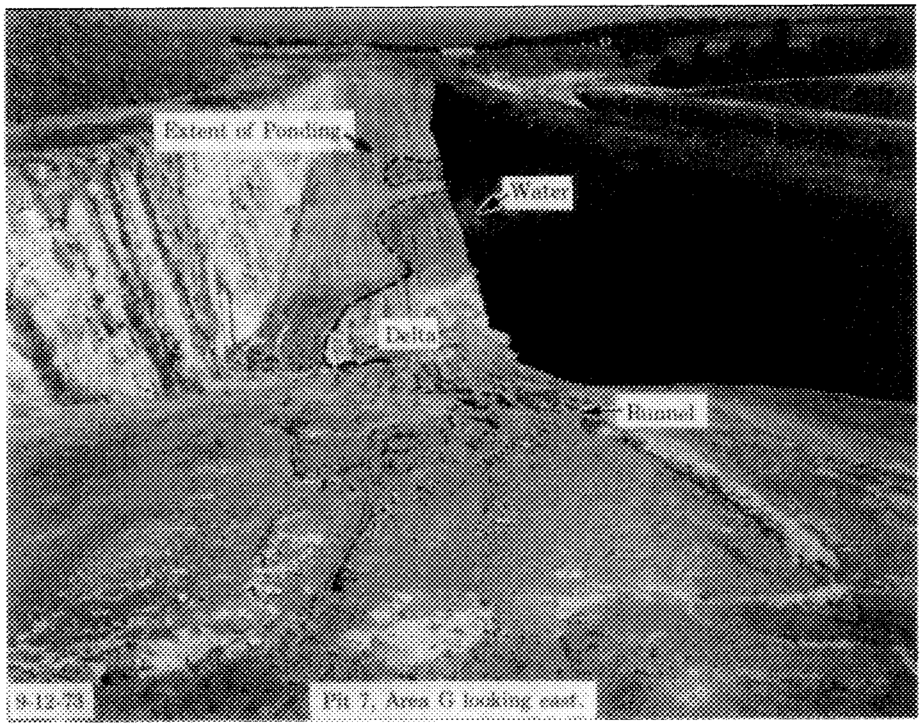
During the geologic inspections of Pits 7 and 24 numerous roots were found in the walls of the pits. The roots, in many cases, extended to the bottom of the pits. Most of the time they were associated with joints. Figure G-23a is an example of roots following vertical joints and brecciating tuff adjacent to the joint plane. Figure G-23b is an example of roots which grew horizontally parallel to a watermark on an exposed joint plane in the north wall of Pit 24. Figure G-23c shows roots penetrating the tuff at a depth of 6.10 m (20 ft) in the south wall of Pit 24; this is a rare case where roots do not appear to be directly associated with joints in the tuff.

September 11, 1973, a root sample was taken from a wall in Pit 7.

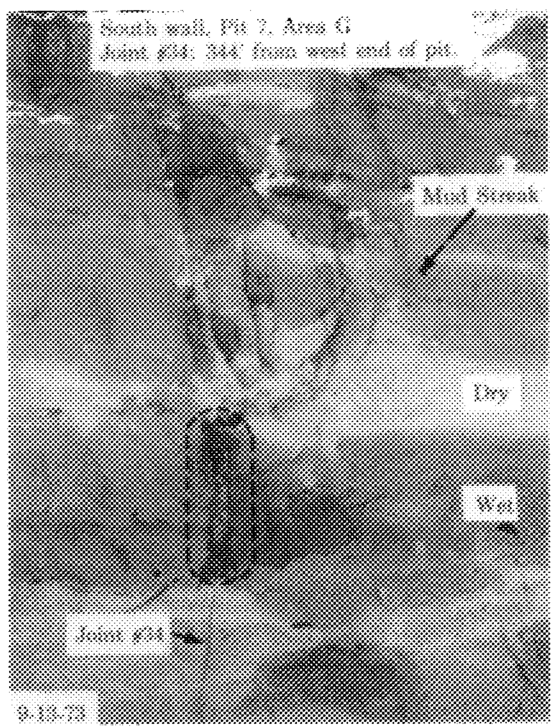
> "*The sample was one of the largest pieces exposed on the pit wall.* [It] *was sent to the Laboratory of Tree Research, University of Arizona, Tucson. They report that insufficient growth rings are present in the sample to permit tree-ring dating. The material is from a coniferous tree, as indicated by cell structure. No estimate of sample age was made.*"[167]

November 2, 1973, five samples of roots were taken from four joints in the north wall and one joint in the south wall of Pit 7 for ^{14}C dating. On November 19, one sample from the north wall of Pit 24 was substituted for one sample from the north wall of Pit 7. The sample from Pit 24 (sample point shown in Fig. G-23b) and one sample from the north wall of Pit 7 were taken beneath watermarks on exposed joint planes.

All root samples indicated a ^{14}C age of post-1950, in the range 1956-1961. The period 1956-1961 spans the beginning of Area G through the excavation of Pit 2. The site of Pits 7 and 24 was not within the perimeter fence of Area G until 1969. At that time the vegetation was removed. It is likely there was some vegetative disturbance at the site of Pits 7 and 24 before 1969. There seems to be a good correlation between the ^{14}C dates on the roots and the known history of the area.



←22a

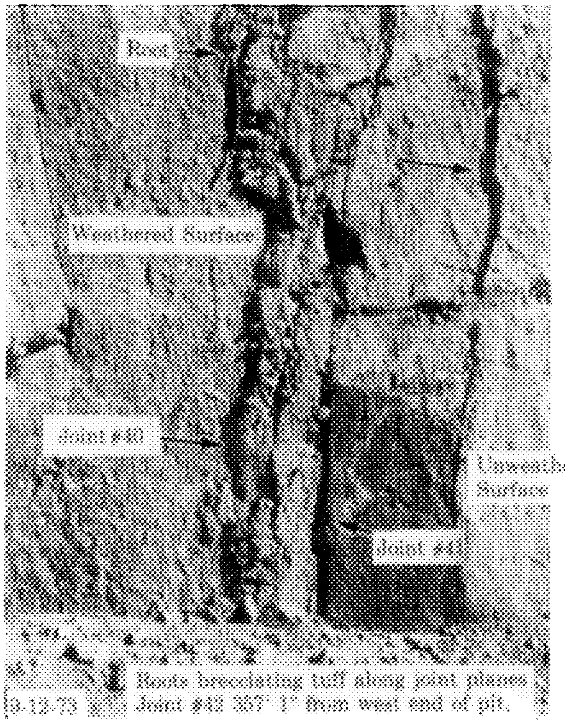


←22b

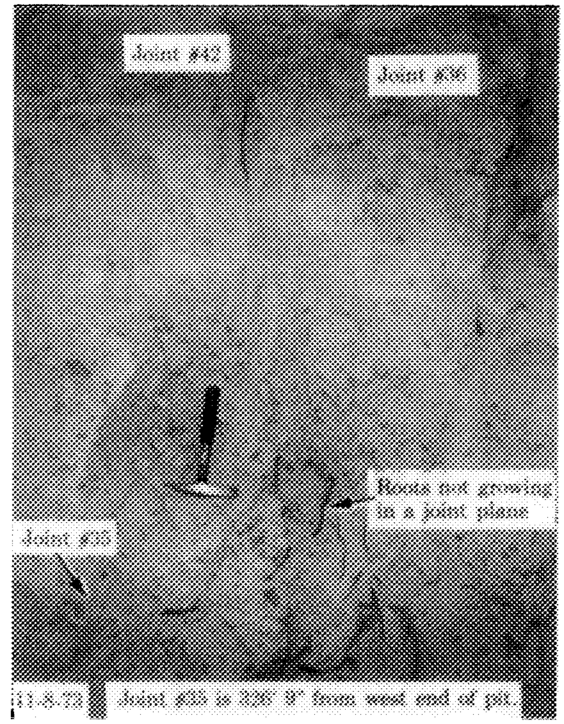
Mud streak in dashed area: Result of water movement through joint #34 and associated joints and not from water movement over the rim.

Fig. G-22
Photographs of Pit 7, Area G, taken immediately after September 10-11, 1973 rains.

North wall, Pit 7, Area G



South wall, Pit 24, Area G

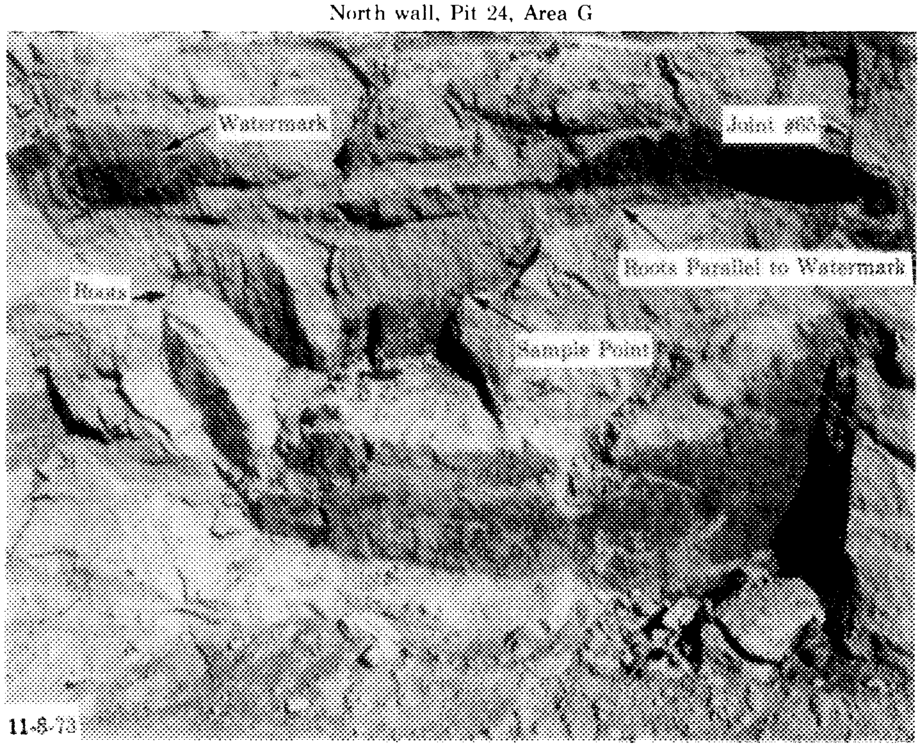


23a

23c

North wall, Pit 24, Area G

23b →



Joint #65 is 509' 5" from west end of pit.

Fig. G-23.
Roots exposed in walls of Pit 7 and Pit 24, Area G.

The ^{14}C dates on two of the samples also dated watermarks which are particularly common in Pit 24. The assumption is that roots grow downward seeking moisture, and spread laterally when they find it. The watermarks (see Fig. G-24 for additional examples) belong, therefore, to the current climatic regime and are not relics of some ancient regime.

Jacques Renault, Geologist, New Mexico Bureau of Mines and Mineral Resources, examined and took samples of fracture fillings in Pit 7 and 24 on November 6, 1973:

"REPORT ON THE EXAMINATION OF FRACTURE FILLINGS IN DISPOSAL PITS NO. 7 AND NO. 24, LOS ALAMOS SCIENTIFIC LABORATORIES"[168]

"Introduction

The disposal Pits No. 7 and No. 24 [Fig. G-25] *were visited on the afternoon of November 11, 1973 with Ms. Margaret Ann (sic) Rogers. Samples were collected from Pit No. 7 for optical and X-ray examination. Fracture numbers in this report are those used by Ms. Rogers in her fracture study of Pit No. 7.*

Field Observations

Caliche filled fractures in Pits Nos. 7 and 24 extend downward about three to seven meters from the original land surface. At the surface, they are up to four centimeters wide and diminish in thickness downward. Caliche is mixed with brown clayey fillings in fractures about five meters below the land surface. Below the mixed zone, fracture fillings are predominately brown clay [Fig. G-26].

Fractures in the pits show varying degrees of permeability with some openings [Fig. G-27] *tens of centimeters wide and others tightly closed. Open fractures display horizontal structures in the brown clayey coatings which can be traced from fracture to fracture within two meters of the floor of Pit No. 24* [Figs. G-23b and G-24]. *The clayey coatings in these fractures show small scale dessication (sic) cracks* [Fig. G-24].

Microscopic Examination

The fracture margins near fracture No. 43 in Pit No. 7 were examined under the binocular microscope. Within a few centimeters of the fracture surfaces, the tuff is unaltered. Delicate rock structures extend from unaltered tuff into clayey material of the fractures without geometric disruption. Pumice fragments show decreasing alteration for a distance of less than 15 mm away from the fracture margins toward fresh rock. Alteration of pumice is to clay minerals stained with limonite [Fig. G-28]. *Rounded pumice fragments are mixed with clay and caliche in fracture No. 52* [Fig. G-29].

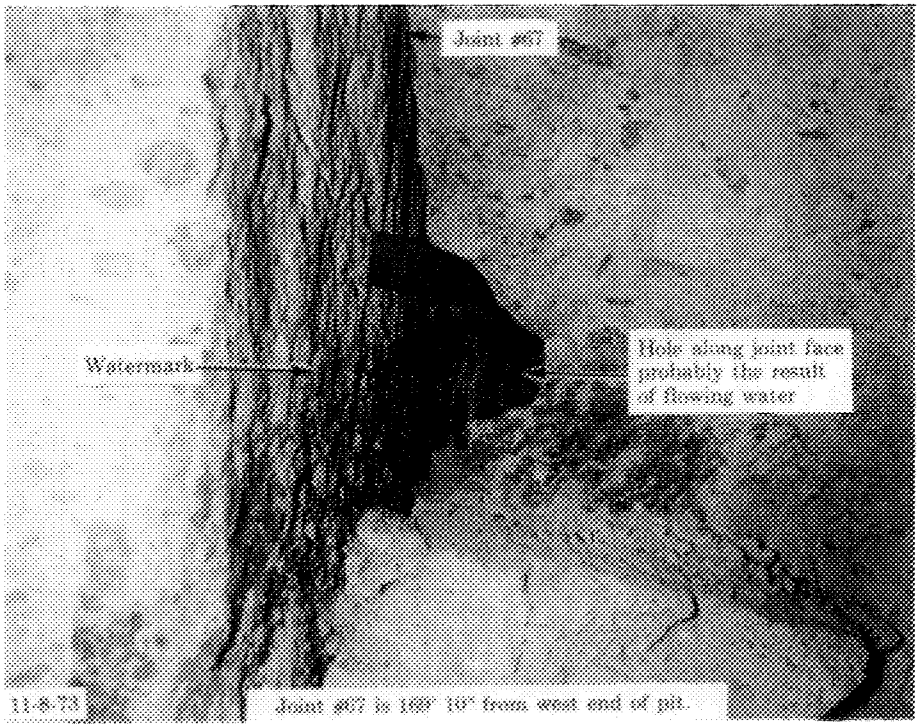
Mineralogy

X-ray diffraction analysis of the fracture filling material indicates only montmorillonite and calcite as the important secondary crystalline phases present. The near surface caliche fillings appear to be relatively pure $CaCO_3$; whereas, the brown clay is predominately (sic) montmorillonite with a trace of low christobalite.

Interpretation

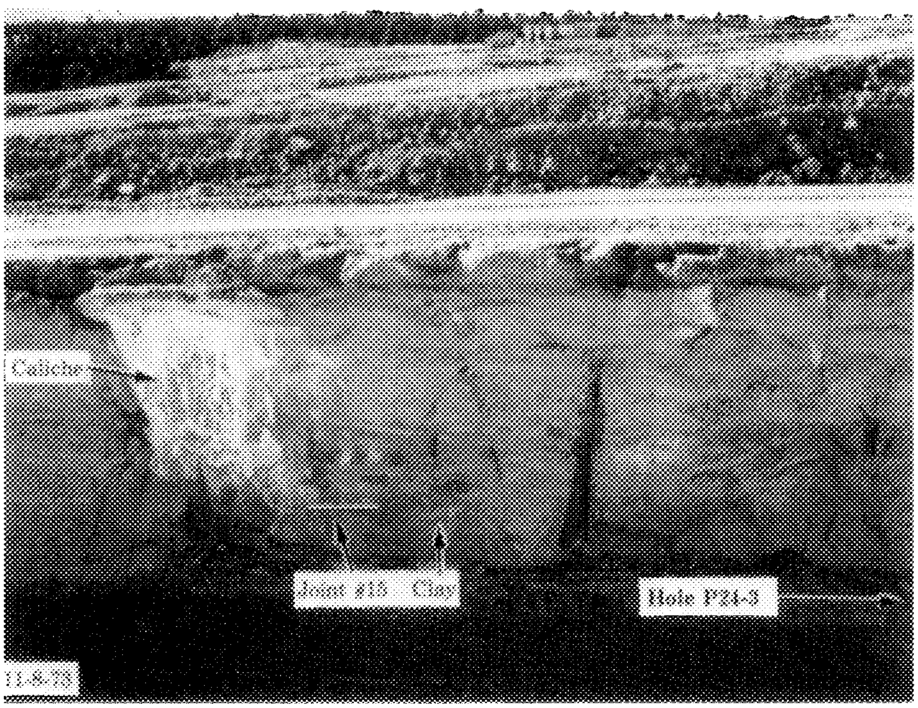
The existence of a caliche zone of fracture filling near the ground surface which is succeeded by mixed montmorillonite-caliche and then montmorillonite filled fractures with depth is most easily explained by ground water activity. The presence of trace christobalite is the only evidence of volcanic origin for some of the components of the fracture fillings, and it is very definitely a trace constituent.

South wall, Pit 24, Area G



South wall, Pit 24, Area G

South wall, Pit 24, Area G



Joint #15 is 473' 6" from west end of pit

Fig. G-24.
Watermarks on joint planes in Pit 24, Area G.

Looking East

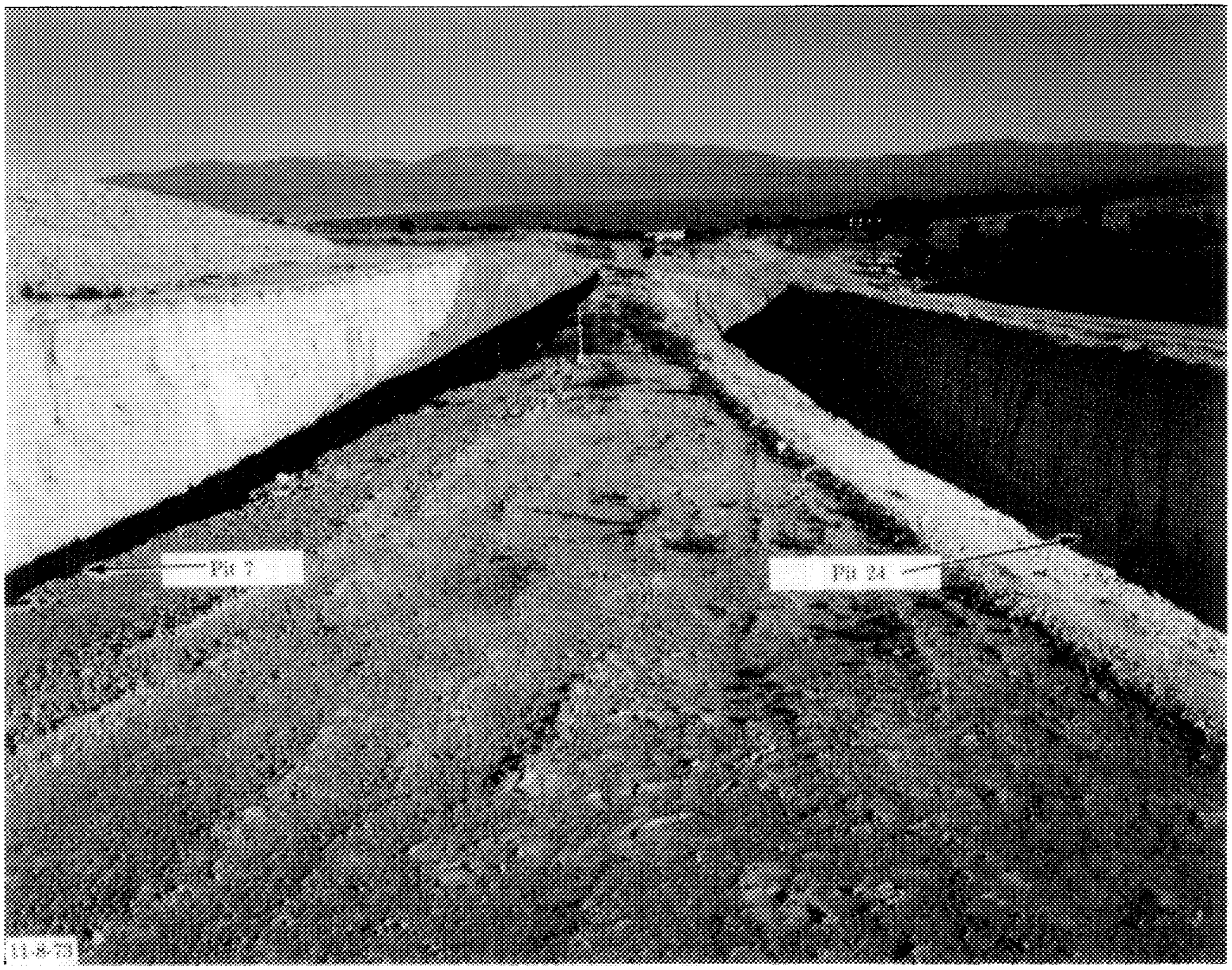


Fig. G-25.
Pit 7 and Pit 24, Area G.

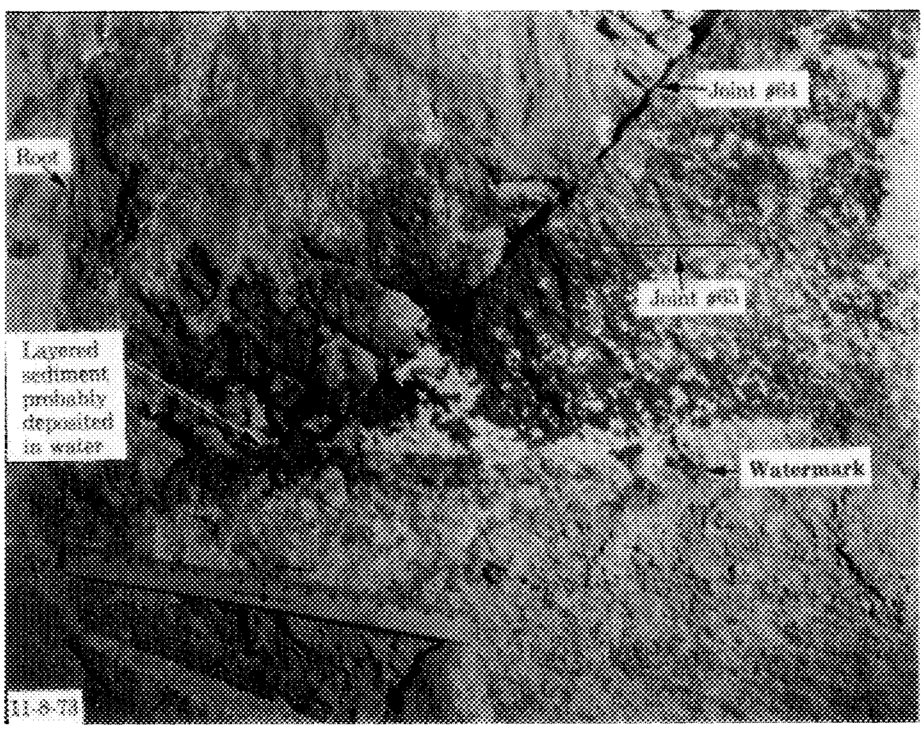
The dessication (sic) cracks and horizontal structures in open fractures suggest that meteoric water was standing in the fractures at some time prior to the excavation of the pits [Figs. G-23b, G-24, G-26]. *Montmorillonite is a swelling clay and in small fractures could be permeable to gas flow* [Figs. G-26 and G-30].

Some rock material may have been transported in the fractures. The rounded pumice fragments in the fractures are evidence of this, but the rounding of the fragments cannot be said with certainty to be due to abrasion, because the pumice fragments within the rock mass are sometimes round.

The gradation of intensity of clayey alteration products at the fracture margins with the preservation of delicate rock structures there is incontrovertible evidence that much of the development of montmorillonite has occurred in place.

North wall, Pit 24, Area G

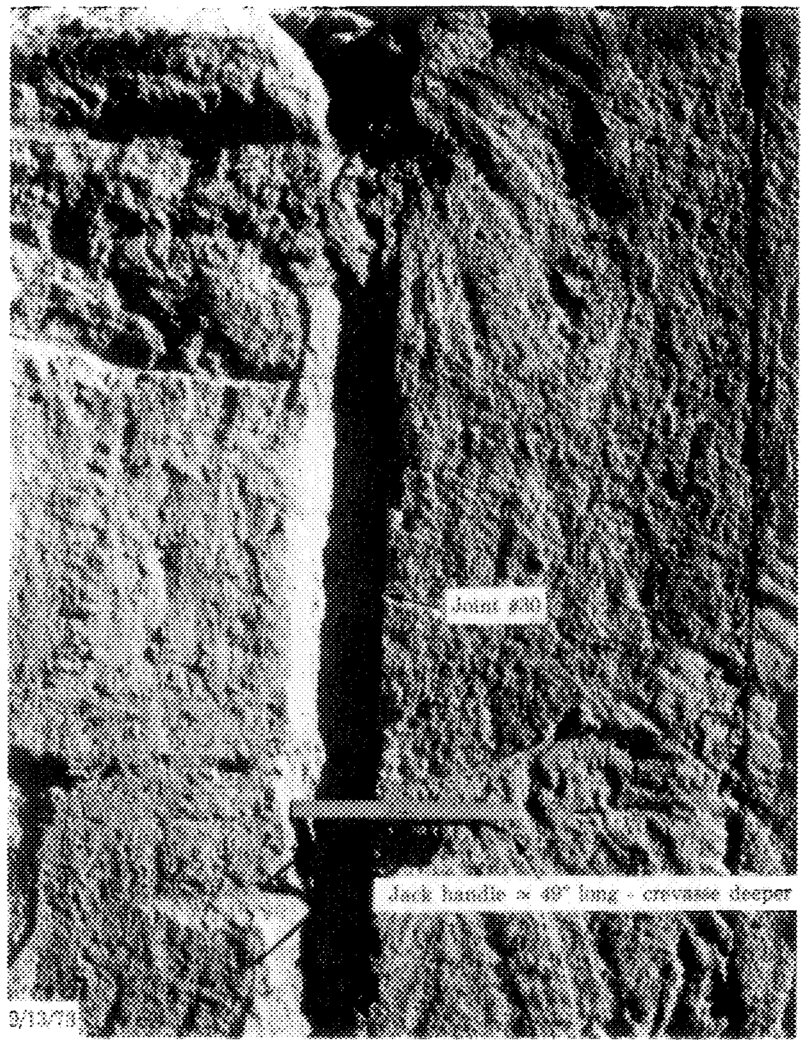
Layered clay along exposed surface of Joint #66
Joint #66 is 515' 7" from west end of pit



Joint #64 is 186' from west end of pit

Fig. G-26.
Caliche and clay filling fractures in Pit 24, Area G.

North wall, Pit 7, Area G



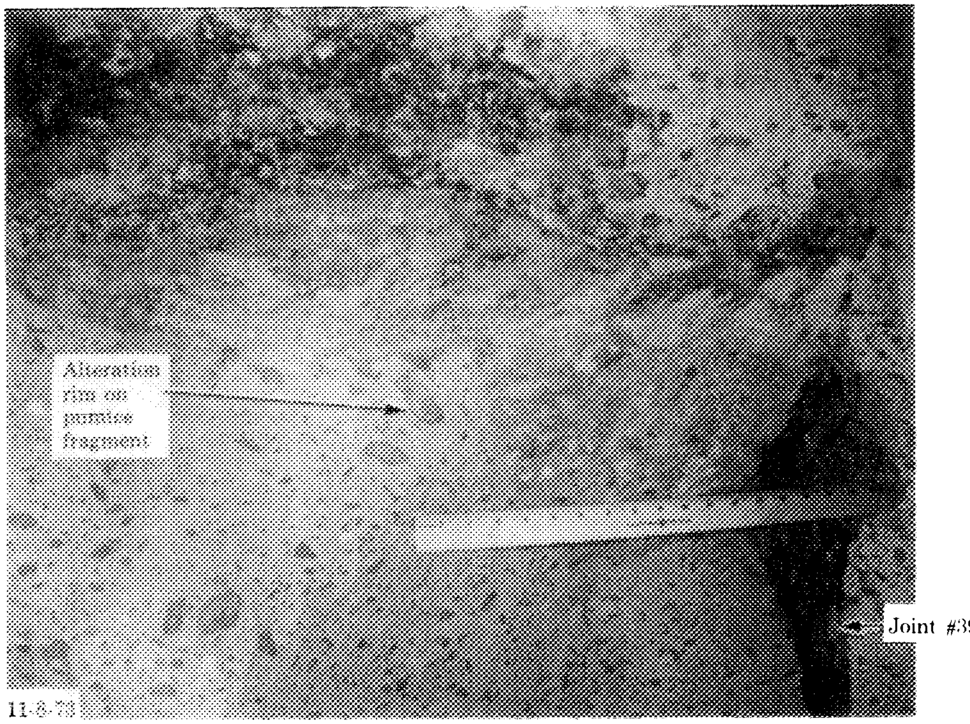
Joint #30, 287' 11" from west end of pit, is an open joint

Fig. G-27.
Open joint in wall of Pit 7, Area G.

The development of caliche in the near surface fractures and of montmorillonite in deeper fractures had undoubtedly diminished the initial permeability of the fracture system. Prior to excavation of the disposal pits, infiltration of meteoric water into the Bandelier tuff by way of these fractures was thus greatly inhibited. The caliche, especially, has served as a barrier to infiltration from the surface and retarded the sealing of deeper fractures by montmorillonite. Nevertheless, meteoric water has found its way into openings in fractures below the caliche zone as evidenced by water lines and dessication (sic) cracks on fracture walls. Excavation of the pits below the caliche zone has made unweathered tuff again susceptible to infiltration by meteoric water.

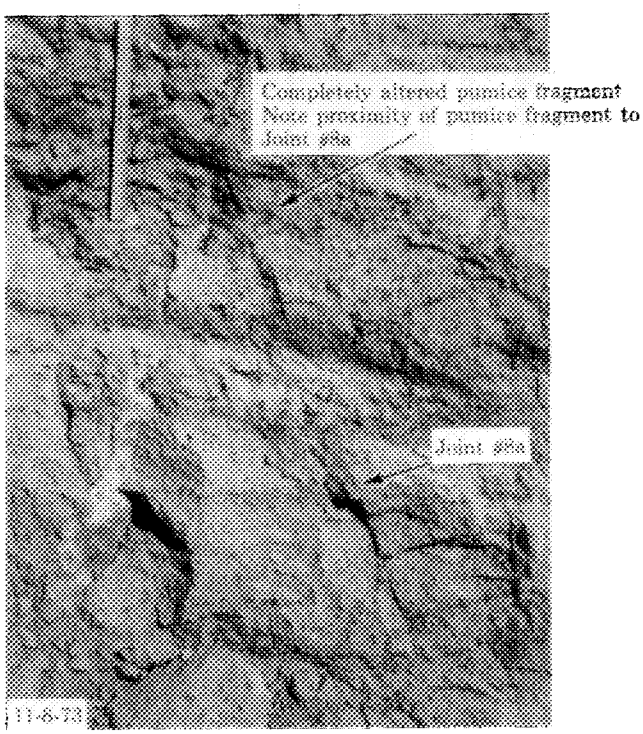
Any excavation which exposes fresh tuff will enhance the tuff's acceptance of meteoric water and the effect will increase with the depth of excavation. In the zone of montmorillonite fracture fillings, the expansion of this clay during wetting may exert sufficient stress on the fracture walls to dilate them irreversibly.

South wall, Pit 24, Area G



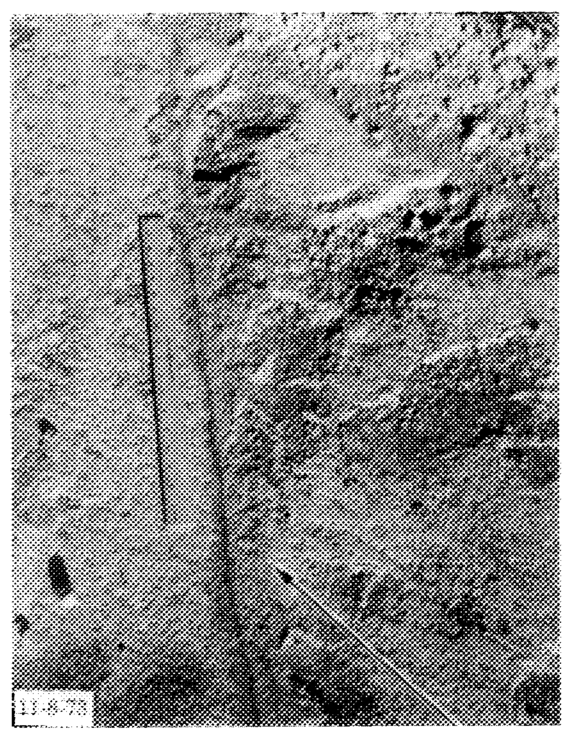
Joint #39 is 302' 8" from west end of pit

North wall, Pit 24, Area G



Joint #8a is 55' from west end of pit

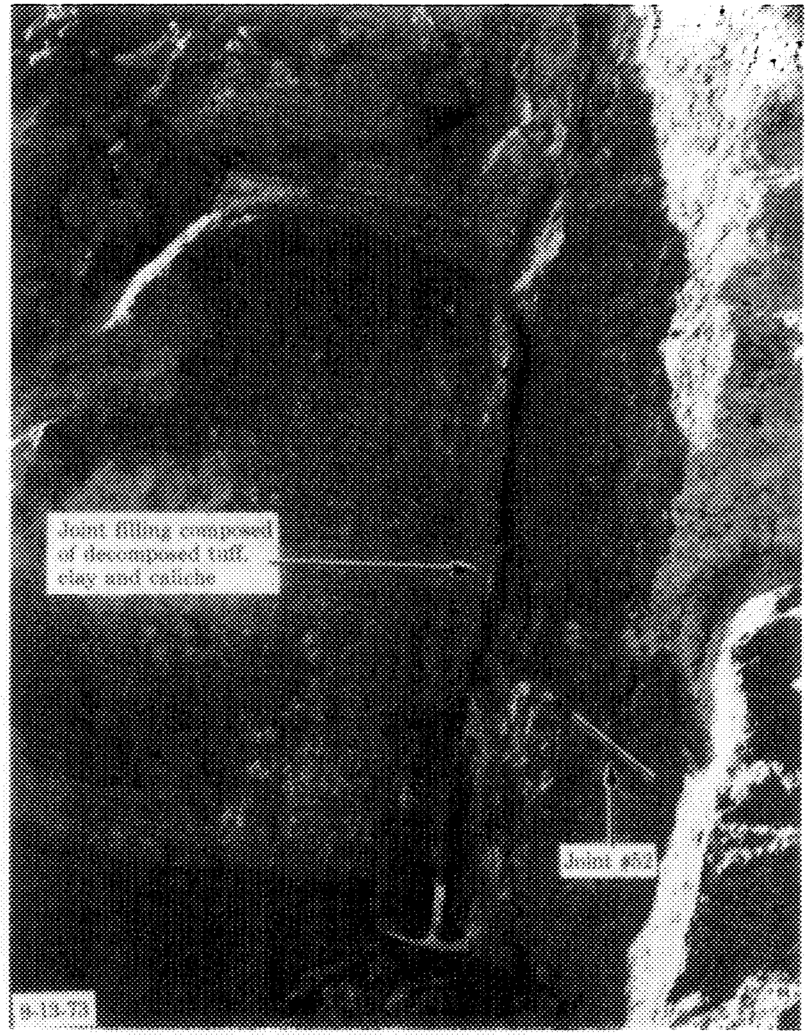
East Ramp, Pit 24, Area G



Weathering halo along a joint

Fig. G-28.
Alteration of the tuff (Tshirege Member of the Bandelier Tuff).

South Wall, Pit 7, Area G



Joint #52 248' 3" from west end of pit

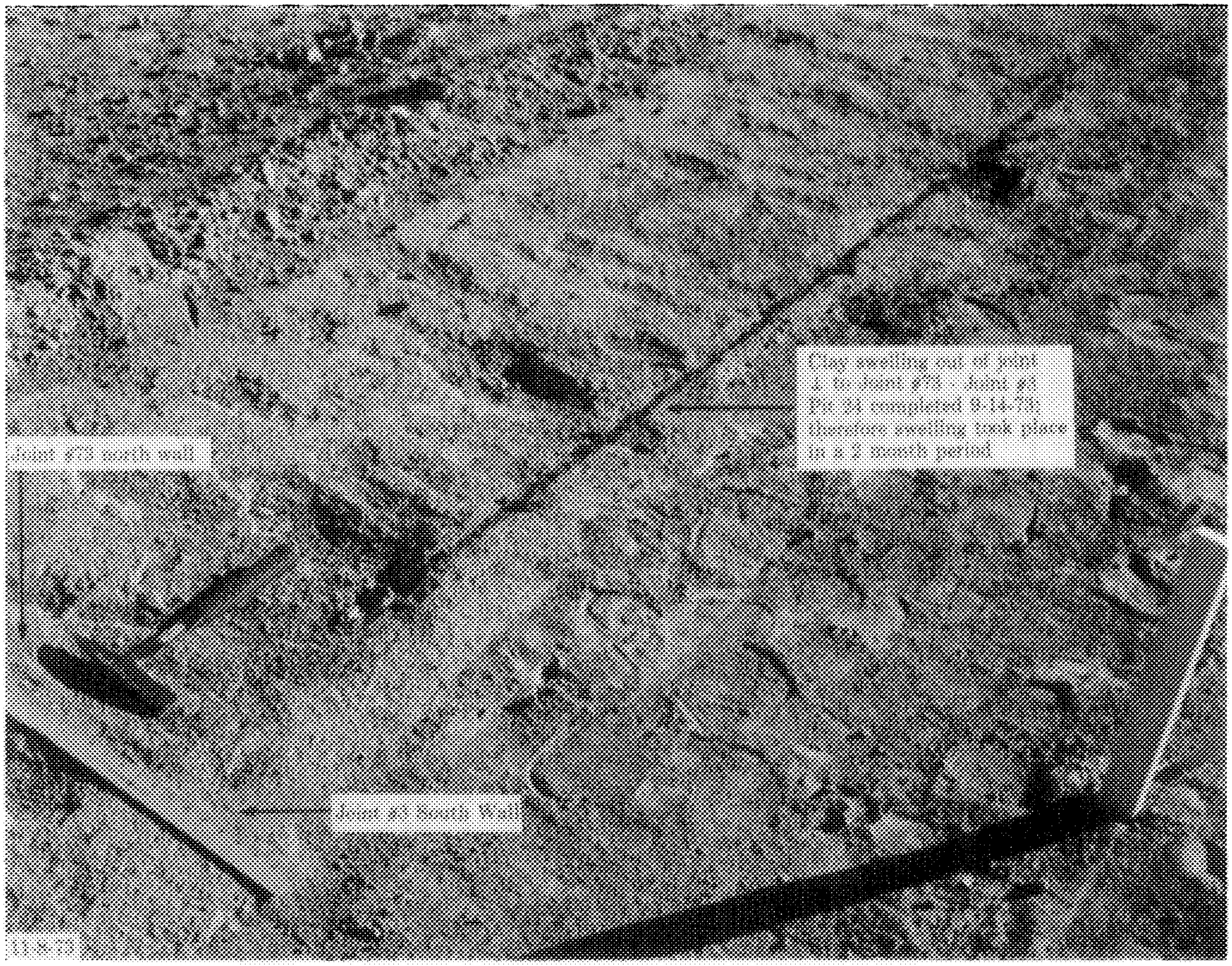
Fig. G-29.
Fracture filling in Joint 52, south wall, Pit 7, Area G.

In view of the zoned character of the fracture filling mineralogy and the physical properties of the montmorillonite, it would seem that disposal pits confined to the caliche zone are less likely to contribute contaminants to the groundwater by way of infiltration than those which extend into the zone of montmorillonite fracture fillings.

Summary and Conclusions

Field relationships, microscopic observations, and X-ray mineralogy demonstrate that the fracture fillings exposed on the walls of disposal Pits No. 7 and 24 are due to alteration of the Bandelier tuff by meteoric water. There are three zones of alteration: 1) an upper zone of caliche-filled fractures, 2) an intermediate zone of mixed caliche and montmorillonite-filled fractures, and 3) a lower zone of

East Ramp, Pit 24, Area G



Joint #73 is 561' from west end of pit

Fig. G-30.
Clay swelling out of joint in east ramp, Pit 24, Area G.

montmorillonite-filled fractures. In recent times water has been stationary in some of the open fractures indicating that 1) water can gain access to the fractures and 2) some of the fractures are plugged at depth. Porosity of the caliche-filled fractures appears to be less than that of the montmorillonite-filled fractures. Prior to excavation of the disposal pits, surface weathering and the resulting deposition of caliche and clays in the fractures inhibited infiltration of meteoric water. Excavation of the pits has exposed unaltered tuff, and as a result, infiltration of meteoric water into the lower zone can be expected to increase. Montmorillonite is a swelling clay and is expected to plug fractures when it is wet; furthermore, it is conceivable that expansion of this clay could cause fracture walls to move apart irreversibly. The montmorillonite filled fractures will have low permeability to gasses when wet and high permeability to gasses when dry. Disposal pit depth should be confined to the caliche zone."[168]

Migration of tritium in the Area G shaft disposal section was reported[169] July 7, 1970. Samples of tuff had been collected during the augering of Shafts 34-38 and 40-49. They were analyzed for moisture content and tritium content in moisture. Table G-IX shows results of the analyses and Fig. G-31 shows locations and status of shafts as of June 24, 1970.

"Laboratory analyses of three samples of tuff from a depth of 25 ft indicated the following hydrologic properties

Porosity	Specific Retention	Specific Yield
	(percent of volume)	
44	17	27
37	20	17
36	18	18

The moisture content of the tuff ranged from 0.1 to 6.4% with an average of 1.2% by volume.

The tritium concentrations from samples collected from Shaft 34 (November 1969), located about 55 ft east of existing Shaft 14, ranges from 62 to 454 $\times 10^{-6}$ *µCi/ml of moisture.*

The concentrations in samples from Shafts 35 to 38, located about 80 ft south of Shaft 14, ranged from 0 to 106 $\times 10^{-6}$ *µCi/ml of moisture.*

High tritium concentrations (range 1779 to 1180, 630 $\times 10^{-6}$ *µCi/ml of moisture) were found in samples collected from Shafts 39 thru 48, which are located in a line about 6 ft east of Shafts 4 thru 13 that are filled with wastes.*

The low moisture content of the tuff indicates that the tritium is being distributed through the pore space of the tuff, as well as joints or fractures, by diffusion in a water vapor. There is probably some moisture gradient (greater in the wastes themselves) which will aid in the outward movement of the tritium as the volumes of greater moisture seek equilibrium in the tuff. There appears to be little if any pattern in the distribution of the tritium, probably due in part to varying concentrations buried at various depths within the shafts and in part to a possible distribution that could be joint controlled."[169]

The question of whether moisture distilled from the tuff for analyses was in part bound water or water of crystallization was raised. Tests were run and it was determined the moisture distilled from the tuff was not in the form of bound water or water of crystallization.[169]

Shafts 1-14 were augered in the spring of 1966.[170] Except for Shaft 14, all had received some waste contaminated with tritium.[170]

This initial report stimulated interest for the study described in the LAMS report, "Underground Movement of Tritium from Solid-Waste Storage Shafts."[170] In August 1970, 14 test holes were laid out and drilled (see Fig. G-32).

"The test holes, 6 in. in diam and 50 ft deep, were drilled with a power auger. Tuff samples representing 5 ft intervals were collected from the auger cuttings. The holes were thoroughly cleaned before each 5-ft sample run, and the results of the tritium analyses indicated that there was

TABLE G-IX

MOISTURE AND TRITIUM CONTENT OF MOISTURE IN SAMPLES OF TUFF COLLECTED FROM SHAFTS IN AREA G, TA-54

Shaft Number	Depth (feet)	Date Collected	Percent Moisture (by weight)	Tritium μCi/ml of moisture ($x\ 10^{-6}$)
34	20	11-7-69	0.4	454 ± 8
34	40	11-7-69	0.1	136 ± 6
34	65	11-7-69	0.3	62 ± 5
35	20	5-26-70	6.4	11 ± 5
35	40	5-26-70	1.2	106 ± 6
36	20	5-27-70	.7	37 ± 5
36	40	5-27-70	1.2	83 ± 6
37	20	5-27-70	.2	7 ± 5
37	40	5-27-70	.6	41 ± 5
38	20	5-27-70	.1	27 ± 5
38	40	5-27-70	.6	0 ± 5
40	25	6-9-70	1.2	52 797 ± 104
41	15	6-9-70	2.0	7 374 ± 32
41	25	6-9-70	1.0	15 135 ± 43
42	15	6-9-70	1.1	115 896 ± 227
42	25	6-9-70	1.4	6 833 ± 25
43	15	6-9-70	1.4	70 761 ± 140
43	25	6-9-70	.9	10 633 ± 36
44	15	6-10-70	1.2	3 115 ± 20
44	25	6-10-70	.2	23 029 ± 52
45	15	6-10-70	1.6	4 644 ± 22
45	25	6-10-70	.6	1 779 ± 16
46	15	6-10-70	1.0	211 094 ± 414
46	25	6-10-70	.8	178 198 ± 198
47	15	6-11-70	.9	30 828 ± 61
47	25	6-11-70	.5	6 813 ± 29
48	15	6-11-70	.9	220 966 ± 432
48	25	6-11-70	.7	1 180 630 ± 1995
49	15	6-12-70	2.3	170 824 ± 336
49	25	6-12-70	.8	324 832 ± 187

Ref: 169

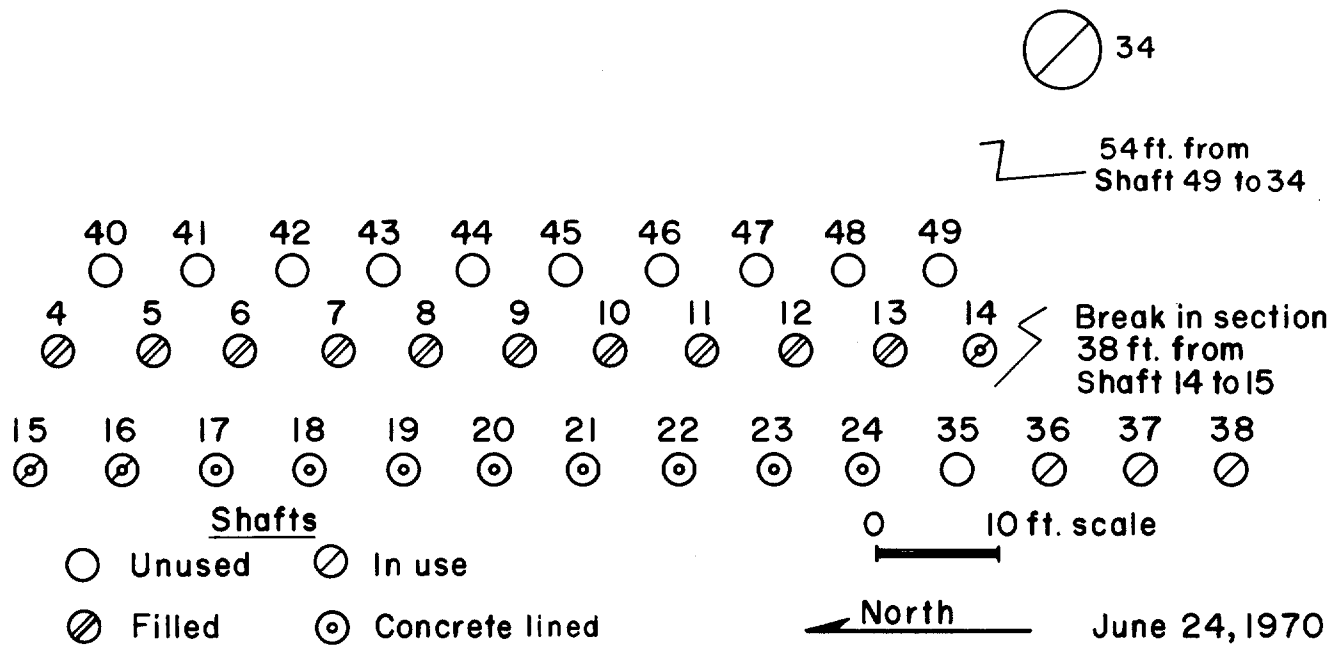


Fig. G-31.
Planview sketch of shafts at Area G, TA-54.

little, if any, cross-contamination between samples from successive 5-ft intervals. ...In general the tritium concentrations increased to a maximum between depths of 10 to 30 ft and then decreased with depth.... [see Table G-X].

Isotritrium contours were constructed at depths of 10 to 15 ft, 20 to 25 ft, 30 to 35 ft, and 40 to 45 ft [Fig. G-33]. *Test holes and burial shafts were used for control points on* [Fig. G-33a] *while only the test holes were used on* [Fig. G-33b]. *The irregularities in the isotritium contours just east of the shafts are due to the movement of the tritium through open joints which provide a much more rapid means of migration than movement through the tuff matrix. The effect of these joints is apparent only near the shafts due to the close spacing of control points used in construction of the contours. West of the shafts where control points (test holes) are located on 20-ft centers the effect of the joints on movement of the tritium is not apparent. The contours are elongated to the west of the shafts showing the principal movement of the tritium.*

Isotritium contours were also constructed for a vertical plane extending east and west through shaft 13 [Fig. G-33c]. *The contours show that the major movement of tritium took place along the contact between the two ashflows. The abundance of pumice fragments in the lower part of the upper ashflow and the presence of the reworked tuff between the two flows causes a greater porosity and permeability in the contact region as compared to the matrix or joints in the overlying or underlying tuff. The tritiated moisture migrating along the contact serves as a source for movement into the upper and lower ashflows.*

A comparison of the isotritium contours in planview [Figs. G-33a & b] *just above and below the contact shows that migration of the tritium was not uniform along the contact but greater in a westerly direction. This is due to a thickening of the layer of reworked tuff lying along the contact which increases the rate of movement in that direction.*

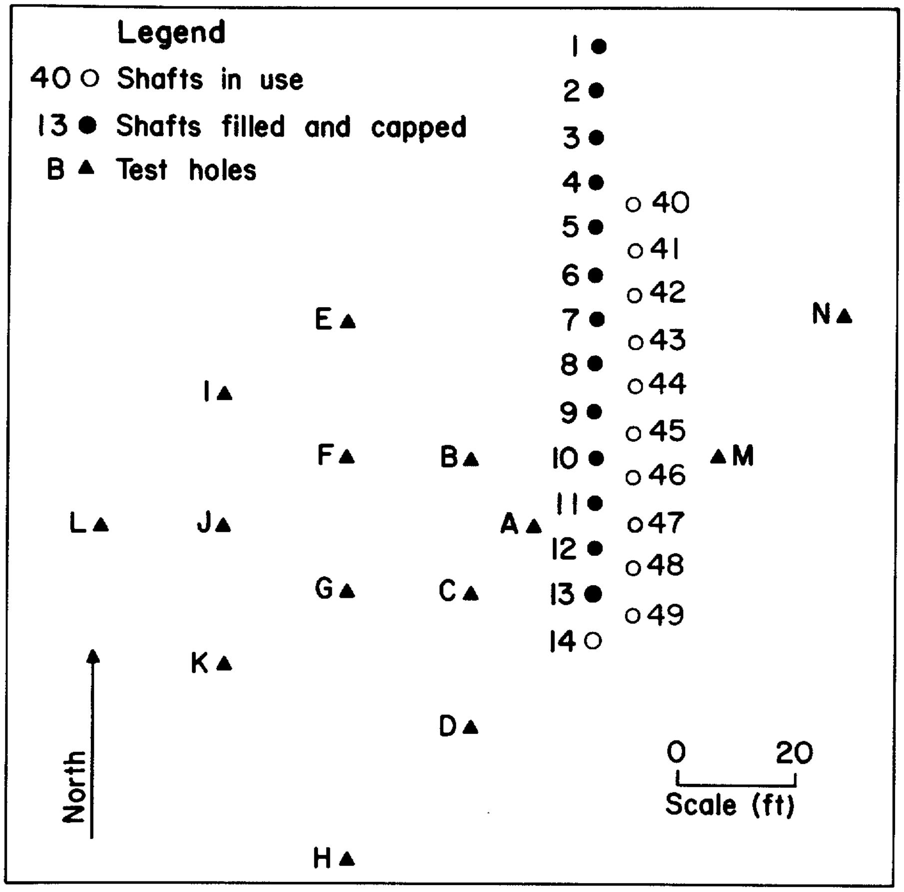


Fig. G-32.
Planview of shafts and test holes, Area G, TA-54.

The tuff in the ashflows is not homogenous. It is broken by joints, and porosity varies within the tuff matrix. The contact between the two ashflows adds to the inhomogeneity. Thus the extent of the migration can only be approximated. About four years after the wastes were stored in Shafts 12 and 13, a 100-pCi/ml contour has moved to a distance of about 105 ft west of the shafts along the contact between the two ashflows [Fig. G-33c], *and the 100-pCi/ml contour extrapolated beneath the shafts is at a depth of about 97 ft below the surface of the mesa. There is a second contact beneath the lower ashflow (G-33c), however, and this contact would slow the vertical migration of tritiated vapors through the tuff by allowing them to move laterally along the more permeable contact. In general, the volume of tuff containing the tritiated moisture has assumed the shape of an irregular lens, shortened to the east and elongated to the west* [Fig. G-33c].

Little water from precipitation infiltrates through the soil into the underlying tuff.[1] *There is not enough water to leach the tritium from the wastes and move it through the 240 ft of dry tuff and 610 ft of dry volcanic rocks and sediments to the main aquifer that lies at a depth of about 850 ft at Area G.*

TABLE G-X

TRITIUM ANALYSES OF MOISTURE FROM DRILL CUTTINGS
TEST HOLES A THROUGH N (pCi/ml)

Depth (ft)	A	B	C	D	E	F	G
0- 5	68,000	5,370	7,510	383	294	531	729
5-10	94,700	11,800	22,300	6,310	1,100	538	1,610
10-15	196,000	8,270	55,500	13,800	439	632	4,190
15-20	159,000	12,900	44,800	14,300	1,010	1,860	7,060
20-25	471,000	13,200	39,700	18,800	744	2,620	9,310
25-30	275,000	9,850	32,800	19,900	611	3,750	9,370
30-35	140,000	6,390	22,900	15,000	516	3,190	7,490
35-40	211,000	4,470	13,900	9,200	742	2,160	6,550
40-45	116,000	4,590	4,790	4,380	918	1,405	3,680
45-50	79,000	4,170	4,950	1,470	816	1,107	3,650

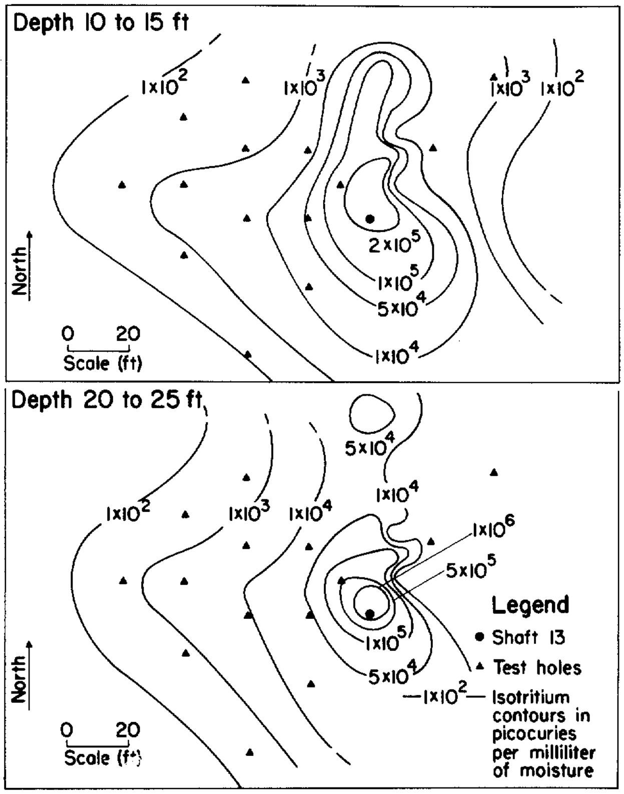
Depth (ft)	H	I	J	K	L	M	N
0- 5	42	41	77	42	37	4,830	250
5-10	30	144	267	154	157	6,680	2,410
10-15	131	182	3,720	405	249	6,920	6,140
15-20	197	320	5,490	876	205	7,480	8,790
20-25	445	195	7,210	912	145	5,780	9,400
25-30	430	207	6,340	1,060	127	4,100	9,820
30-35	512	196	969	1,060	122	3,690	9,290
35-40	330	140	1,230	728	87	2,780	7,760
40-45	278	144	966	801	57	3,020	6,250
45-50	235	136	844	569	44	2,550	4,710

Ref: 170

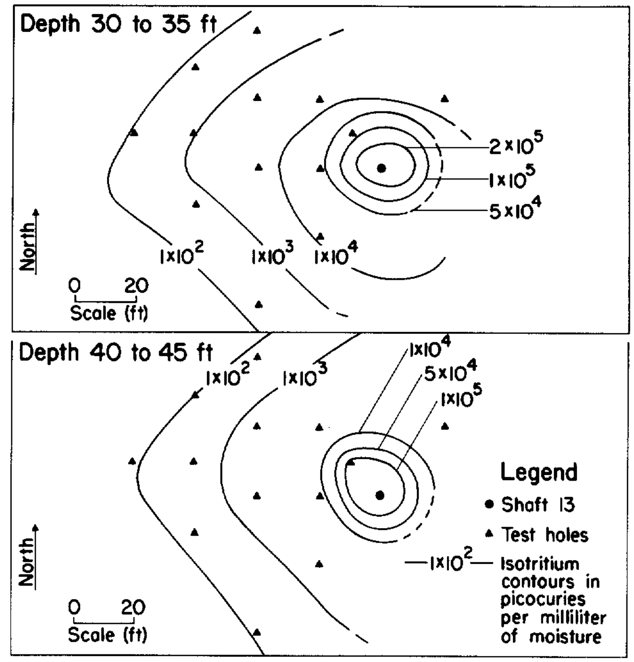
RELEASE OF TRITIUM TO THE ATMOSPHERE

Intake of air during periods of high atmospheric pressure and exhaust of air during periods of low pressure have been noted for burial shafts and test holes in the tuff in Area G. The soil and weathered surface tuff forms a partial barrier against the exchange of air between the underlying tuff and the atmosphere.[2] *Air was pumped from Shaft 47 to determine if measurable amounts of tritium could be released to the atmosphere during an atmospheric low.*

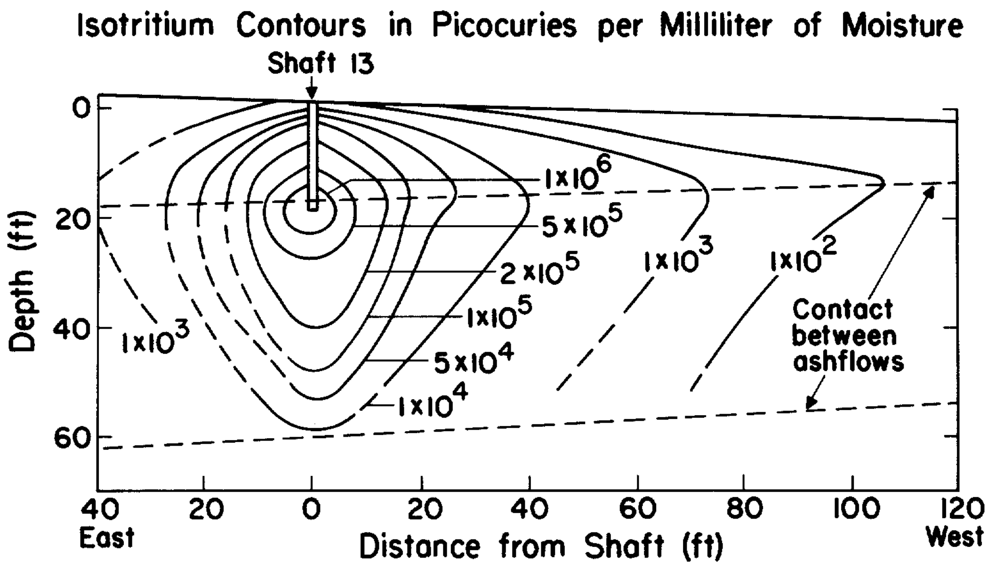
The air in the shafts is nearly saturated with water vapor. The measured relative humidity varied from 94 to 98% at a temperature of about 70°F. Prior to receiving wastes, Shaft 47 was sealed at the surface and air pumped out of the unlined shaft at a rate of about 2.5 cfm for 24 h. Moisture was collected in a condenser at the pump and analyzed for tritium. The tritium concentration was 577 000 pCi/ml of water, about half the concentration found in moisture from a sample of tuff collected from a depth of 25 ft [Table G-IX].



a. Isotritium concentrations in picocuries per milliliter of moisture in planview at depths of 10 to 15 ft and 20 to 25 ft.



b. Isotritium concentrations in picocuries per milliliter of moisture in planview at depths of 30 to 35 ft and 40 to 45 ft.



c. Isotritium concentrations in picocuries per milliliter of moisture in section east and west of shaft 13.

Fig. G-33.

Isotritium concentrations found during the 1970 tritium migration study at Area G.

A number of samples of surface soil were collected west of Shaft 13 out to a distance of 120 ft [Table G-XI]. *Tritiated moisture concentrations generally decreased with distance from Shafts 12 and 13. The sample collection at 80 ft consisted of tuff since there was no soil cover at that point. We therefore conclude that tritium is being released to the atmosphere as a result of the evaporation of soil moisture near the shafts.*

In an effort to determine whether or not vegetation has any influence on the transfer of tritiated moisture from the disposal shafts to the atmosphere, five samples of vegetation and moisture transpired from vegetation were collected in the immediate vicinity of the disposal shafts [Table G-XI]. *These analyses indicate that there is an uptake of tritium by plants from the soil and tuff and that tritiated moisture is being transpired to the atmosphere. Measurements from two samples collected about 0.5 miles west of the shafts are included for comparison. No attempt was made to determine the amount of tritiated moisture being released to the atmosphere due to transpiration from plants and evaporation from surface soil adjacent to the shafts."*[170]

"(1)*W. D. Purtymun, "Geology and Hydrology of Mesita del Buey," Los Alamos Scientific Laboratory report LA-4660 (1971).*

(2)*J. L. Kunkler, "Measurement of Atmospheric Pressure and Subsurface Gas Pressure in the Unsaturated Zone of the Bandelier Tuff, Los Alamos, New Mexico," U.S. Geol. Survey Prof. Paper 650-D (1969)."*

On May 26, 1971, H-1 requested that H-8 take background information on tritium in the newly excavated Pits 8, 12, 16, 17, and 21.[171]

"In the past, Group H-6 has detected tritium in the soil from and around our old pits. If possible, I would like Group H-8 to sample soil from the new pits, possibly core drilling in the bottom of one or more. These samples would give us a background which we do not have for the old pits."[171]

"Nine test holes were drilled in August 1971 in and adjacent to the new disposal pits at TA-54 [see Fig. G-34]. *Five of the test holes (8A, 12A, 16A, and 21A) were drilled to a depth of 30 ft in the floor of the pits. Four of the test holes (8B, 16B, 17B, and 21B) were drilled to depths of 60 ft, three on the perimeter and one near the center of the area....*

Samples of tuff were collected over a five-foot interval. The moisture content of each sample was determined and moisture distilled out for tritium analyses [see Table G-XII].

There was no pattern to the distribution of tritium with depth. Concentrations are low, within background data on tritium collected from a shaft at Area L (20 pCi/ml).

In undisturbed areas on the mesa moisture concentrations in the tuff will range from 3 to 8% by weight in the upper 10 ft of soil and tuff. The concentrations decrease with depth. Soil cover in the areas of holes 8B, 16B, 17B, and 21B was disturbed by heavy equipment used in construction of the pits. The moisture content of samples in the upper 10 ft of soil and tuff from the above holes ranged from 0.6 to 5.0% by weight with an average of 1.8.

The moisture contents of tuff from holes 8A, 12A, 16A, 17A, and 21A (located in bottom of pits) and below depths of 10 ft in holes 8B, 16B, 17B, and 21B ranged from <0.1 to 1.4% by weight with an average of 0.4. The moisture in the soil and tuff is in the low moisture range where movement is by diffusion.

TABLE G-XI

MOISTURE CONTENT AND TRITIUM ANALYSES
OF MOISTURE FROM SOIL AND TUFF
WEST OF SHAFT 13, AUGUST 5, 1970

Distance (ft)	Moisture Content (% by wt)	Tritium (pCi/ml)
5	8.8	1 100
10	17.3	327
20	10.2	131
40	7.0	40
60	6.4	68
80	2.7	122
100	7.1	30
120	8.2	21

TRITIUM ANALYSES OF MOISTURE FROM PLANTS

Location	Type of Plant	Type of Sample	Tritium (pCi/ml)
40 ft South of Shaft 13	Ragweed	DIS	392
40 ft South of Shaft 13	Tumble Weed	DIS	398
At Shaft 13	Unknown	SWT	101 000
85 ft North of Shaft 13	Chamisa	SWT	17 700
At Shaft 14	Unknown	DIS	7 970
0.5 Mile West of Area G	Chamisa	SWT	<5
0.5 Mile West of Area G	Unknown	SWT	<5

DIS - Analyses made of moisture distilled from plant by heating.

SWT - Analyses made of moisture transpired from plant.

Ref: 170

The pits are constructed in Unit 2b of the Tshirege Member of the Bandelier Tuff....

The test holes drilled in the bottom of the pits (within the lower ashflow) are completed into the top of Unit 2a. The test holes drilled on the perimeter and near the center of the area are completed through Unit 2b into the top of Unit 2a.

Radiochemical analyses of samples collected from test hole 21B were composited according to stratigraphic units (i.e. upper ashflow, reworked material, and lower ashflow of Unit 2b and upper ashflow of Unit 2a) and analyzed for gross alpha and beta activity as well as ^{238}Pu, ^{239}Pu, ^{137}Cs *and Natural Uranium* [Table G-XIII]. *The results of the analyzes (sic) are within limits of background data in the Los Alamos area. The positive value of 0.005 pCi/g (picocuries per gram) of* ^{239}Pu *in the upper ashflow (depth 0-10 ft) is within limits established for* ^{239}Pu *fallout in Los Alamos, Santa Fe, and Espanola areas."*[172]

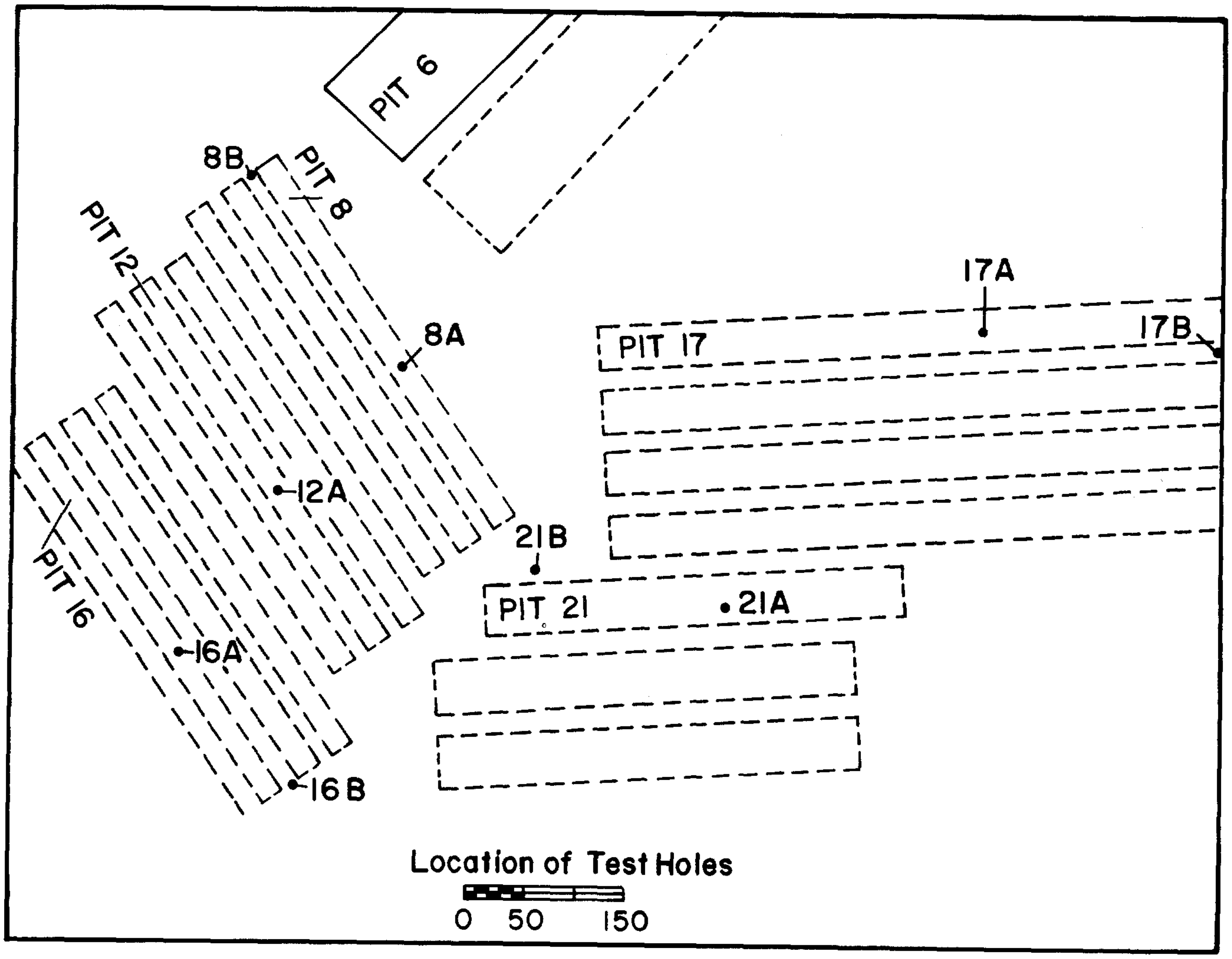


Fig. 34.
Location of 1971 test holes, Area G.

In early December 1973, five test holes were augered in the fill over Pits 1 and 2 (see Fig. G-35). The results of the study were reported February 13, 1974.[173]

"***Sampling Procedures***

In early December 1973, samples were collected of the cover material on Pits 1 and 2, Area G, Ta-54. Material was collected by two methods; holes were drilled using a 4-in. power auger, and samples of the material brought to the surface were collected at regular depth intervals; a split-spoon sampler was driven into the material with an impact hammer, returned to the surface, and the samples removed from the sampler.

The samples were analyzed for moisture content using standard gravimetric techniques. Moisture samples were removed from the soil by heat distillation and analyzed for tritium content. Selected

TABLE G-XII

TRITIUM CONCENTRATIONS AND MOISTURE CONTENTS IN CUTTINGS FROM TEST HOLES

Depth Internal (feet)	Tritium Picocuries per Milliliter of Moisture								
	Hole 8A	Hole 12A	Hole 16A	Hole 17A	Hole 21A	Hole 8B	Hole 16B	Hole 17B	Hole 21B
0-5	9	11	12	15	11	27	12	10	15
5-10	8	15	10	13	12	13	15	7	24
10-15	11	13	5	11	4	10	15	12	23
15-20	<4	13	14	10	9	14	14	13	20
20-25	9	10	16	12	10	21	16	20	33
25-30	11	12	--	6	8	12	17	18	24
30-35	--	--	--	--	--	20	18	14	25
35-40	--	--	--	--	--	22	12	12	18
40-45	--	--	--	--	--	10	10	15	26
45-50	--	--	--	--	--	13	15	12	21
50-55	--	--	--	--	--	27	16	16	15
55-60	--	--	--	--	--	20	17	13	17

Note limits of detection 4 picocuries per milliliter

Depth Internal (feet)	Moisture Content of Tuff Percent Moisture by Weight								
	Hole 8A	Hole 12A	Hole 16A	Hole 17A	Hole 21A	Hole 8B	Hole 16B	Hole 17B	Hole 21B
0-5	0.2	<0.1	0.1	<0.1	0.8	5.0	0.6	2.0	1.9
5-10	1.1	<0.1	0.3	<0.1	0.7	2.7	0.4	1.0	1.2
10-15	0.9	<0.1	<0.1	1.0	0.8	1.3	0.5	0.3	0.5
15-20	0.7	0.2	<0.1	<0.1	<0.1	0.8	0.4	0.2	0.5
20-25	0.8	0.1	0.1	0.4	<0.1	0.7	6.0	0.3	0.4
25-30	1.4	0.1	<0.1	1.2	<1.0	0.2	0.2	0.5	0.1
30-35	--	--	--	--	--	1.0	0.2	1.1	0.4
35-40	--	--	--	--	--	0.6	0.1	0.4	0.2
40-45	--	--	--	--	--	0.6	0.8	0.6	0.3
45-50	--	--	--	--	--	0.9	0.4	0.4	<0.1
50-55	--	--	--	--	--	1.1	<0.1	0.3	0.4
55-60	--	--	--	--	--	0.8	0.3	0.6	0.2

Ref: 172

samples will be analyzed for plutonium, cesium, and strontium. A summary of the resultant data is summarized in [Table G-XIV]. *The technique used in collecting the samples is indicated in the table. A sketch map of the location of the sample holes is presented as* [Fig. G-35].

The various sample holes are of varying depths, primarily reflecting thickness of cover material in the various locations. Great care was taken to cease penetration at the first indication that waste material was being encountered. A thorough monitoring of the samples and sampling equipment performed by an H-1 monitor indicated no detectable contamination.

After the drilling was completed, the holes were backfilled a short distance and a 2-in. plastic pipe placed in the hole. The hole was backfilled around the pipe, and the pipe was capped. These casings will be used as access tubes for a neutron moisture meter to provide further monitoring of moisture movement in the fill material.

TABLE G-XIII

RADIOCHEMICAL ANALYSES OF TUFF FROM TEST HOLE 21B

		Picocuries per gram					Micrograms per gram
Description	Depth (feet)	Gross Alpha	Gross Beta	^{238}Pu	^{239}Pu	^{137}Cs	Natural Uranium
Unit 2b							
Upper Ashflow	0-10	6	2	b/	0.005	c/	0.20
Reworked Material	10-15	8	a/	b/	b/	c/	0.28
Lower Ashflow	15-40	7	a/	b/	b/	c/	0.24
Unit 2a							
Upper Ashflow	40-60	7	a/	b/	b/	c/	0.31

a/ Below limits of detection 1 pCi/g

b/ Below limits of detection 0.002 pCi/g

c/ Below limits of detection 2 pCi/g

Ref: 172

TABLE G-XIV

DATA SUMMARY AREA G AUGER HOLES IN FILL MATERIAL COVERING PITS 1 AND 2*

Hole No.	Depth Interval m	Moisture Content % by wt.[173]	Tritium Content pCi/mℓ Water[173]	^{238}Pu pCi/g	^{239}Pu pCi/g	Location
G-1 (Split spoon)	0-0.7	10.1	4 246			S.W. End, Pit No. 1
	0.7-1.5	13.1	14 823			
	1.5-2.3	10.1	38 207			
	2.3-3.0	8.2	57 850			
	2.7-2.9			no analysis	0.020±0.006	
	3.0-3.5	8.3	102 042			
	3.3-3.5			0.000±0.002	0.015±0.004	
G-2 (Auger)	0-0.8	9.5	7 280			S.W. End, Pit No. 1
	0.8-1.5	11.7	6 977			
	1.5-2.3	11.4	19 557			
	2.3-3.0	7.5	130 426	no analysis	no analysis	
	3.0-3.8	7.0	297 271	0.001±0.002	0.074±0.007	
G-3 (Split spoon)	0-0.8	3.3	685			N.W. End, Pit No. 2
	0.8-1.5	4.8	698			
	1.5-2.0	4.8	835			
	1.5-1.7			0.032±0.009	0.27 ±0.03	
	1.8-2.0			0.000±0.000	0.000±0.000	
G-3A (Auger)	0-0.9	3.3	645			N.W. End, Pit No. 2
	0.9-1.5	5.7	841			
	1.5-2.3	4.7	908	no analysis	0.014 0.005	
	2.3-3.0	5.0	935	0.002 0.002	0.010 0.004	
G-4 (Auger)	0-0.8	5.0	157			S.W. End, Pit No. 2
	0.8-1.2	3.9	443			

* In 1974 minimum detection limits for routine analyses of radioactivity in typical solids was 0.6nCi/ℓ for ^{3}H, 5fCi/g for ^{238}Pu, and 5fCi/g for ^{239}Pu.

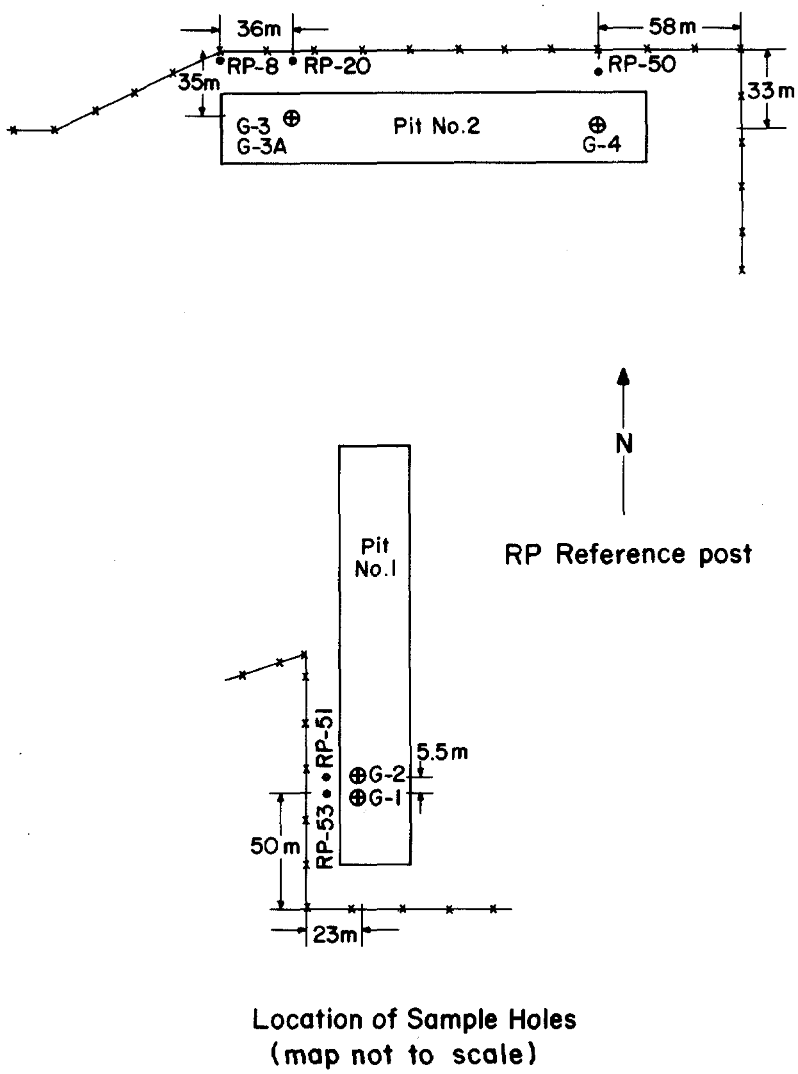


Fig. G-35.
Location of 1973 sample holes, Area G.

Three additional sets of holes have been drilled in tuff material underlying disposal pits which were not in full service."[174] *"Samples were collected using the power auger described above, and analyzed for moisture content....*[See Tables G-XV, G-XVI, and G-XVII]. *Analysis for tritium was not performed. However, data from field investigations in 1971 indicated that background tritium concentrations in undisturbed tuff are on the order of 10-20 pCi/m."*[172]

"Discussion

The fill material on Pit No. 1 and Pit No. 2 appears to have been undisturbed since covering was completed in April 1961 and July 1963, respectively. This lack of disturbance is indicated by the presence of mature specimens of ***Chrysothamus perrihowardi*** *(rabbitbrush) in the vicinity of the sample holes. This plant species requires ten to twenty years to reach adult size.*

In general, a peak in the water content was located at one to two meters depth. Below this interval moisture contents decreased with depth, and then at depths of about three meters remained somewhat constant with depth. This indicates that moisture penetration by precipitation is confined primarily to the upper 2 to 3 meters of material. Penetration below that depth may occur during years of unusually high precipitation, and from slow redistribution of near surface moisture.

Moisture contents were well below field capacity values (estimated as 15-20% for this material) indicating that moisture movement is primarily caused by capillary forces. No actual movement rates can be inferred from this data without additional field measurements. The variation in moisture contents observed between the fill on Pit No. 1 and that on Pit No. 2 may be due either to variations in soil conductivity or differences in surface slopes. Further work is planned to substantiate this.

It is interesting to compare the moisture content of the fill material with that of the tuff beneath disposal Pits 7, 8, and 24. Pits 7 and 24 were constructed in the fall of 1973, and the bottoms had been exposed to precipitation for only a few months when the moisture samples were collected. The moisture contents are similar to, or lower than, those recorded in other undisturbed portions of the tuff.[1] Pit 8 was constructed in August 1971, and was thus exposed to precipitation for more than two years. Water is known to have accumulated in the bottom of the pit on at least one occasion (September 1973).[2] This increased moisture input is reflected in the higher moisture contents observed beneath Pit 8, compared with Pits 7 and 24.

No firm comparison can be made between the moisture transmitting capacity of the fill material (crushed tuff) and the undisturbed tuff. However, the similarity of the moisture regime beneath Pit No. 8 and that in the fill material indicates that the transmission capabilities of the two materials are in the same range of values. Generally speaking, both materials can be characterized as "poor conductors" of moisture. For comparison, moisture contents of undisturbed natural soils range up to 20% by weight at depths of one to two meters.[1]

The recorded tritium concentrations are of considerable interest. Environmental monitoring in the Los Alamos area indicates that background tritium concentrations are in the range of 10-20 pCi/mℓ[(39),172] for both solid and near surface tuff. The tritium concentrations observed in the fill on Pit No. 1 are more than three orders of magnitude higher than this. A search of disposal records for that pit did not reveal any single item that would appear to be a source of the tritium. Several entries recorded the disposal of 50-100 curie quantities of tritium, but none were in the near vicinity of the moisture sample holes. The significant concentration gradient towards the surface indicates that tritium is diffusing towards, and perhaps out of, the ground surface. Additional monitoring will be necessary to determine the actual quantities of tritium entering the atmosphere of vegetation at this site.

Conclusion

Moisture sampling data indicates that precipitation is penetrating to a depth of one to two meters in the fill material. The material appears to have about the same moisture transmission capacity as undisturbed tuff, both materials being lower than natural soils in the area.

TABLE G-XV

PERCENT MOISTURE BY WEIGHT FROM AUGER HOLES IN PIT 7, AREA G

Depth (feet)	9/17/73 Hole #1	9/20/73 Hole #4	9/18/73 Hole #2	9/20/73 Hole #3
0-5	0.7	5.5	1.2	1.0
5-10	0.4	0.5	0.6	0.5
10-15	0.7	0.1	0.3	0.6
15-20	0.9	0.4	0.3	2.1
20-25	0.7	0.3	0.2	2.4
25-30	0.7	0.4	0.4	0.3
30-35	).7	0.3	0.2	0.3
35-40	0.3	0.4	0.5	0.5
40-45	0.3	2.0	0.3	0.5
45-50	0.9	0.5	0.3	0.5
50-55	1.2			
55-60	2.3			
60-65	2.0			
65-70	0.9			
70-75	1.7			
75-80	0.7			
80-85	1.4			
85-95	1.7			
95-107	3.0			
107-117	2.5			

Ref: 175

Unusually high tritium concentrations were observed in the fill on Pit No. 1, but cannot be attributed to any specific source. Tritium appears to be migrating towards the ground surface."[173]

"(1) *J. H. Abrahams, Jr., J. E. Weir, Jr., and W. D. Purtymun, "Distribution of Moisture in Soil and Near-Surface Tuff on the Pajarito Plateau, Los Alamos County, New Mexico," U.S. Geological Survey, Prof. Paper 424-D, 1961.*

(2) *M. A. Rogers, Personal communication September 1973.*

(3) *J. E. Herceg, "Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, Calendar Year 1972." Los Alamos document LA-5184 (March 1973)."*

In the fall of 1973 three 15.24 m (50 ft) deep holes in Pit 24 were also augered. As in Pit 7, samples of cuttings at 1.52 m (5 ft) intervals were taken and analyzed for moisture content (see Tables G-XV and G-XVI).

TABLE G-XVI

PERCENT MOISTURE BY WEIGHT
FROM AUGER HOLES
IN PIT 24, AREA G

Depth (feet)	Hole 1	Hole 2	Hole 3
0-5	0.9	2.4	0.1
5-10	1.1	2.3	1.9
10-15	0.8	4.2	0.2
15-20	1.0	0.6	0.3
20-25	0.3	0.5	0.5
25-30	0.3	0.5	0.3
30-35	0.5	0.1	0.3
35-40	0.6	0.3	0.5
40-45	3.2	0.3	1.3
45-52	3.4	0.6	1.2

Ref: 175

"*As yet* [there is no] *profile showing bottom elevations of Pits 7 and 24 for correlation purposes; however, drilling breaks were indicated at 15 to 17 ft in Pit 7 and at 19-24 ft in Pit 24 which are about the contacts of Unit 2b and Unit 2a. A second drilling break occurred ~50 ± 5 ft in both pits. The second contact is between Unit 2a and Unit 1b and is shown by a slight increase in moisture contents in Hole 1 (Pit 7), and Holes 1 and 3 (Pit. 24) indicating a change in the hydrologic characteristic of the two ashflow units.*

Test holes in Pits 7 and 24 were logged at 2-ft intervals with the neutron moisture sonde for background information. The moisture content of the tuff was below limits of the calibration curve which is ~5% moisture by volume. ....calculations indicate that in the low range of ~5 to 10% by volume the moisture will be redistributed by diffusion. Above 10% distribution would be by diffusion and capillary with some effect of gravity."[174]

The neutron moisture probe was run down the holes several months after they were augered and before plastic pipe was cemented into the top of the holes (see Fig. G-36). When the pits are filled with wastes, the pipe will serve as access tubes for the neutron moisture probe. In the first quarter of 1974

"Zia carpenters added wood shielding planks around the pipes embedded in the floors of Pits 7 and 24. The additional shielding should provide better protection for these pipes during pit filling operations."[123]

Pit 8 contains a number of 210 ℓ (55 gal) drums of sludge from H-7's waste treatment plants. While drums were being off-loaded January 5, 1973,[176] the lids from two drums came loose spilling sludge on the pit floor. Heavy plastic bags were placed over the drums; and one cubic yard of fill was placed on top of the spilled sludge.

"The original idea of shoveling the sludge back into another drum had to be shelved as the material was frozen solid to the ground.

TABLE G-XVII

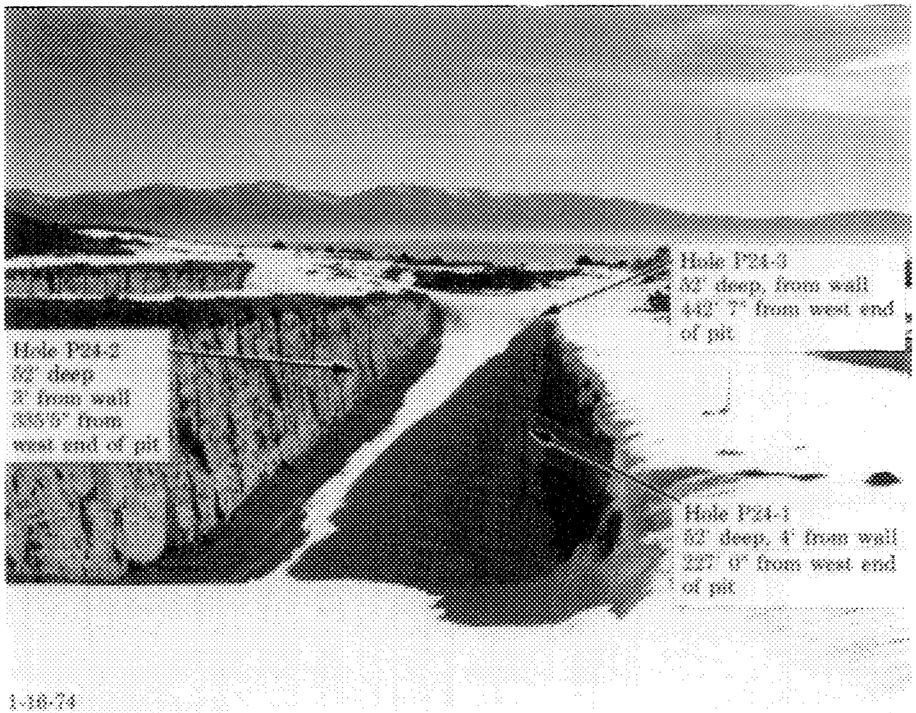
MOISTURE CONTENT OF CUTTINGS FROM TEST HOLES DRILLED IN JANUARY 1974, AREA G, PIT 8

Depth ft	Hole 1	Hole 2	Hole 3
0-5	8.7	8.5	8.2
5-10	9.3	9.8	7.1
10-15	8.6	8.2	8.1
15-20	7.5	4.1	8.1
20-25	6.0	4.0	5.2
25-30	2.8	1.9	2.5
30-35	2.5	1.6	2.2
35-40	3.4	2.4	2.3
40-45	3.6	3.5	3.1
45-50	3.9	3.9	3.7

Hole 1 North side of drums - East
Hole 2 North side of drums - West
Hole 3 South side of drums

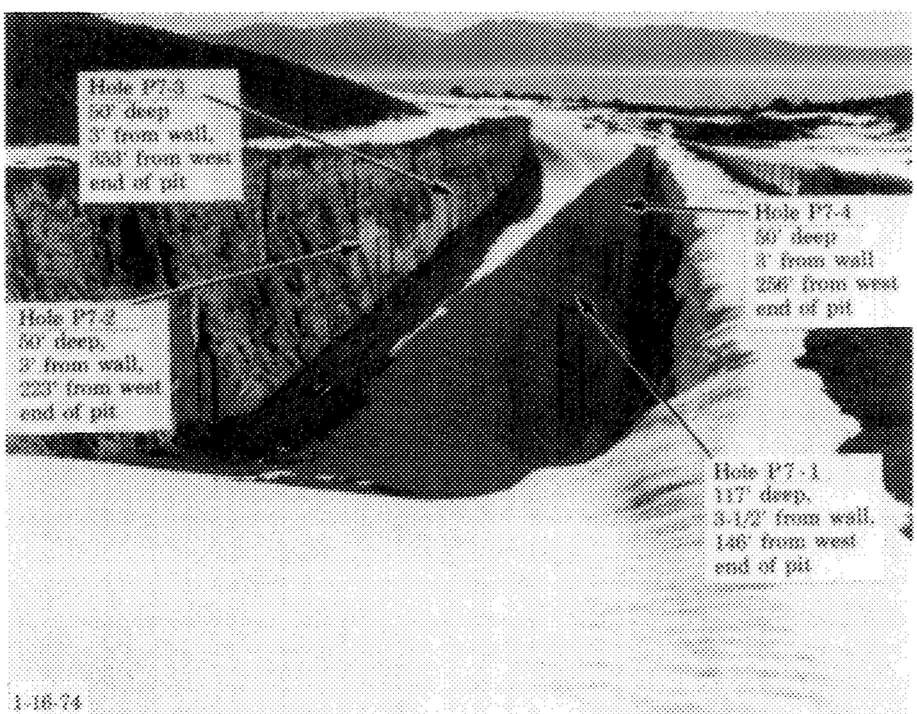
Ref: 174

Pit 24, Area G, Looking East



Moisture neutron probe access pipes in place

Pit 7, Area G, Looking East



Moisture neutron probe access pipes in place

Fig. G-36.
Access pipes in Pits 7 and 24, Area G, for monitoring moisture with the neutron moisture probe.

Apparently H-7 has been using second hand drums to hold sludge. [It is recommended] *that only new drums be used and that H-7 inspect each drum prior to loading onto the skip-type containers to assure that the lids are secured properly."*[176]

The drums in Pit 8 have had other problems. Damage during transport and damage as a result of palletizing promoted corrosion in some cases. (The Pit 8 drums were made part of a corrosion study.)

After the September 10-11, 1973 rains a sample of the ponded water in Pit 8 was taken for plutonium analysis. The results were negative. Because the drums were known to be leaking, it was felt the situation offered an excellent opportunity to study migration of transuranics in the tuff and fill material. H-8 made a request[177] for monitoring in Pit 8, Area G, on January 7, 1974.

"The following procedures are recommended for monitoring the movement of soil moisture and radionuclides within and out of Pit No. 8.

1. Placement of access holes for moisture measurement with neutron thermalization probe. Three 10-meter boreholes will be augered in the bottom of the pit, two on the north end and one on the south, located within a meter of the present stack of drums. Five-centimeter plastic casing will be cemented into the upper one meter of the bore-holes, and extended above the surface of the filled pit.

2. Placement of access tubes for installation of soil moisture cells. Five-centimeter plastic casing will be located at four positions around the perimeter of the drum stack and extended above the surface of the filled pit. These casings will be used for locating electronic soil-moisture-sensing cells after the pit is filled. The cells are not expected to be on hand at the time the pit is filled. After the cells have been placed, the casings will be pulled back at least a meter, and used for moisture monitoring with a neutron probe.

3. Placement of access tubes for coring the tuff. Four to six steel pipes will be located around the perimeter of the stack, and if possible in the interior of the stack. These pipes will be set a few centimeters into the tuff to secure the bottoms and extended above the surface of the filled pit. They will permit core sampling of the tuff after the pit has been filled, and ensure that no waste containers are encountered during the sampling. Three of the pipes will be located within a meter of the moisture access tubes.

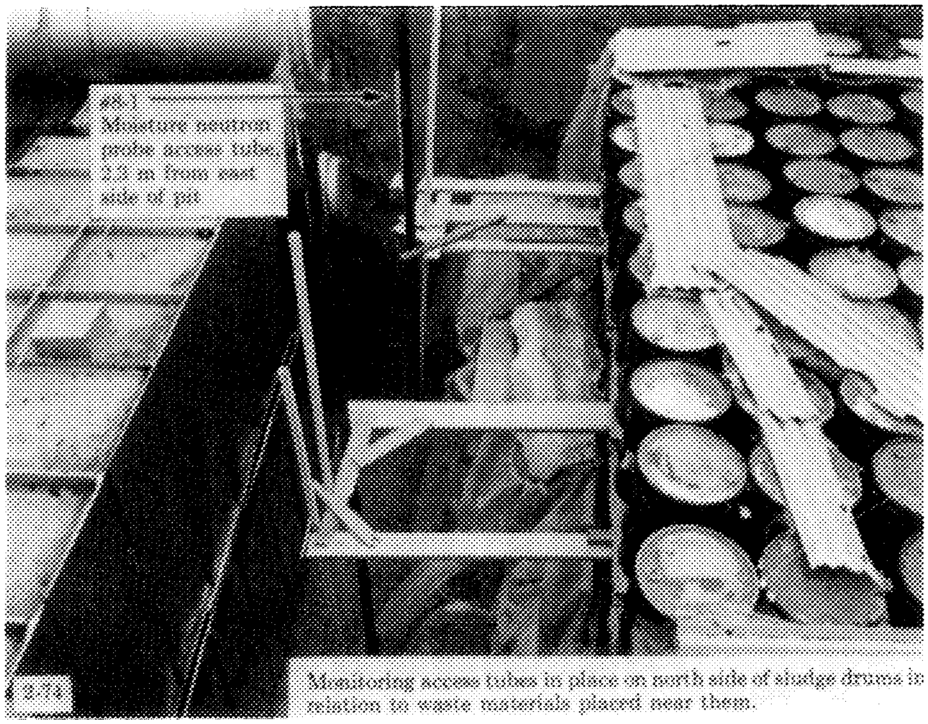
4. Placement of access tubes for sampling fill material. Four to six plastic casings will be located around the perimeter of the drum stack, with the bottoms of the casings about one meter above the bottom of the drum stack. These casings will permit sampling of the fill material adjacent to the drums, and ensure that no waste containers are encountered during the sampling."[177]

At the end of February 1974 all access holes for moisture measurement had been augered around the drums. All access tubes for coring the tuff, all access tubes for sampling the fill material and all access tubes for the installation of soil moisture cells had been placed around the drums.

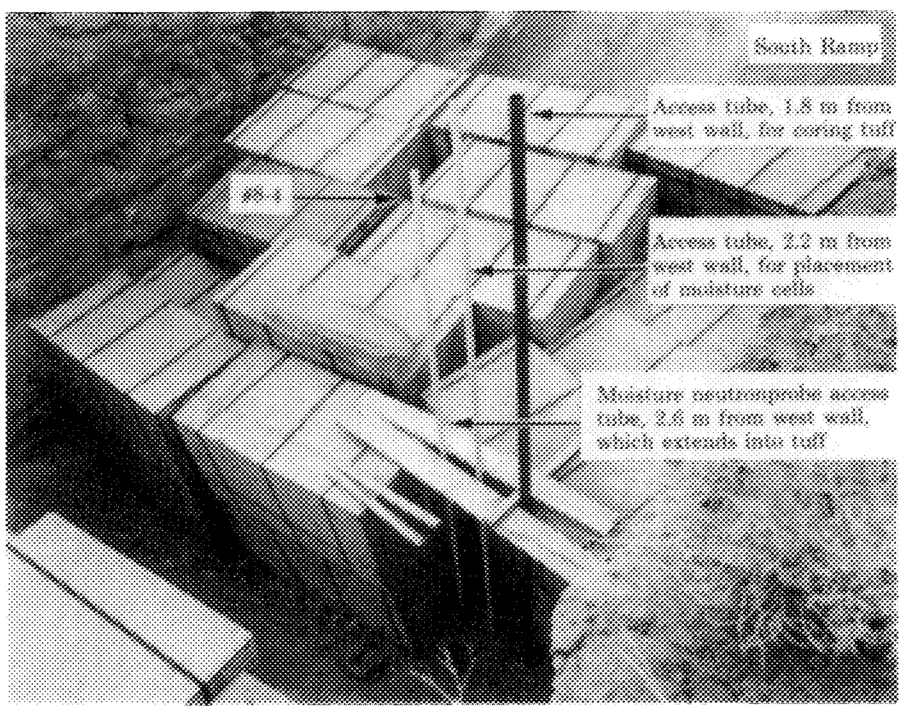
January 14, 1974, a plan was proposed[178] for the disposal by burial of the leaking drums of ^{238}Pu contaminated sludge. At the end of February when the monitoring network was set up, other types of waste were placed around the drums (see Fig. G-37). Pit 8 received its final cover of dirt March 27, 1974. When the pit was back-filled with crushed tuff there was disturbance of the monitoring pipe. Figure G-38 shows the monitoring network as it exists.

The moisture content of samples taken during the augering of holes in Pit 8 for the moisture neutron probe was reported[174] on February 7, 1974.

Pit 8, Area G, Looking East



Pit 8, Area G



Monitoring access tubes 3.4 m south of sludge drums

Fig. G-37.
Access tubes for monitoring in Pit 8, area G.

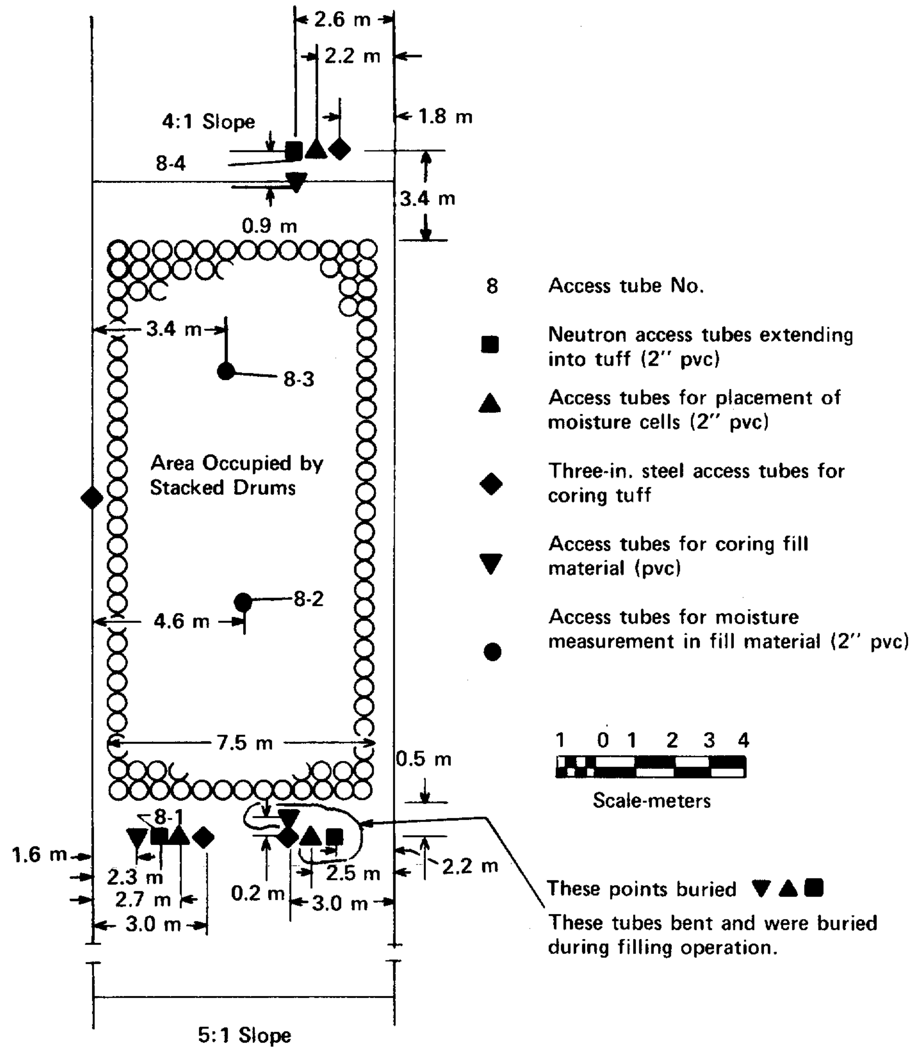


Fig. G-38.
Monitoring system, Pit 8, Area G.

"The increase in moisture content of the tuff as the result of water ponding in a pit left open over a period of years is shown in the data from the holes drilled in Pit 8 in January 1974. Pit 8 was constructed in the summer of 1971. Background data (Memo H8-M2371 attached)[172] *indicated that the moisture content of cutting from Hole 8A drilled in August 1971 ranged from 0.2 to 1.4% by weight. The moisture content of the tuff in cuttings from the three holes drilled in January 1974 ranged from 1.6 to 9.8% by weight."*[174] (see Table G-XVII).

The monitoring in the ^{238}Pu Retrievable Storage complex was described[179] December 6, 1974.

"Several types of monitoring have been installed within the storage complex to monitor the moisture and temperature regime surrounding the casks, and to determine the composition and pressures of any generated gas.

....Corrugated metal "Q-Decking" was placed over the casks, forming a small air-space as shown in [Fig. G-39]. *The air-spaces over the various cells are independent of each other. Perforated plastic pipe was inserted into the air-space at each end of the cell, permitting sampling of the atmosphere over the casks. The pipes are capped when not being used for sampling.*

Moisture sensor (Soil Test Model MC-301A) and copper-constantan thermocouples were located underneath several casks prior to their placement in the trenches. The moisture sensors can measure both soil moisture levels and temperature. Additional thermocouples have been placed inside the waste drums, and inside the casks taped to the outside of the drums. These various thermocouples will be used to define the temperature regime of the storage complex.

Sample tubes lead from the surface to the inside of selected drums, and to the inside of the casks, outside the drums. The tubes connected to the drums are equipped with pressure gages; all tubes can be used to sample the environment inside the cask or drum. Neutron moisture probe access pipes have been installed at several locations in the trenches. These pipes uniformly end on top of the tuff in the bottom of the trench. The pipe will be used for monitoring soil moisture conditions in the fill overlying and surrounding the casks.

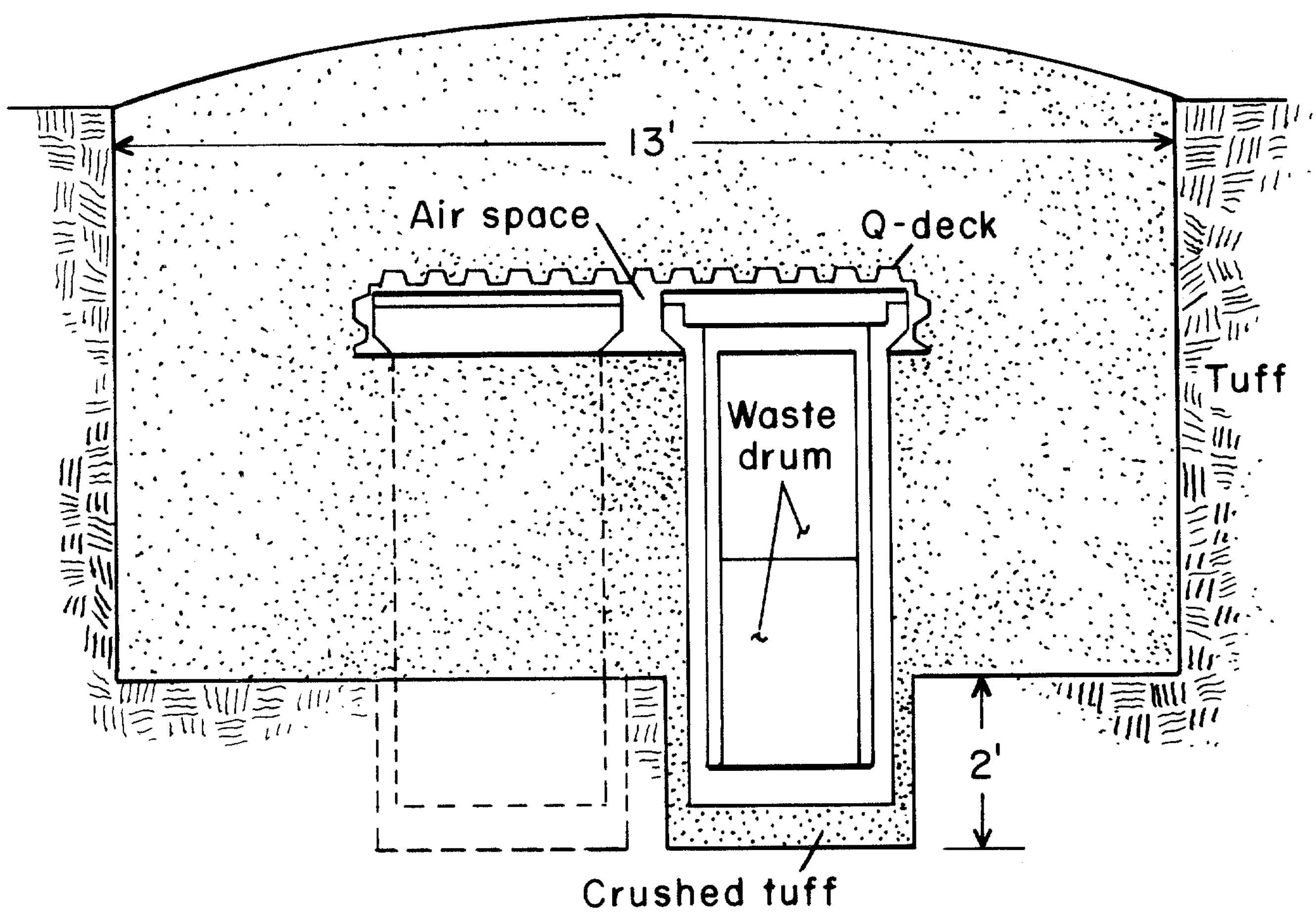


Fig. G-39.
Cross section of trench with casks in place, Area G.

[Table G-XVIII] *presents a summary of the monitoring in Trench A and B.... The composition of the waste contained in monitored drums and casks is given in* [Table G-XIX]. *A cross-section of the storage complex is shown in* [Fig. G-39], *and the location of the various monitoring equipment is shown in* [Fig. G-40.]"[179]

Ten drums of ^{238}Pu-contaminated hydrogenous waste in interim storage are instrumented for monitoring temperatures each month and withdrawing gas samples at 1-, 3-, 6- and 12-month intervals, and semiannually thereafter. Some of these samples will be tested for explosivity.[293]

Selected data from the ongoing monitoring of ^{238}Pu-contaminated hydrogenous waste stored in Trenches A and B follows..."*Drums 223 and 232, which have been emplaced for 1.7 yr, apparently are losing H_2 more rapidly than it is being generated. Drum 301, which contained an explosible gas mixture after 36 d but not after 64, now shows a significant increase in mol percentage of H_2, but the O_2 content apparently is all combined as CO and CO_2. Of the latest two drums instrumented, radiolytic gas generation is significant in Drum 330 after 23 d. Drum 260 ... currently has an internal temperature of 44.5°C, with the ambient air temperature 23°C and the soil 19°C. The gas sample withdrawn from this drum shows no evidence of H_2 formation from radiolysis. The 20.2 g of ^{238}Pu contaminant is apparently concentrated in a small volume near the thermocouple, but not in contact with hydrogenous matrix....*"[294] No stored drum has pressurized because their seals are not gas tight. Gases diffuse through the drum seals and walls of the concrete casks that surround the drums.[293]

Between April 2 and June 6, 1976, five horizontal and one vertical boreholes were drilled at Area G, TA-54. These holes were drilled with air and continuously cored from a platform cut into the rock bottom of the draw adjacent to Pit 3. The horizontal holes, MH-1, MH-2, MH-3, MH-4, and MH-5, beneath Pit 3 were drilled into a cut face of the mesa wall. The vertical hole, VH-6, was drilled into the drilling platform (see Fig. G-41 and Table G-XX).

The vertical borehole was drilled to enhance knowledge of the stratigraphy beneath Mesita del Buey at TA-54. The hole passed through 48.8 m (160 ft) of tuff, Tshirege Member and probably Otowi Member of the Bandelier Tuff, before encountering the Chino Mesa basalts.

The purpose of the horizontal holes is to determine the extent, if any, of radionuclide and moisture migration beneath Pit 3.

In late July 1976, preparation of the site on Pit 6 for the installation of the meteorological tower began.[286] The steel tower is 12.2 m (40 ft) high...."*Initial instrumentation will include three Gill U.V.-component anemometers and three temperature thermisters, both positioned at 1-, 3-, and 10-m heights on the tower; a dew cell, a weighing bucket rain gauge, and IR thermometer, and several soil heat-flow disks. These instruments will measure, respectively, windspeed, temperature, humidity, precipitation, surface temperature, and heat transfer in the soil. The tower will be operated in two modes. First, routine surveillance of wind-direction and velocity will assist in the tracking of any accidental atmospheric release during burial site operations. That data will not be archived. Secondly, intensive research studies will be performed to model atmospheric dispersion processes, soil moisture flux, and evaporation of precipitation. These studies will add to the understanding of possible processes resulting in radionuclide migration at the disposal site.*"[295] The tower construction is not complete (January 1977).

There were three fires at Area G. The first, September 16, 1960 was in Pit 1; the second, November 21, 1964 was in Pit 3. Both of these fires were reported by a Security Guard. The third fire occurred April 14, 1976 in Pit 24.

The Fire Department hosed down smoldering debris in Pit 1. "*Fire had apparently started during the noon hour and had burned most of the exposed waste prior to discovery.*"[180]

The fire in Pit 3 was reported about 5:30 p.m.[181,182] It was located in boxed trash at the north end of the pit on the east side. An area about 7.71 m (25 ft) wide and 30.5 m (100 ft) long was burned. The wind, at the time of the fire, was estimated to be about 5 mph from the west.[181]

"The smoke from the fire crossed the road along the east edge of the pit and passed on down the mesa. A survey of the roadway and the perimeter fence that was in the smoke path indicated alpha activity from 1500 to 2000 c/m. An attempt to monitor the area outside the fence will be made on 11/24. The north approach to Pit 3 was also highly contaminated (2000 to 20 000 c/m)."[181]

"The smoke from the fire traveled slowly east of Pit #3 and a monitoring survey of this area indicated radioactive contamination out as far as about 450 feet from the area fence. This is only the second time, after a fire in a contaminated dump, that radioactive contamination has been detected outside of the area fence."[182]

The fire was put out at 9:45 p.m.[181]

"An inspection of the burned area was made on 11/22/64... in an effort to determine the probable cause of the fire. Some charred metal turnings were observed as well as two 5-gallon glass jars. Reactive metal turnings could have started it and the glass jars could also have focused the sun's rays onto paper and started the fire. Actually we still don't know how it was caused. Burning embers from the fire in Pit #4 also should not be ruled out as a possible source. An inspection of the Dump Run Log book shows that Dempster Dumpsters from DP West, CMR Bldg., TA-46, TA-48, and Shops Bldg. were emptied before the fire started."[181]

"Pit 4 was completed during the summer and was used to receive scrap material from TA-1. A trench, dug along the south floor of the pit, was used for burning combustible scrap. Air samples taken during burning operations, were all negative which would indicate that the smoke generated did not contain measurable amounts of radioactive material."[182]

"On 4/14/76 a small fire of unknown origin occurred during a routine waste covering operation in pit 24. A flame several feet high was seen for a few seconds and just as quickly disappeared. No contamination was detectable in the surrounding area, on equipment or personnel."[286]

TABLE G-XVIII

DESCRIPTION OF MONITORING IN ^{238}Pu RETRIEVABLE STORAGE COMPLEX[a]

Sensor	Designation	Array No.	Proximate to Tag	Proximate to Cask	Function
Moisture Cells	M-1	A-1	857	2	
	M-2	A-1	858	1	
	M-3	B-5	859	81	Measures soil moisture and temperature beneath casks
	M-4	B-4	928	61	
	M-5	B-3	1926	41	
	M-6	B-2	1954	21	
Cu-Con	T-1	A-1	857		Measures temperature inside Drum 215
Thermocouples	T-2	A-2	858		Measures temperature inside Drum 218
	T-3	A-5	859		Measures temperature inside Drum 192
	T-4	B-4	928	61	
	T-5	B-3	1926	41	Measures temperature beneath casks
	T-6	B-2	1954	21	
	T-7	B-1	b	1	
	T-8	A-1	871	3	Measures temperature inside Drum 224
	T-9	A-1	871	3	Measures temperature inside cask, outside drums[c]
	T-10	A-1	870	4	Measures temperature inside Drum 223
	T-11	A-1	870	4	Measures temperature inside cask, outside drums[c]
	T-12	A-1	869	5	Measures temperature inside Drum 232
	T-13	A-1	869	5	Measures temperature inside cask, outside drums[c]
	T-14	A-1	868	6	Measures temperature inside Drum 233
	T-15	A-1	868	6	Measures temperatures inside cask, outside drums[c]
	T-16	B-5	885	86	Measures temperature inside Drum 255
	T-17	B-5	885	86	Measures temperature inside cask, outside Drum 255
	T-18	B-5	886	85	Measures temperature inside Drum 260
	T-19	B-5	886	85	Measures temperature inside cask, outside Drum 260
	T-20	B-4	986	80	Measures temperature inside cask, outside Drum 281
	T-21	B-5	985	82	Measures temperature inside cask, outside Drum 301
	T-22	B-3	1926	41	Measures temperature inside Drum 323
	T-23	B-3	1926	41	Measures temperature inside cask, outside Drum 323
	T-24	B-2	1927	40	Measures temperature inside Drum 330
	T-25	B-2	1927	40	Measures temperature inside cask, outside Drum 330
Gas Sampling	G-1	A-1	871	3	Samples gas inside Drum 224
Tubes	G-2	A-1	871	3	Samples gas inside cask, outside drums
	G-3	A-1	870	4	Samples gas inside Drum 223
	G-4	A-1	870	4	Samples gas inside cask, outside drums
	G-5	A-1	869	5	Samples gas inside Drum 232
	G-6	A-1	869	5	Samples gas inside cask, outside drums
	G-7	A-1	868	6	Samples gas inside Drum 233
	G-8	A-1	868	6	Samples gas inside cask, outside drums
	G-9,G-10	A-1			
	G-11,G-12	A-2			
	G-13,G-14	A-3			Samples gas in air space above cells
	G-15,G-16	A-4			
	G-17,G-18	A-5			
	G-19,G-20	A-6			
	G-21	B-5	885	86	Samples gas inside Drum 255
	G-22	B-5	885	86	Samples gas outside drums, inside Cask 86
	G-23	B-5	886	85	Samples gas inside Drum 260
	G-24	B-5	886	85	Samples gas outside drums, inside Cask 85
	G-25	B-4	986	80	Samples gas inside Drum 281
	G-26	B-5	985	82	Samples gas inside Drum 301
	G-27	B-3	1926	41	Samples gas inside Drum 323
	G-28	B-3	1926	41	Samples gas outside drums, inside Cask 41
	G-29	B-2	1927	40	Samples gas inside Drum 330
	G-30	B-2	1927	40	Samples gas outside drums, inside Cask 40
Neutron	N-1	A-1			
Access	N-2	B-4,B-5			
Pipes	N-3	B-3,B-4			
	N-4	B-2,B-3			
	N-5	B-1,B-2			

[a]This table compiled from information in Reference 179 and from personal communication with A. Zerwekh, CMB-1, 1977.

[b]No tag number because this cask is unfilled as of the date of this report.

[c]TC [thermocouple] fastened to outside of drum, midway on side.

TABLE G-XIX

WASTE COMPOSITION IN MONITORED DRUMS IN ^{238}Pu RETRIEVABLE STORAGE COMPLEX[a]

I.D. Tag No.	Drum No.	^{238}Pu[b] g	Average Concentration mCi/g	Waste Description	Monitoring
857	215[c]	10.7	19.6	Oxide trash	Temperature, moisture
	219	34.7	36.8	Oxide trash	
858	182[c]	3.0	1.2	Metal	Temperature, moisture
	218	22.9	36.6	Combustibles	
859	192[c]	31.7	46.7	Combustibles	Temperature, moisture
	220	38.6	62.7	Oxide trash	
868	233[c]	17.0	20.4	Trash	Temperature, gas
	225	2.4	2.9	CWS filter	
869	232[c]	29.4	50.2	Combination	Temperature, gas
	227	6.7	7.2	CWS filter	
870	223[c]	14.9	14.8	Combustibles	Temperature, gas
	221	0.4	0.5	Trash	
871	224[c]	22.1	26.5	Combustibles	Temperature, gas
	228	4.3	4.9	CWS filter	
885	255	19.9	13.9	CWS filters Oxide trash	Temperature, gas
886	260	20.2	20.8	Oxide trash	Temperature, gas
986	281	19.7	25.3	Mixed combustibles	Temperature, gas
985	301	18.7	31.9	Mixed combustibles	Temperature, gas
1926	323	16.7	14.3	Plastic vials & mounts	Temperature, gas
1927	330	17.4	22.4	Mixed combustibles	Temperature, gas

[a] This table compiled from information in Reference 179 and from personal communication with A. Zerwekh, CMB-1, 1977.

[b] One gram ^{238}Pu generates approximately 0.5 watt of heat.

[c] Drum containing monitoring.

TABLE G-XX

BORE HOLES NEAR PIT 3, AREA G, TA-54

Hole Number	Dates Drilled	Depth*	Core Recovered*	% Recovery	Elevation of Hole at Collar*	Elevation of Hole at Western End*	Elevation of Bottom Pit 3*
MH-1	April 7-13, 1976	287.0 ft	161.8 ft(tuff)	56.3	6626.1 ft	6608.8 ft	6632.5 ft
MH-2	April 14-19, 1976	272.0 ft	201.4 ft(tuff)	74.0	6626.6 ft	6624.6 ft	6632.3 ft
MH-3	April 29- May 5, 1976	280.0 ft	166.8 ft(tuff)	59.6	6626.4 ft	6621.3 ft	6631.5 ft
MH-4	May 6-12, 1976	304.0 ft	156.3 ft(tuff)	51.4	6626.6 ft	6615.2 ft	6630.5 ft
MH-5	May 13-25, 1976	240.0 ft	179.4 ft(tuff)	74.8	6626.9 ft	6629.5 ft	6631.2 ft
VH-6 (MH-6)	May 26-28, 1976	169.0 ft	3.5 ft(basalt)	2.1	**	**	**

* To convert feet to meters multiply by 0.3048.

** Not applicable.

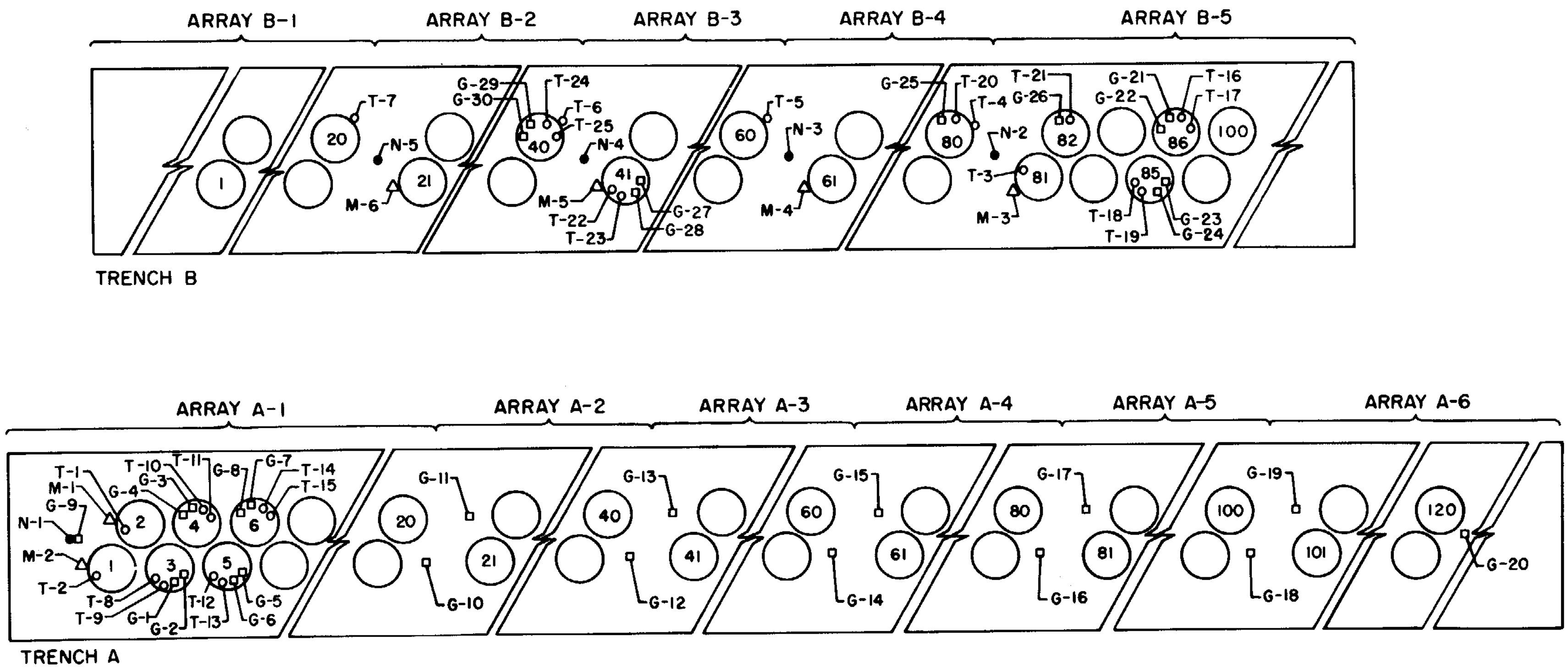


Fig. G-40.
Location of monitoring points within trench storage complex, Area G.

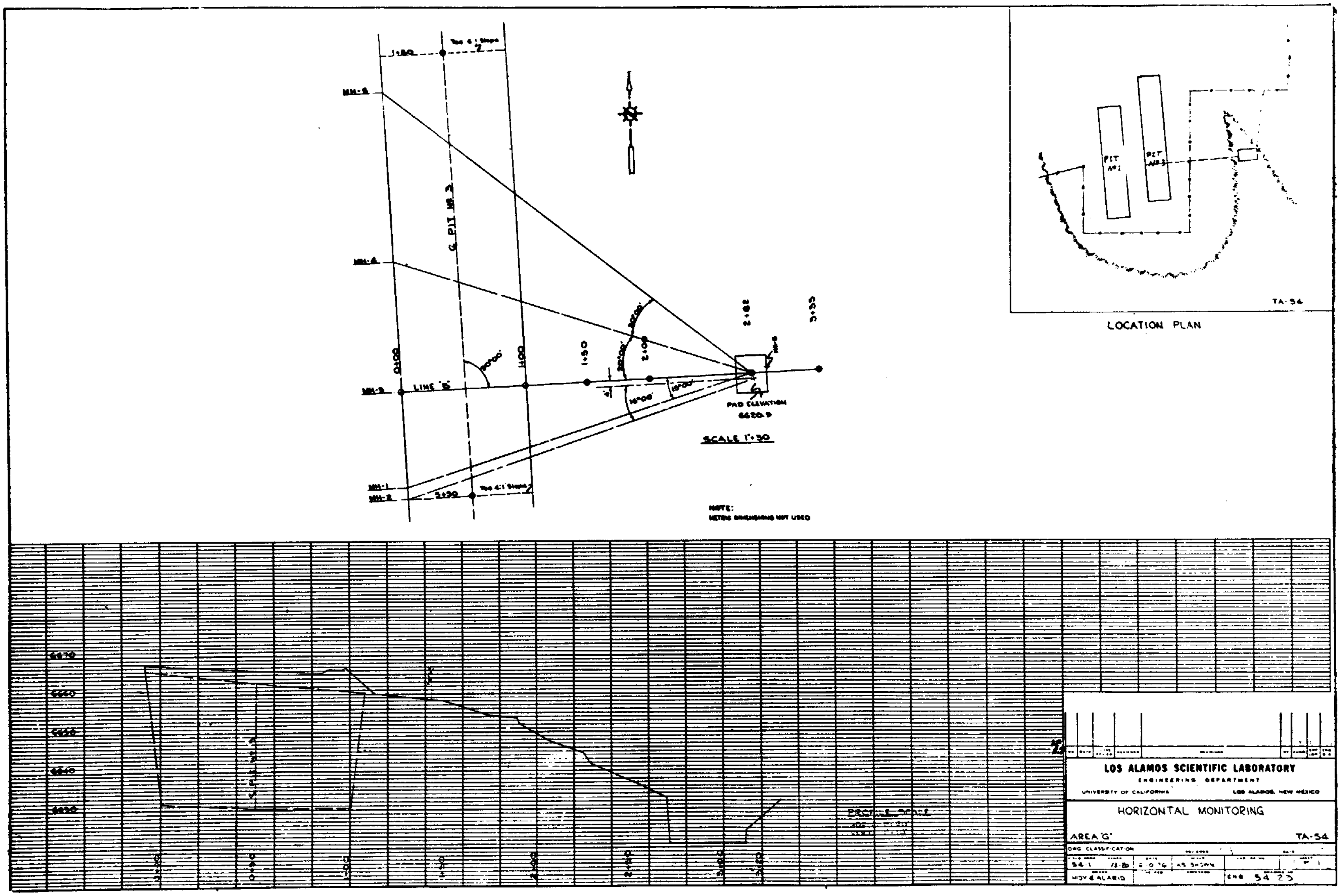


Fig. G-41.
Location of Horizontal Holes beneath Pit 3, Area G.

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141. Los Alamos Scientific Laboratory internal memo from John Enders, H-7 through John Warren, H-7 to Margaret Anne Rogers, H-8. Subject: Additional Information Concerning Disposal Shafts and Pits at Area G, TA-54. Date: March 4, 1976, 2 p. Symbol: H7-SW-120.

142. Los Alamos Scientific Laboratory internal memo from J. L. Warren, H-8 via LaMar Johnson, H-8 to Distribution. Subject: Proposal for a Retrievable Transuranic Solid Waste Storage Facility at LASL. Date: January 25, 1974, 5 p., 3 figs. Symbol: H8-WM-101.

143. Los Alamos Scientific Laboratory internal memo from John Warren, H-8 to Distribution. Subject: Special Pit Usage at Area G, TA-54. Date: March 24, 1975, 2 p. Symbol: H8-WM-435.

144. Los Alamos Scientific Laboratory internal memo from Linda Trocki, H-8 to Margaret Anne Rogers, H-8. Subject: Photographs of Pit 20, TA-54 with Geologic Explanations. Date: January 8, 1976, 7 p. Symbol: H8-7-76.

145. Los Alamos Scientific Laboratory internal memo from Dean D. Meyer, H-1 Group Leader to S. E. Russo, ENG-3 Group Leader. Subject: Disposal Wells for Contaminated Waste. Date: 5-5-65, 1 p.

146. Los Alamos Scientific Laboratory internal memo from John Enders, H-1 to Dean Meyer, Group Leader, H-1. Subject: Solid Radioactive Waste Disposal for the Second Quarter. Date: 8-3-61, 2 p.

147. Los Alamos Scientific Laboratory internal memo from John Enders, H-1 to Dean Meyer, Group Leader, H-1. Subject: 1965 Annual Report on Disposal of Solid Radioactive Waste. Date: 1-27-66, 8 p.

148. Los Alamos Scientific Laboratory internal memo from Gerald Eagan, H-1 to John Enders, H-1 Section Leader. Subject: Cement Capping of Disposal Wells. Date: October 2, 1968, 1 p. Symbol: H-1-CMR.

149. Los Alamos Scientific Laboratory Internal memo from Gerald Eagan, H-1 to John Enders, H-1 Section Leader. Subject: Cement Capping of Disposal Wells at Area "G". Date: March 27, 1968, 1 p. Symbol: H-1-CMR.

150. Los Alamos Scientific Laboratory internal memo from C. O. Martinez, H-1 to John Enders, H-1 Section Leader. Subject: Cement Capping of Disposal Wells. Date: 4-11-69, 1 p.

151. Los Alamos Scientific Laboratory internal memo from John Enders, H-1 to Dean Meyer, Group Leader, H-1. Subject: 1966 Annual Report on Disposal of Solid Radioactive Waste. Date:1-13-67, 5 p.

152. Los Alamos Scientific Laboratory internal memo from Dean Meyer, H-1 Group Leader to Charles Reynolds, ENG-4 Group Leader. Subject: Radioactive Waste Disposal Wells — Area G, Mesita del Buey. Date: 5-10-66, 1 p.

153. Zia Company Record of TA-54 Holes, 1 p.

154. Los Alamos Scientific Laboratory internal memo from John Enders, CMR Building Monitoring Section, H-1 to Dean Meyer, Group Leader, H-1. Subject: Solid Radioactive Waste Disposal Report for the Third Quarter of 1970. Date: 11-11-70, 4 p.

155. Los Alamos Scientific Laboratory internal memo from J. Enders, H-8 to C. O. Martinez, H-8. Subject: Numbering of New Disposal Shafts. Date: May 28, 1974, 1 p.

156. Los Alamos Scientific Laboratory internal memo from John Enders, Leader, CMR Building Monitoring Section, H-1 to Dean Meyer, Group Leader, H-1. Subject: Quarterly Report on Solid Radioactive Waste Disposal for the First Quarter of 1972. Date: 4-24-72, 3 p.

157. Los Alamos Scientific Laboratory internal memo from John Enders, H-8 to LaMar Johnson, H-8 Group Leader. Subject: Solid Radioactive Waste Disposal Report for the First Quarter of 1973. Date: April 10, 1973, 7 p.

158. Los Alamos Scientific Laboratory internal memo from M. Wheeler, H-8 to File. Subject: Summary of Fracture Data on Disposal Shafts 52-69, TA-54, Area G. Date: March 9, 1976. Symbol: H8-WM-577.

159. W. D. Purtymun and E. John, "Site for a Municipal Supply Well in Pajarito Canyon near Los Alamos, New Mexico," U.S. Geol. Survey administrative release (1964).

160. J. G. Abrahams, Jr., "Physical Properties of and Movement of Water in the Bandelier Tuff, Los Alamos, and Santa Fe Counties, New Mexico," prepared in cooperation with the Atomic Energy Commission and the Los Alamos Scientific Laboratory. U.S. Geol. Survey unpublished report (1963).

161. Los Alamos Scientific Laboratory internal memo from John L. Warren, H-8 via LaMar J. Johnson, H-8 to C. Daggett, ENG-4. Subject: Road Improvements to and at Area G, TA-54. Date: March 4, 1974. 1 p. Symbol: H8-WM-134., 1 map.

162. Los Alamos Scientific Laboratory internal memo from W. Hanson, Ecology H-8 to J. Herceg and J. Mohrbacher, Solid Waste Management H-8. Subject: Pit 7, Radioactive Waste Disposal Area G, TA-54. Date: August 21, 1973, 2 p. Symbol: H8-73-169.

163. Los Alamos Scientific Laboratory internal memo from Dean D. Meyer, Group Leader, H-1 to Charles A. Reynolds, Group Leader, ENG-4. Subject: Stabilizing Waste Disposal Area, TA-54. Date: February 9, 1972, 1 p. Symbol: H-1-72-24.

164. Los Alamos Scientific Laboratory internal memo from John Warren, H-8 to Wayne Hanson, H-8, Jack Nyhan, H-8, and J. A. Mohrbacher, H-8. Subject: Erosion Control and Soil Fixation at Area G, TA-54. Date: March 28, 1974, 1 p., 1 fig. Symbol: H8-WM-151.

165. Los Alamos Scientific Laboratory internal memo from Wayne Hanson, H-8 via LaMar Johnson, Keith Schiager, H-8 to John Warren, H-8. Subject: Revegetation and Rehabilitation of Area G, TA-54. Date: June 4, 1974, 1 p. Symbol: H8-74-203.

166. M. A. Rogers, S. Barr, W. D. Purtymun, and L. Trocki, "Ponding in Open Pits at Area G After the September 10-11, 1973 Rains," unpublished report. 12 p., 5 figs., 2 tables, 81 photographs (1973).

167. Los Alamos Scientific Laboratory internal memo from M. L. Wheeler, H-8 to Margaret Anne Rogers, H-8. Subject: Dating of Root Samples from Pit #7, Area G. Date: October 23, 1973, 1 p. Symbol: H8-73-242.

168. Jacques Renault, Geologist, New Mexico Bureau of Mines and Mineral Resources, "Report on the Examination of Fracture Fillings on Disposal Pits No. 7 and No. 24, Los Alamos Scientific Laboratories," (December 3, 1973), 3 p.

169. Los Alamos Scientific Laboratory internal memo from Wm. D. Purtymun, H-6 to Dean D. Meyer, Group Leader, H-1. Subject: Migration of Tritium in Shaft Disposal Area TA-54, Area "G". Date: July 7, 1970, 2 p., 1 table, 1 map.

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172. Los Alamos Scientific Laboratory internal memo from Harry S. Jordan, Group Leader, H-8 to Dean Meyer, Group Leader, H-1. Subject: Tritium and Radiochemical Analyses, Pits 8, 12, 16, 17 and 21, TA-54. Date: December 2, 1971, 2 p., 2 tables, 1 map. Symbol: H8-M2371.

173. Los Alamos Scientific Laboratory internal memo from M. Wheeler, H-8 to J. Mohrbacher, H-8. Subject: Moisture and Tritium Concentrations in Fill Material, Area G, TA-54. Date: February 13, 1974, 3 p., 2 tables, 1 map. Symbol: H8-WM-112.

174. Los Alamos Scientific Laboratory internal memo from William D. Purtymun, H-8 to Merlin Wheeler, H-8. Subject: Moisture Contents of Cuttings from Auger Holes in Pits 7, 8 and 24, Area G. Date: February 7, 1974, 2 p., 1 fig., 2 attachments. Symbol: H8-74-M64.

175. Los Alamos Scientific Laboratory internal memo from Bill Purtymun and Linda Trocki, H-8 to Margaret Anne Rogers, H-8. Subject: Percent Moisture by Weight from Auger Holes in Pit #7, Area G. Date: December 12, 1973, 1 p. Symbol: H8-73-M296.

176. Los Alamos Scientific Laboratory internal memo from John Enders, Leader, CMR Building Monitoring Section, H-1 to Dean Meyer, Group Leader, H-1. Subject: Report of Spilled Sludge at Pit #8, TA-54. Date: 1-7-72, 1 p.

177. Los Alamos Scientific Laboratory internal memo from M. Wheeler, K. Schiager, W. Purtymun, H-8 to J. A. Mohrbacher, H-8. Subject: Request for Monitoring in Pit No. 8, Area G. Date: 1-7-74, 2 p. Symbol: H-8-WM-90., 1 map.

178. Los Alamos Scientific Laboratory internal memo from J. Warren, H-8 to LaMar Johnson, H-8. Subject: Plan for Disposal by Burial of ^{238}Pu Contaminated Sludge in the Leaky Drums in Pit #8. Date: 1-14-74, 2 p. Symbol: H-8-WM-97.

179. Los Alamos Scientific Laboratory internal memo from M. Wheeler, H-8 to Distribution. Subject: Monitoring in ^{238}Pu Retrievable Storage Complex. Date: December 6, 1974, 2 p., 2 figs., 2 tables. Symbol: H8-WM-352.

180. Los Alamos Scientific Laboratory internal memo from John Enders, H-8 through LaMar Johnson, Group Leader, H-8 to Roy Reider, Group Leader, H-3. Subject: Fires Involving Solid Radioactive Waste. Date: 8-30-73, 2 p.

181. Los Alamos Scientific Laboratory internal memo from John Enders, H-1 to Dean Meyer, Group Leader, H-1. Subject: Report on Fire at Pit #3, Area G. (Mesita del Buey). Date: 11-24-64, 2 p., 3 maps.

182. Los Alamos Scientific Laboratory internal memo from John Enders, H-1 to Dean Meyer, Group Leader, H-1. Subject: 1964 Annual Report on Disposal of Solid Radioactive Waste. Date: 1-14-65.

183. W. D. Purtymun, "Materials Waste Pit, Area A, TA-21 — Excavated April 1969," U.S. Geol. Survey letter report (1969).

184. Los Alamos Scientific Laboratory internal memo from David Dow to Colonel G. R. Tyler. Subject: New Disposal Pit for CM Division. Date: July 5, 1945, 1 p.

185. Los Alamos Scientific Laboratory internal memo from Dean D. Meyer, Group Leader, H-1 to C. W. Christenson, Group Leader, H-7. Subject: Volume of Transuranium Wastes Buried at Los Alamos. Date: 1-4-71, 2 p.

186. Los Alamos Scientific Laboratory internal memo from Geo. L. Voelz, M.D., Health Division Leader to E. E. Wingfield, Chief, Operations Br., AEC-LAAO. Subject: Waste Storage Tanks. Date: 10-30-73, 1 p.

187. Los Alamos Scientific Laboratory internal memo from J. R. Buchholz, H-7, T. K. Keenan, H-7 Group Leader, P. E. McGinnis, H-7 to Margaret Anne Rogers, H-8. Subject: Activities at Area T, TA-21 During 1975. Date: February 3, 1976, 2 p. Symbol: H7-76-PEM-86.

188. Los Alamos Scientific Laboratory internal memo from Dean Meyer, CMR-12 to Jack Cully, ENG-4. Subject: Disposal of Solid Contaminated Materials at Los Alamos. Date: June 14, 1949, 2 p.

189. Los Alamos Scientific Laboratory internal memo signed by John Bolton, Assistant Director for Engineering to Carroll L. Tyler, Manager, SFO, USAEC. Subject: Location of Classified and Contaminated Dumps in Los Alamos Area. Date: January 30, 1952, 1 p.

190. Los Alamos Scientific Laboratory internal memo from W. B. Gibson, CMB-11 to W. J. Maraman, CMB-11. Subject: General's Tanks — Memo from Dean D. Meyer, December 3, 1971. Date: 12-6-71, 1 p.

191. Los Alamos Scientific Laboratory internal memo from P. E. McGinnis, H-7 through L. A. Emelity, H-7 Alt. Group Leader and J. R. Buchholz, H-7 to Margaret Anne Rogers, H-8. Subject: General's Tanks Waste. Date: March 12, 1976, 2 p. Symbol: H7-76-PEM-162.

192. Los Alamos Scientific Laboratory internal memo from J. L. Desilets, ENG-2 to C. A. Reynolds, ENG-4 Group Leader. Subject: Materials Disposal Area "A", DP West. Date: November 9, 1972, 1 p.

193. Letter from Thomas K. Keenan, H-7 Group Leader, Waste Mgmt., Los Alamos Scientific Laboratory to Delacroix Davis, Jr., Director, Nuclear Matls. & Waste Mgmt. Div., Albuquerque Operations Office. Date: January 9, 1976, 4 p.

194. Los Alamos Scientific Laboratory internal memo from Wilbur Workman, H-1 Section Leader, DP Site to Dean D. Meyer, Group Leader, H-1. Subject: Use of Radioactive Waste Pit at TA-21. Date: 6-30-72, 1 p.

195. Los Alamos Scientific Laboratory internal memo from M. Wheeler to file. Subject: Test Borings at Area A, TA-21. Date: June 21, 1976. Symbol: H8-WS-610, 3p.

196. Los Alamos Scientific Laboratory internal memo from Engineering Department to L.J. File 1757; Materials Disposal Areas, Q. Date: April 9, 1965, 1 p.

197. Los Alamos Scientific Laboratory internal memo from Asst. Operations Officer (signed by C.V. Forrest) to David Dow. Subject: New Disposal Pit for CM Division. Date: July 12, 1945, 1 p.

198. Los Alamos Scientific Laboratory internal memo from David Dow to Major Stevens. Subject: Contaminated Pit. Date: July 30, 1945, 1 p.

199. Los Alamos Scientific Laboratory internal memo from John Bolton to Henry R. Hoyt. Subject: Contaminated Materials Disposal Ditch. Date: January 10, 1947, 1 p.

200. W. D. Purtymun and W. R. Kennedy, "Distribution of Moisture and Radioactivity in the Soil and Tuff at the Contaminated Waste Pit near Technical Area 21, Los Alamos, New Mexico," U.S. Geol. Survey open-file report (1966).

201. Los Alamos Scientific Laboratory internal memo from Dean D. Meyer, Group Leader, H-1 to Salvatore E. Russo, ENG-4. Subject: Location of Contaminated Waste Burial Pits. Date: January 31, 1952, 1 p.

202. Los Alamos Scientific Laboratory internal memo from Safety Office (signed by James G. Stearns, Safety Engineer) to ENG-3. Subject: Review of Preliminary Drawings: "Materials Disposal Areas." Date: June 12, 1964, 1 p.

203. Los Alamos Scientific Laboratory internal memo from CMR Division Safety Department (signed by Herbert W. Drager) to E. R. Jette. Subject: Contaminated Dump Fire, May 3, 1948. Date: May 5, 1948, 2 p.

204. Los Alamos Scientific Laboratory internal memo from Carl Buckland, Monitoring Section, H-2 to Harriet L. Hardy, M.D., Occupational Health. Subject: Contaminated Dump Fire. Date: 5-5-48, 1 p.

205. Los Alamos Scientific Laboratory internal memo from William F. Romero, H-1, DP West to Dean D. Meyer, Group Leader, H-1. Subject: Beta Gamma Survey of Material Waste Pit, Area B, TA-21. Date: September 19, 1966, 1 p.

206. Los Alamos Scientific Laboratory internal memo from Wilbur Workman to Dean Meyer. Subject: Cave In of Asphalt at County Trailer Parking Lot, DP Road. Date: November 10, 1971, 1 p.

207. Los Alamos Scientific Laboratory internal memo from Engineering Department (signed by S. E. Russo) to Distribution. Subject: Approximate Acreages of Materials Disposal Areas A through X. Date: May 29, 1968, 2 p.

208. Los Alamos Scientific Laboratory internal memo from Construction and Maintenance Group (signed by Geo. L. Williams, Acting Group Leader) to AEC Operations Division, Attention: W. A. Curtis. Subject: New Contaminated Dump at TA-4 (Alpha Site). Date: May 10, 1948, 1 p. Reference LAB-A-5.

209. Letter from John H. Abrahams, Soil Scientist, GWB, U.S.G.S. to Dean Meyer, H-1. Information compiled by W. D. Purtymun. Subject: Burial of radioactive wastes in Area C at a maximum depth of 60 ft. Date: February 13, 1962, 2 p.

210. Los Alamos Scientific Laboratory internal memo from John Enders, H-1 to Dean Meyer, Group Leader, H-1. Subject: Disposal of solid radioactive trash, 3rd quarter, 1959. Date: 11-2-59, 2 p.

211. Los Alamos Scientific Laboratory internal memo from Ellis L. Stout, CMB-AS to C. A. Reynolds, ENG-4. Subject: LASL Chemical Disposal Area. Date: November 12, 1959, 1 p.

212. Los Alamos Scientific Laboratory internal memo from James G. Stearns, Safety Engineer to Distribution. Subject: Closing out of the Hazardous Chemical Pit, Area C. Pajarito and Pecos Road Intersection. Date: May 22, 1964, 2 p.

213. Los Alamos Scientific Laboratory internal memo from John Enders, H-1 to Dean Meyer, Group Leader, H-1. Subject: Solid Radioactive Waste Disposal Report for the First Quarter of 1965. Date: 4-23-65, 3 p.

214. Los Alamos Scientific Laboratory internal memo from Merlin Wheeler, H-8 to Distribution. Subject: Tritium Content of Disposal Areas. Date: October 7, 1974. Symbol: H8-WM-290.

215. Los Alamos Scientific Laboratory internal memo from Philip F. Belcher, Assistant Director for Classification and Security to Donald P. Dickason, Chief, Security Branch, LAAO. Subject: Disposition of Classified Waste Material. Date: 3-31-59. 2 p. Symbol: ADCS-10832.

216. Los Alamos Scientific Laboratory internal memo from Carl Buckland, H-1 Monitoring Section to Chas. H. Perry, Glenn Vogt, Dean Meyer, Jack Aeby, Robert Barker, Chas. Blackwell, Ralph Gosline, and Reynold Hoover. Subject: Contaminated Dump. Date: 12-30-50, 1 p.

217. Los Alamos Scientific Laboratory internal memo from John Enders, H-1 to Dean Meyer, Group Leader, H-1. Subject: Covering Contaminated Trash at Contaminated Dump. Date: 2-5-57, 1 p.

218. Los Alamos Scientific Laboratory internal memo from John Enders, H-1 to Dean Meyer, Group Leader, H-1. Subject: Disposal of Contaminated Trash for 1956. Date: February 4, 1957, 5 p.

219. Los Alamos Scientific Laboratory internal memo from John Enders, Section Leader H-1, CMR-Bldg. to Dean Meyer, Group Leader, H-1. Subject: Quarterly Report on Disposal of Solid Radioactive Trash, 2nd Quarter, 1958. Date: July 15, 1958, 2 p.

220. Los Alamos Scientific Laboratory internal memo from John Enders, H-1 to Dean Meyer Group Leader, H-1. Subject: Quarterly Report on Disposal of Contaminated Trash from July 1, 1957 to September 30, 1957. Date: 12-9-57, 5 p.

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223. A History of Radioactive Contaminated Waste Disposal at Los Alamos." Written by Dean Meyer (personal communication, February 1974). Date: January 23, 1973, 4 p.

224. Los Alamos Scientific Laboratory internal memo from Jack Aeby, H-1 to Carl Buckland, H-1. Subject: Emergency Run to Fire at the Contaminated Dump. Date: 11-7-50, 1 p.

225. Los Alamos Scientific Laboratory internal memo from Charles D. Blackwell, General Monitoring Section H-1 to Dean D. Meyer, Group Leader, H-1. Subject: Fire at Contaminated Dump on Pajarito Road. Date: 3-25-53, 1 p.

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228. K. J. Shiager and K. E. Apt, "Environmental Surveillance at Los Alamos During 1973," Los Alamos Scientific Laboratory report LA-5586 (May 1974).

229. Los Alamos Scientific Laboratory internal memo from T. E. Hakonson to M. A. Rogers. Subject: Area C as a source of ^{3}H to honey bees. Date: September 5, 1974. Symbol: H8-74-335.

230. Los Alamos Scientific Laboratory internal memo from Engineering Department (signed by S. E. Russo, Records and Land Surveys) to Distribution. Subject: Materials Disposal Areas — Drawing ENG-R102 (Revision 14). Date: May 23, 1967, 1 p.

231. Los Alamos Scientific Laboratory internal memo from Carl Buckland, Monitoring Section, H-1 to Roger Westcott, M-Div. Subject: TA-33 and P Site. Date: 7-22-48, 1 p.

232. Los Alamos Scientific Laboratory internal memo from Carl Buckland, Monitoring Section, H-1 to Harry O. Whipple, M.D., Acting H-Division Leader. Subject: Second Excavation at TA-33 and Monitoring. Date: 9-7-48, 1 p.

233. Los Alamos Scientific Laboratory internal memo from Carl Buckland, Monitoring Section, H-1 to Thomas N. White, Group Leader H-1. Subject: Results of Monitoring the Experiment of TA-33 on December 23, 1948. Date: 1-4-49, 1 p.

234. Los Alamos Scientific Laboratory internal memo from Chas. D. Blackwell, General Monitoring Section, H-1 to Dean D. Meyer, Group Leader, H-1. Subject: Excavation and Shot in Chamber #2 at "Hot Point," TA-33. Date: 4-23-52, 6 p. Symbol: H-1-M-20.

235. Los Alamos Scientific Laboratory internal memo from B. F. Schnap to Dean Meyer. Subject: TA-33, Po assay. Date: 11-15-52, 1 p., 1 map.

236. Los Alamos Scientific Laboratory internal memo from Charles D. Blackwell, Alt. Ldr., General Monitoring Section, A-1 to Henry Petrzilka, W-3. Subject: Contamination Survey at Hot Point, TA-33. Date: August 26, 1953, 1 p.

237. Los Alamos Scientific Laboratory internal memo from Charles D. Blackwell, Alt. Leader,, General Monitoring Section, H-1 to Henry Petrzilka, W-3. Subject: Radiation Survey of Old Hot Point, TA-33. Date: 10-28-53, 1 p.

238. Los Alamos Scientific Laboratory internal memo from O. W. Stopinski, H-6 Weather Section to Don Winchell, TA-33. Subject: Preliminary Wind Survey, Selected TA-33 Sites. Date: 5-2-55, 2 p.

239. Los Alamos Scientific Laboratory internal memo from Dean D. Meyer, Group Leader, H-1 to Herman P. Deinken, W-3. Subject: Contaminated Disposal Area G, TA-33 (should be Area E, TA-33). Date: November 7, 1962, 1 p.

240. Los Alamos Scientific Laboratory internal memo from B. F. Schnap to Dean D. Meyer. Subject: Po Assay of TA-33 Soil Samples. Date: 3-17-52, 1 p., 1 map.

241. Los Alamos Scientific Laboratory internal memo from Carl W. Buckland, Leader, General Monitoring Section, H-1 to Dean D. Meyer, Group Leader, H-1. Subject: Report of Fire in Contaminated Pit #4 at TA-33 Adjacent to Underground Chamber #3 (TA-33-29). Date: 4-15-53, 1 p.

242. Los Alamos Scientific Laboratory internal document Laboratory Section — Industrial Hygiene Group H-5 Soil Analysis. Date: 5-11-54, 1 Field Data Sheet, 1 map.

243. Los Alamos Scientific Laboratory internal memo from N. E. Bradbury, Director to Division and Group Leaders. Subject: Disposal Pit at TD Site. Date: May 15, 1946, 1 p.

244. Los Alamos Scientific Laboratory internal memo from ENG-3 to ENG-3. Subject: Request for Survey Service (Set brass caps and tie in Area "T"). Date: 5-1-67, 1 p.

245. Letter from W. D. Purtymun for W. E. Hale, Dist. Chief, WRD, U.S.G.S. to William Kennedy, Group Leader, H-6. Date: February 20, 1967, 4 p., 3 tables, 1 map.

246. Letter from W. D. Purtymun, Hydrologist for W. E. Hale, Dist. Chief WRD, U.S.G.S. to C. W. Christenson, Group Leader, H-7. Subject: Geology at Disposal Area Near Bldg. 257, TA-21. Date: April 19, 1969, 2 p., 2 cross-sections.

247. Los Alamos Scientific Laboratory internal memo from James F. Tribby to Dr. L. H. Hempelmann. Subject: Periodic survey of canyon areas for radioactive contamination. Date: April 29, 1947, 1 p.

248. Los Alamos Scientific Laboratory internal memo from C. W. Christenson, Group Leader, H-7 to Dean Meyer, Group Leader, H-1. Subject: Status of Waste Disposal to Pits at Building DP-257. Date: August 20, 1969, 1 p. Symbol: H-7-CWC-411.

249. Los Alamos Scientific Laboratory internal memo from L. A. Emelity, H-7 through C. W. Christenson, Group Leader, H-7, to LaMar Johnson, Group Leader, H-8. Subject: Summary of Contaminated Wastes to Disposal Pits, July 1 through December 31, 1973. Date: 1-14-74, 1 p. Symbol: H-7-LAE-20.

250. Los Alamos Scientific Laboratory internal memo from C. W. Christenson, Group Leader H-7 to Dean Meyer, Group Leader, H-1. Subject: Summary of Contaminated Wastes to Disposal Pits, July 1, 1970 through December 31, 1970. Date: January 6, 1971, 1 p. Symbol: H-7-CWC-705.

251. Los Alamos Scientific Laboratory internal memo from C. W. Christenson, Group Leader H-7 to Dean Meyer, H-1. Subject: Summary of Contaminated Wastes to Disposal Pits at Bldg. DP-257, May, 1968 through December, 1969, 1 p. Symbol: H-7-CWC-589.

252. Los Alamos Scientific Laboratory internal memo from C. W. Christenson, Group Leader, H-7 to Dean Meyer, Group Leader, H-1. Subject: Summary of Contaminated Wastes to Disposal Pits, July 1, 1971 through December 31, 1971. Date: 1-4-72, 1 p. Symbol: H-7-CWC-4.

253. Los Alamos Scientific Laboratory internal memo from C. W. Christenson, Group Leader, H-7 to Dean Meyer, Group Leader, H-1. Subject: Summary of Contaminated Wastes to Disposal Pits, Jan. 1, 1970 through June 30, 1970. Date: 7-7-70, 1 p. Symbol: H-7-CWC-594.

254. Los Alamos Scientific Laboratory internal memo from P. E. McGinnis, H-7 through J. R. Buchholz, H-7 to J. L. Warren, H-7. Subject: Addendum to Semi-Annual Solid Waste Summary July 1, 1974 through December 31, 1974. Date: March 17, 1976, 1 p. Symbol: H7-76-PEM-181.

255. Los Alamos Scientific Laboratory internal memo from C. W. Christenson, Group Leader, H-7 to Dean Meyer, Group Leader, H-1. Subject: Summary of Contaminated Wastes to Disposal Pits, January 1, 1971 through June 30, 1971. Date: July 7, 1971, 1 p. Symbol: H-7-CWC-865.

256. Los Alamos Scientific Laboratory internal memo from C. W. Christenson, Group Leader, H-7 to Dean Meyer, Group Leader, H-1. Subject: Summary of Contaminated Wastes to Disposal Pits, January 1, 1972 through June 30, 1972. Date: 7-11-72, 1 p. Symbol: H-7-CWC-210.

257. Los Alamos Scientific Laboratory internal memo from P. E. McGinnis, Engineering Section, H-7 through L. A. Emelity, Assistant Group Ldr., H-7 to LaMar Johnson, Group Leader, H-8. Subject: Summary of Contaminated Wastes to Disposal Pits, January 1, 1974 through June 31, 1974. Date: September 6, 1974. Symbol: H7-PEM-406.

258. Los Alamos Scientific Laboratory internal memo from C. W. Christenson, Group Leader, H-7 to Dean Meyer, Group Leader, H-1. Subject: Summary of Contaminated Wastes to Disposal Pits, July 1, 1972 through December 31, 1972. Date: 1-8-73, 2 p. Symbol: H-7-CWC-10.

259. Los Alamos Scientific Laboratory internal memo from C. W. Christenson, H-7 Group Leader to LaMar Johnson, H-8 Group Leader. Subject: Summary of Contaminated Wastes to Disposal Pits, January 1 through June 30, 1973. Date: July 1973, 1 p. Symbol: H-7-CWC-290.

260. Los Alamos Scientific Laboratory internal memo from P. E. McGinnis, Liquid Waste Treatment, H-7 through L. A. Emelity, Alt. Group Leader, H-7, and J. R. Buchholz, Liq. Waste Engr. Sec., H-7 to John L. Warren, Solid Waste Engr. Sec., H-7. Subject: Change of Waste Disposal Shaft Designation Area T, TA-21-157. Date: March 12, 1976, 1 p, 2 figs. Symbol: H7-76-PEM-163.

261. Los Alamos Scientific Laboratory internal memo from Paul E. McGinnis through J. R. Buchholz to John Warren. Subject: Summary of Radionuclides to Disposal Shafts in Area T, TA-21-257 for the Period May 1965 — December 31, 1975. Date: March 19, 1976, 1 p. Symbol: H7-76-PEM-185.

262. Los Alamos Scientific Laboratory internal document Group CMR-12 Monthly Report — J. F. Tribby, Group Leader. Date: October 20, 1947, 1 p.

263. Los Alamos Scientific Laboratory internal document Monthly Report — October 21 to November 20, 1947 by Schnap and Cox, 3 p.

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291. Los Alamos Scientific Laboratory internal memo from Linda Trocki, H-8 to John Warren, H-7. Subject: Geologic Survey of Pit B, TA-54. Date: October 19, 1976, 1 p. Symbol: H8-WS-675.

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295. Los Alamos Scientific Laboratory internal memo from Don VanEtten,H-8 to File. Subject: Soil Moisture Monitoring and Meteorological Tower of TA-54 Radioactive Waste Burial Site. Date: September 14, 1976, 2 p., 2 maps. Symbol: H8-WS-648.

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AREA T

I. GENERAL INFORMATION

Area T is the DP-West absorption bed area located east of Buildings TA-21-286 and TA-21-288, and west of Building TA-21-257 (Fig. T-1). It can be reached from the north perimeter road and is less than a quarter mile from the intersection of the north perimeter road and DP Road. The axis of the area runs southeast. Most of the area is found within LASL coordinates N.87+50 and N.90+00, and E.157+50 and E.160+00. Area T is an open area with approximate acreage of 0.88.[207]

Engineering Drawing ENG-C 2217, June 13, 1945, shows the absorption bed area enclosed by a fence. Latest engineering drawings show no boundaries for the area, but locate points within the area. The job history given on May 11, 1967, request for survey service[244] states,

"Location of Area T has been established and coordinates computed. Brass caps cannot be set in the area until the DP rehab has been completed, and this work isn't expected to be completed for two years, so this request should be closed. Disposal area caps can be included with the DP site brass caps when the rehab has been completed."[244]

II. GEOLOGY AND HYDROLOGY

"The pits [absorption beds] *are probably excavated in Unit 3 of the Tshirege Member of the Bandelier Tuff. The lower part of this unit is nonwelded tuff grading up to a moderately welded tuff which underlies the pits. Joints are more numerous in the upper part of the unit due to the denser welding. Most of the joints are oriented vertical or near vertical. The total thickness of the unit is about 110'. It is underlain by moderate to dense (sic) welded tuff. The total thickness of the Bandelier Tuff underlying the mesa at Building 35* exceeds 800 ft. The tuff is in the zone of aeration; the top of the main zone of saturation is about 1150' below the surface of the mesa."*[245]

With the construction of the disposal shafts which are principally located between Absorption Beds 2 and 4, new geologic data were acquired. Two cross sections were drawn based on information from Shafts 3, 11, 18, 19, 26, and 27. These shafts range in depth from 4.6-19.8 m (15-65 ft). The cross sections show three units with the following description.

"The lower unit is a light gray moderately welded tuff with an approximate thickness of 100'; it is overlain in part by reworked tuff which is deposited in a channel, or low relief cut into the lower light gray tuff unit. The upper unit forming the surface of the mesa of the disposal area is a light brownish-gray moderately welded tuff."[246] (See Figs. T-2 and T-3).

[The reworked tuff and pumice contain cobbles and boulders in the lower part and] *"...was deposited by gaseous forces accompanying the emplacement of the upper ash flow. The cobbles and boulders occur in tabular shapes, or if in mass, show faceted sides as if deposited by sliding rather than rolling as one would expect with water-laid material. The blast caused by the expanding gases accompanying the emplacement of the upper ash flow deposited the larger materials (cobbles and boulders) into areas of low relief in the upper surface of the lower unit. As the upper unit and reworked tuff were emplaced contemporaneously they have cooled as a single unit thus the contact between the two is gradational and not very distinct. A sharp contact is found between the reworked tuff and lower gray unit."*[246]

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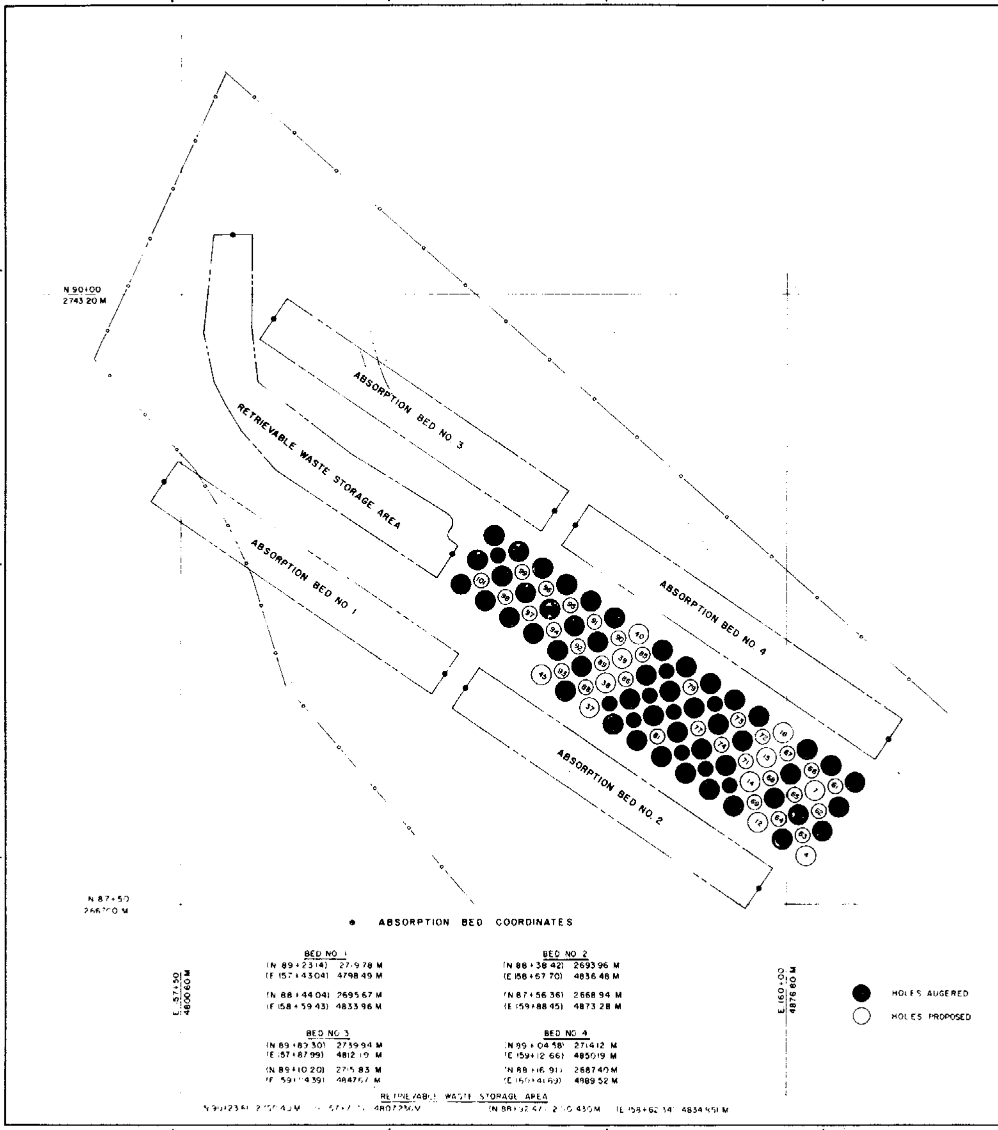
*Author's note: Building 35, TA-21-35, has been removed. It was located immediately south of the absorption beds. (Ref: Engineering Drawing ENG-C-35571).



SHAFT NUMBER	SHAFT DIAMETER	DATE COMPLETED *	APPROXIMATE DEPTH *
1	8' 2.4 M	5-17-71	
2	8'	10/69	25
3	8'	7/69	65
4			
5	8'	3-24-71	65
6	8'	3-20-75	27
7			
8	8	6-6-74	66
9	8'	10/69	65
10	8'	8/70	29
11	8'	7/69	25
12			
13	8'	8-18-73	65
14			
15			
16			
17	8'	11/68	65
18	8'	1/69	59
19	8'	4/69	65
20	8'	11-25-70	65
21	8'	3/71	21
22	8'	4-9-70	65
23	8'	12-1-70	65
24	8'	3-13-70	60
25	8'	11-26-68	65
26	8'	1/69	23
27	8'	4/69	60
28	8'	7-5-73	66
29	8'	4-19-71	65
30	8'	8-7-70	60
31	8'	4-3-71	19
32	8'	3-6-70	20
33	8'	N A	64
34	8'	5-6-71	65
35	8'	6-2-72	66
36	8'	4-22-71	65
37			
38			
39			
40			
41	8'	5-2-71	65
42	8'	8-28-70	23
43	8'	8-22-74	66
44	8'	5-28-71	30
45			
46	8'	10-11-72	67
47	8'	8-23-74	27
48	8	10-31-72	65
49	8'	9-12-74	67
50	[illegible]	10-25-72	65
51	8'	7-20-73	28
52	8'	10-31-72	26
53	8	7-24-73	52
54	8'	10-20-72	65
55	8'	9-12-73	69
56	8'	10-6-72	67
57	8'	7-23-73	27
58	8'	10-28-72	27
59	8'	9-17-74	58
60	8'	10-16-72	65
61			
62			
63			
64			
65			
66			
67			
68			
69			
70 (6-10)	6' 1.8 M	8-20-75	68
71			
72			
73			
74			
75 (6-15)	6'	3-25-75	66
76 (6-16)	6'	8-15-75	67
77			
78	6'	12-1-75	65
79			
80	6'	10-30-75	66
81			
82	6'	9-30-75	64
83 (6-23)	6'	10-15-75	24
84	6	3-12-76	
85			
86			
87	6'	[illegible]-10-75	65
88			
89			
90			
91			
92			
93			
94			
95			
96			
97			
98			
99			
100	6	3-25-76	N A
[illegible]			

* INFORMATION AS SHOWN IN ENG 4 FILES

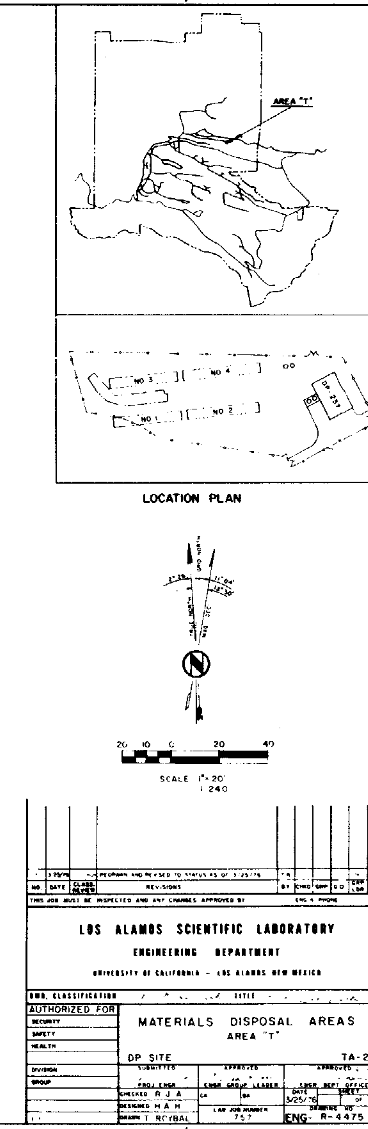


Fig. T-1.
Materials Disposal Area T, DP Site, TA-21.

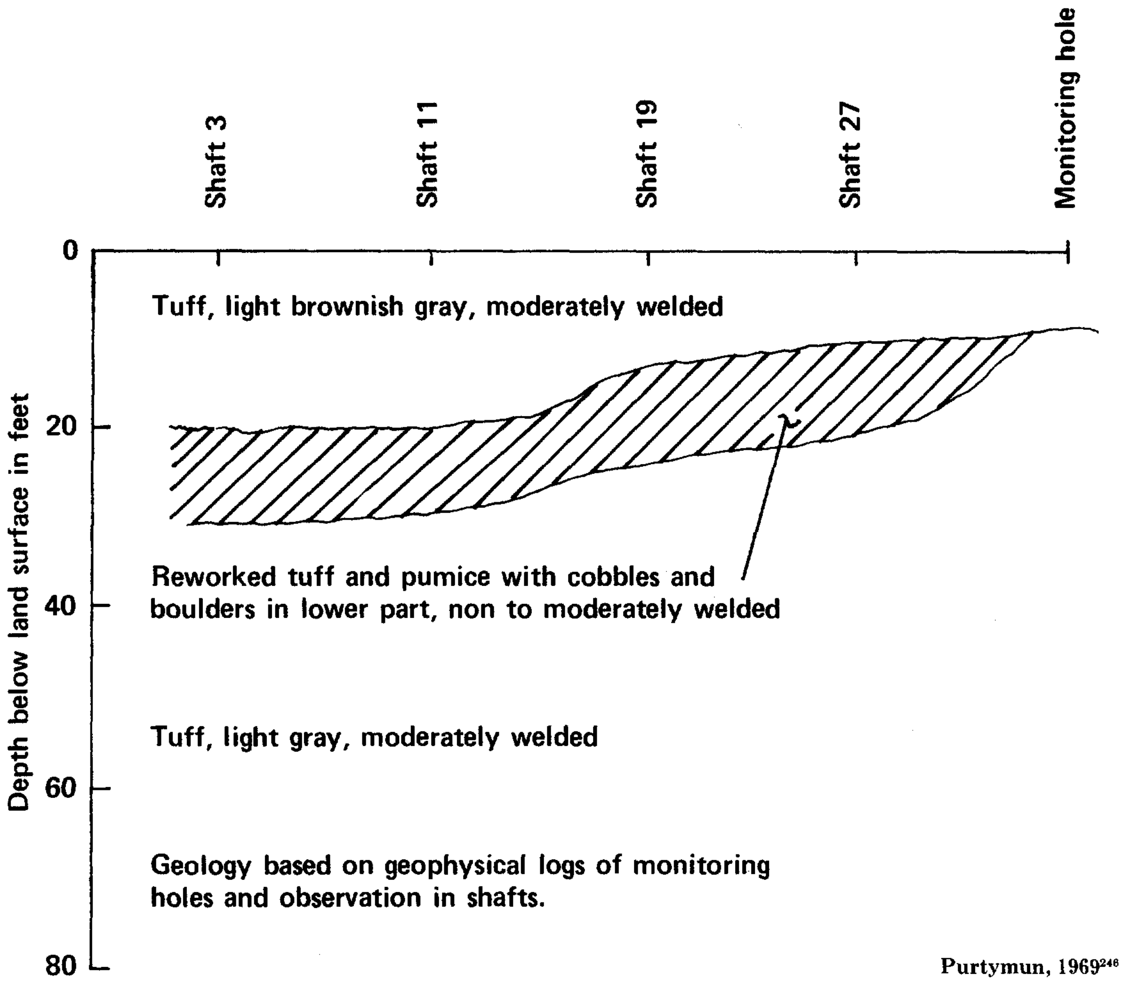


Fig. T-2.
Cross section from Shaft 3 to Shaft 27 in Area T.

December 17-18, 1974 joint data were collected for the pit, the Retrievable Waste Storage Area, between Absorption Bed 1 and Absorption Bed 3.

III. ABSORPTION BED, SHAFT, RETRIEVABLE WASTE STORAGE AREA DESCRIPTION

A. Background

Area T is one of the first disposal areas used at the Laboratory. Construction of four absorption beds for disposal of DP-West liquid waste was completed in 1945. Untreated waste from the processing of plutonium at TA-21 was released to the pits from 1945 to 1952.

In April 1947 plans were submitted to the post engineers to connect all the TA-21 and DP-Site contaminated effluent lines into a central line and disposal plant.[247] It is not clear whether the 1947 proposed disposal plant initiated planning for the DP-West disposal treatment plant, Building TA-21-35, however, TA-21-35 was installed in 1952 to remove the plutonium and other radionuclides.[245] The reason for this installation was that *"the tuff had become clogged with suspended solids."*[11] When the amount of wastes discharged to the absorption beds had reached the order of several thousand gallons per day, the beds

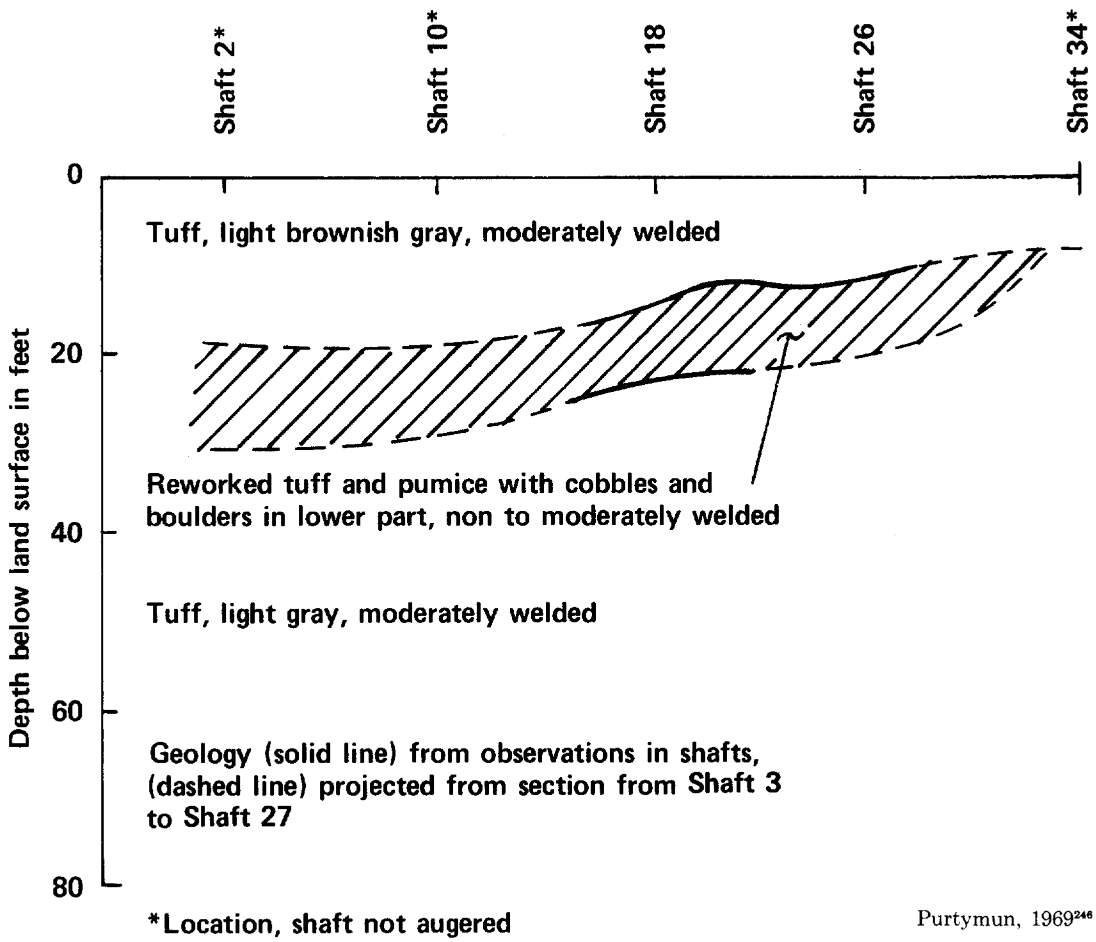


Fig. T-3.
Cross section from Shaft 2 to Shaft 34 in Area T.

had to be abandoned. At infrequent intervals, a few hundred gallons of treated wastes from TA-21-35 were released to the absorption beds from 1952 until 1967. From 1965 through 1967, Absorption Beds 1 and 2 also received low-level radioactive wastes from DP East (written communication, L. A. Emelity, H-7, 1974). A new treatment plant, TA-21-257, was built in 1967. Since mid-1968, treated wastes from TA-21-257 are mixed with cement and pumped down shafts augered between the south absorption beds and the north absorption beds. Beginning December 31, 1975[187] treated wastes from TA-21-257 which contain >10nCi(^{239}Pu-^{241}Am)/g are mixed with cement and pumped into 6 m × 0.75 m (20 ft × 30 in.) corrugated metal pipe (CMP) stored in a pit dug between Absorption Bed 1 and Absorption Bed 3. Effluents from TA-21-257 are discharged to the canyon north of the plant, as were the effluents from TA-21-35.

B. Type of Waste

The amount of untreated waste released into the absorption beds during the period 1945 to 1952 was on the order of 53 000 m^3 (14 000 000 gal.) (written communication, L. A. Emelity, H-7, 1974).

"The concentration of plutonium in effluents during this period has been estimated at 60 c/m/ml (counts per minute per milliliter) [120 dis/min/ml] *with an average fluoride concentration (associated with the waste) of 160 ppm (parts per million). In addition, 10 450 gallons (39.6 m^3) of effluent, highly concentrated with ammonium citrate, was released into the beds from June 1951 to*

July 1952. The plutonium concentration of this waste averaged about 7000 c/m/ml [14 000 dis/-min/ml] *and the fluoride concentrations were about 200 ppm."*[245]

From 1953 through 1967 16 000 m^3 (4 300 000 gal.) of effluent went into the absorption beds (written communication, L. A. Emelity, H-7, 1974). Of this amount, 7500 m^3 (2 000 000 gal.) came from DP East (see Table T-I). It was still possible to release treated wastes to Absorption Bed 4 as of July 1976.

As of January 1973,[79] the absorption beds contained 4 Ci of ^{3}H and 10 Ci of ^{239}Pu (generally consisting of approximately 94 wt% ^{239}Pu and 6 wt% ^{240}Pu). These values were decay corrected from the original magnitude to that as of December 31, 1972.

There are 62 disposal shafts in Area T. The wastes going to the shafts are mixed with cement.

"Various wastes such as the neutralized americium 'strip', alkaline fluoride and plant sludge are being mixed with cement in a pug mill operation and the slurry is being pumped to deep holes [shafts] *on the site. This procedure was started on May 1, 1968."*[248]

Also, 0.9-m (3-ft) diameter experimental bathyspheres have been placed in shafts — three to a layer and at various depths.[248] Besides ^{239}Pu, ^{238}Pu, ^{241}Am, and ^{235}U, the shafts contain some mixed fission products which are mostly strontium and cesium.[248] Table T-II gives the equivalent ^{239}Pu, in grams, in each shaft. As of July 1976,[261] the disposal shafts contained 7 Ci of ^{233}U, 47 Ci of ^{238}Pu,* 191 Ci of ^{239}Pu,* 3761 Ci of ^{241}Am, and 3 Ci of Mixed Fission Products. These values have been decay corrected from the original magnitude to that as of December 31, 1975.

Twenty-eight CMP have been filled in the Retrievable Waste Storage Area. Table T-III gives curies of ^{238}Pu, ^{239}Pu and ^{241}Am in each pipe.

C. Mode of Disposal

The construction of the absorption beds is shown on Engineering Drawing ENG-C 2217. The four beds are numbered — 1, southwest bed; 2, southeast bed; 3, northwest bed; and 4, northeast bed. Each bed is 36.6 m (120 ft) long, 6.1 m (20 ft) wide, and 1.2 m (4 ft) deep. The east and west sides of the beds were sloped so that only the center 30.5 m (100 ft) of each bed has a depth of 1.2 m (4 ft). The north and south sides of the beds appear on ENG-C 2217 as vertical cuts. The bottoms of the beds were cut level. The distance between the centers of Beds 1 and 3 and Beds 2 and 4 is 24.4 m (80 ft).

The original surface of the site sloped to the north at 12 to 1. Therefore, embankments were placed to the north of the beds and surface water interceptors were cut to the south of the beds. Probably the two embankments were built from material derived from the excavation of the beds. Each embankment had a minimum width of 3.1 m (10 ft) and a minimum height of 0.6 m (2 ft). One embankment extended across the west end of Bed 1, the north sides of Beds 1 and 2, and across the east end of Bed 2. The other extended across the west end of Bed 3, the north side of Beds 3 and 4, and across the east end of Bed 4. The surface water interceptors were cut approximately 0.6 m (2 ft) deep and 0.9 m (3 ft) wide, 3.1 m (10 ft) from the south sides of each pit.

The beds are sometimes referred to as covered pits. This is misleading because the beds were never roofed. They were filled with stone, gravel, sand, and earth. The bottoms of the beds were to be trimmed and cleared of earth and loose material before filling. The bottom 61.0 cm (24 in.) of fill was stone, to be clean and free from dirt, which ranged in size from ±7.6 to 25.4 cm (±3 to 10 in.). The stone was to be graded from large at the bottom to small at the top in order to form a deck for the gravel. The next 15.2

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*These totals for ^{238}Pu and ^{239}Pu do not include the years 1968 through 1971 because the actual values for those years are not determinable. It is estimated the amount of ^{238}Pu and ^{239}Pu for 1968 through 1971 is relatively small. (Personal communication, J. L. Warren, H-7, 1976.)

TABLE T-I

VOLUMES OF WASTES DISCHARGED TO AREA T ABSORPTION BEDS

(in cubic meters)

Year	From DPE	From DPW	Year	From DPE	From DPW
1945	0	3 000 (est)	1966	4 355	0
1946	0	4 000 (est)	1967	666	0
1947	0	5 000 (est)	1968	0	0
1948	0	6 000 (est)	1969	0	0
1949	0	5 971	1970	0	0
1950	0	10 030	1971	0	0
1951	0	13 600	1972	0	0
1952	0	5 400	1973	0	0
1953	0	822			
1954	0	206			
1955	0	1 389			
1956	0	1 970			
1957	0	1 587			
1958	0	657			
1959	0	731			
1960	0	750			
1961	0	117			
1962	0	51			
1963	0	230			
1964	0	98			
1965	2 492	137			

Compiled by L. A. Emelity, H-7, May 1974.

TABLE T-II

SHAFT DISPOSAL OF RADIOACTIVE WASTE AT AREA T

Shaft Number	Status	Approximate Depth m (ft.)	Cement Paste in Liters	Equivalent ^{239}Pu in g	Number Spheres and g of ^{239}Pu
1[a,249]	Filled on 10-25-73	5.7 m (18.7 ft)	67,440	1204	
2[b,250]	Filled on 10-14-70	6.4 m (21.0 ft)	23,919	111.15	
3[248,251]	Filled on 4-10-69	8.2 m (27.0 ft)	10,750	10	3 spheres 290 g ^{239}Pu
5[252]	Filled on 9-9-71	18.8 m (61.8 ft)	87,200	905.68	
6[187]	Filled on 8-4-75	8.2 m (26.8 ft)	35,000	700	
8	Augered on 6-6-74	20.4 m (66.8 ft)			
9[253]	Filled on 2-16-70	19.2 m (63.0 ft)	88,775	1142.62	
10[252]	Filled on 7-20-71	7.1 m (23.2 ft)	18,660[c]	158.52[d]	
11[251]	Filled on 11-19-69	8.5 m (28.0 ft)	18,953[e]	147[e]	
13[f,254]	Filled on 7-2-74	19.8 m (65.0 ft)	85,500	1988	
17[248,251]	Filled on 4-10-69	15.2 m (50.0 ft)	87,240	1237	9 spheres 342 g ^{239}Pu
18[251]	Filled on 11-6-69	18.0 m (59.0 ft)	83,442	713	3 spheres 134 g ^{239}Pu
19[248,251]	Filled on 9-5-68	19.8 m (65.0 ft)	80,280	241	3 spheres 245 g ^{239}Pu
20[255]	Filled on 2-11-71	19.2 m (63.0 ft)	89,540	1182.72	
21[256]	Filled on 6-12-72	19.0 m (62.3 ft)	87,293	841.06	
22[250]	Filled on 8-10-70	19.5 m (64.0 ft)	88,758	908.20	
23[255]	Filled on 5-25-71	19.1 m (62.7 ft)	80,699	1182.64	
24[253]	Filled on 5-6-70	18.6 m (61.0 ft)	84,103	1066.95	
25[250]	Filled on 9-15-70	4.9 m (16.0 ft)	23,458	490.14	
26[253]	Filled on 3-16-70	4.6 m (15.0 ft)	21,306	175.73	3 spheres 210 g ^{239}Pu
27[248,251]	Filled on 11-22-68	17.7 m (58.0 ft)	82,770	906	
28[257]	Filled on 3-13-74	20.4 m (67.0 ft)	89,880	2063	
29[256]	Filled on 6-12-72	18.5 m (60.7 ft)	87,847	795.22	
30[250]	Filled on 11-5-70	18.9 m (62.0 ft)	87,086	678.98	

TABLE T-II (Continued)

Shaft Number	Status	Approximate Depth m (ft.)	Cement Paste in Liters	Equivalent ^{239}Pu in g	Number Spheres and g of ^{239}Pu
31[256]	Filled on 2-18-72	5.6 m (18.3 ft)	25,900	113.78	
32[250]	Filled on 6-3-70	4.6 m (15.0 ft)	22,509	413.11	
33[248,251]	Filled on 8-14-69	19.5 m (64.0 ft)	90,486	1352	
34[256]	Filled on 2-7-72	18.4 m (60.3 ft)	89,265	815.15	
35[258]	Filled on 8-10-72	19.0 m (62.3 ft)	87,725	1058.36	
36[258]	Filled on 3-2-72	18.7 m (61.3 ft)	89,410	956.31	
41[258]	Filled on 10-4-72	18.9 m (62.0 ft)	68,600	913.67	
42[250]	Filled on 12-8-70	6.4 m (21.0 ft)	32,731	101.23	
43[187]	Filled on 4-3-75	18.9 m (62.0 ft)	89,000	2080	
44[252]	Filled on 11-12-71	19.2 m (62.9 ft)	87,890	917.52	
46[259]	Filled on 2-23-73	20.1 m (65.8 ft)	82,540	1510.57	
47[187]	Filled on 5-13-75	7.6 m (25.0 ft)	35,100	880	
48[g,257]	Filled on 5-16-74	19.2 m (63.0 ft)	65,760	1520	
49	Filled on 12-5-74	18.9 m (62.0 ft)	92,800	2894	
50[259]	Filled on 3-28-73	19.9 m (65.3 ft)	72,290	1052.64	
51[257]	Filled on 4-5-74	9.1 m (30.0 ft)	38,620	672	
52[259]	Filled on 2-23-73	7.1 m (23.3 ft)	32,740	699.61	
53[249]	Filled on 12-6-73	4.8 m (15.8 ft)	71,610	1983	
54[259]	Filled on 5-23-73	19.1 m (62.8 ft)	90,630	1542.28	
55[h,254]	Filled on 8-23-74	18.9 m (62.0 ft)	90,600	1533	
56[259]	Filled on 6-22-73	19.2 m (63.0 ft)	83,870	1332.57	
57[187]	Filled on 4-22-75	7.6 m (25.0 ft)	37,200	700	
58[259]	Filled on 1-17-73	6.8 m (22.3 ft)	31,950	388.98	
59[187]	Filled on 2-7-75	16.5 m (54.0 ft)	77,400	1980	
60[249]	Filled on 8-3-73	5.8 m (19.1 ft)	90,460	1908	

TABLE T-II (Continued)

Number	Status	Approximate Depth m (ft.)	Cement Paste in Liters	Equivalent ^{239}Pu in g	Number Spheres and g of ^{239}Pu
70[187] 6-10[i]	Filled on 12-11-75	20.7 m (67.8 ft)	52,400	1708	
75[187] 6-15[i]	Filled on 7-2-75	20.3 m (66.5 ft)	52,800	1980	
76[187] 6-16[i]	Filled on 10-9-75	20.5 m (67.3 ft)	52,600	3010	
78[187(281)]	Filled on 5-12-76	19.7 m (64.7 ft)	49,800	68.73	
80[187(281)] 6-20[i]	Filled on 2-20-76	20.1 m (66.0 ft)	56,300	34.04	
82[187] 6-22[i]	Augered on 9-30-75	19.5 m (64.0 ft)			
83[187] 6-23[i]	Filled on 12-16-75	7.3 m (24.0 ft)	18,000	430	
84[j]	Filled on 7-28-76	15.1 m (49.5 ft)	37,700	36.97	
87[187] 6-27[i]	Augered on 10-10-75	20.0 m (65.5 ft)			
91	Augered on 9-17-76	7.9 m (26.0 ft)			
92	Augered on 9-21-76	8.2 m (26.8 ft)			
94	Augered on 9-23-76	6.6 m (21.7 ft)			
95	Augered on 9-28-76	4.9 m (15.9 ft)			
100	Augered on 3-19-76	20.2 m (66.3 ft)			

[a]"Shaft was used for wash waters for 21 PMR runs and contains an unknown amount of activity from these washings."[249]

[b]"Shaft 2 received wash water of 33 runs. Wash water contains unaccounted activity."[250]

[c]Plus about 14,200 liters of solids from washdown.[252]

[d]Does not include radioactivity from washdown solids.

[e]"Cement paste only. Remainder of shaft about 21,300 liters, was filled with washdown residue over a period of about 8 months (21 pug mill runs). Equivalent ^{239}Pu in the residue is probably greater than the ^{239}Pu in the cement paste added to this shaft."[251]

[f]"This shaft was used for rinse water from 13 Pug Mill Runs and contains an unknown amount of rinse solids'[254]

[g]Contains washings from 63 PMR runs and contains an unknown amount of activity from these runs[254]

[h]"This shaft was used for rinse water from 10 Pug Mill Runs and contains an unknown amount of rinse solids"[254]

[i]Shaft number before 3-12-76[260]

[j]Personal communication P.E. McGinnis, H-7

TABLE T-III

CORRUGATED METAL PIPE (CMP) STORAGE OF RADIOACTIVE WASTE AT AREA T

CMP I.D. No.	Date Filled	Cement Paste liters	^{238}Pu Ci	^{239}Pu Ci	^{241}Am * Ci
001150	12/31/75	2,800	0.05	0.90	9.9
001151	12/31/75	2,800	0.05	0.90	9.2
001152	1/16/76	2,800	0.04	0.90	18.2
001153	1/16/76	2,800	0.04	0.90	20.9
001154	1/23/76	2,800	0.04	0.88	20.9
001155	1/23/76	2,800	0.04	0.40	20.4
001156	1/23/76	2,800	0.04	0.40	20.2
001157	2/5/76	2,800	0.04	0.34	21.6
001158	2/5/76	2,800	0.05	0.28	25.1
001159	2/5/76	2,800	0.05	0.27	24.2
001160	2/26/76	2,800	0.07	0.37	24.2
001161	2/26/76	2,800	0.09	0.48	25.1
001162	2/26/76	2,800	0.09	0.48	25.1
001163	3/16/76	2,800	0.06	0.45	16.1
001164	3/16/76	2,800	0.04	0.44	9.1
001165	3/16/76	2,800	0.04	0.48	9.9
001166	4/6/76	2,800	0.05	0.52	8.8
001167	4/6/76	2,800	0.06	0.56	8.2
001168	4/6/76	2,800	0.06	0.56	8.2
001169	4/23/76	2,800	0.10	0.69	10.8
001170	4/23/76	2,800	0.14	0.85	13.5
001171	4/23/76	2,800	0.14	0.85	13.5
001172	5/19/76	2,800	0.11	0.74	16.3
001173	5/19/76	2,800	0.06	0.56	22.1
001174	5/19/76	2,800	0.06	0.57	22.3
001175	5/19/76	2,800	0.06	0.55	21.6
001176	6/8/76	2,800	0.24	0.18	12.1
001177	6/8/76	2,800	0.32	0.02	8.3
001178	6/8/76	2,800	0.30	0.02	7.9

* Numbers are based on H-7 analysis of Pug Mill Feed Solutions
Ref. 281,283

cm (6 in.) of fill was gravel followed by 15.2 cm (6 in.) of sand. The top layer of fill was 30.5 cm (12 in.) of earth. The total thickness of graded fill was 1.2 m (4 ft).

Liquid waste moved through 15.2-cm (6-in.) iron pipe from DP West Buildings 2, 3, 4, and 5 to a distribution box between Beds 1 and 2. The distribution box was 1.2 m (4 ft) long, 0.9 m (3 ft) wide, and 1.2 m (4 ft) deep with 15.2-cm (6-in.) walls. It was built of concrete, and the interior was painted with two coats in Inertial Standard Black, or equal. The box had a 5.1-cm (2-in.) creosoted wood cover which was hinged to the concrete and equipped with a hasp and heavy lock. One 15.2-cm (6-in.) round plug 61.0 cm (24 in.) long was provided with the distribution box. The plug was probably used to divert waste into either Bed 1 or Bed 2 instead of allowing waste to flow to both. The floor drain from Building 12*, TA-21-12, emptied into a 15.2 cm (6-in.) iron pipe leading into Bed 1. Overflow pipes of 15.2 cm (6-in.) iron connected Beds 1 and 3 and Beds 2 and 4. The overflow pipes were positioned in Beds 1 and 2 at the top of the stone layer, i.e., 0.6 m (2 ft), above the bottom and in Beds 3 and 4 at the bottom. All piping was standard weight steel pipe cut in 1.5-m (5-ft) lengths and coated with jennite. All joints were threaded.

"*Report*[edly] *more water* [liquid waste] *moved into pits* [Beds] *1 and 3 than moved into 2 and 4, and at times some of the pits became clogged and overflowed, the overflow moving northward toward a canyon.*"[30] However, overflow from the beds never reached the canyon (personal communication, C. W. Christenson, H-7, 1974).

Sixty 2.4 m (8 ft) diameter disposal shafts were located in the site, principally between Beds 2 and 4. Forty-nine of these shafts have been augered using a 1.2-m (4-ft) diam bucket auger and reaming to a 2.4-m (8-ft) diam (Fig. T-4). The shafts are on 3.7-m (12 ft) centers. Shafts 4, 7, 12, 14, 15, 16, 37, 38, 39, 40, and 45 have not been augered. Shafts 14-16 will not be augered because of a power line. Shafts 37-40 are aligned where the overflow pipe is between Beds 2 and 4. Forty-one 1.8 m or 1.2 m (6 ft or 4 ft) diameter shafts have been located in the original shaft field between the 2.4 m (8 ft) diameter shafts. Thirteen of these shafts have been augered. Table IV gives the following information on individual shafts: dates shafts were completed and filled, shaft depths, and type of rock encountered during augering. The table is composed of data obtained from the Zia Company and Group H-7.

The Retrievable Waste Storage Area is a pit 36.6 m (120 ft) long, 7.3 m (24 ft) wide, and 5.8 m (19 ft) deep. The ramp which leads to the bottom is 18.3 m (60 ft) long. The pit will eventually be filled with 6 m × 0.75 m (20 ft × 30 in.) corrugated metal pipe (CMP) placed on end in the pit. Between December 31, 1975 and June 8, 1976,[281] CMP numbers 001150 through 001178 have been filled.

The waste treatment plant, TA-21-257, is located east of the shaft field and Retrievable Waste Storage Area. Sludge goes from a holding tank to a pug mill where cement is added on a continuous basis. This mixture is then pumped down either the 2.4 m × 18.3 m (8 ft × 60 ft) or 1.8 m or 1.2 m × 18.3 m (6 ft or 4 ft × 60 ft asphalt-lined shafts or the 6 m × 0.75 m (20 ft × 30 in.) CMP. Irregularities in the substrate prevent all shafts from reaching a depth of 18.3 m (60 ft) (Figs. T-5 and T-6).

IV. STUDIES AND MONITORING

Some of the earliest environmental monitoring surveys at LASL include data on Area T. In "Survey of Los Alamos and Pueblo Canyon for Radioactive Contamination and Radioassay Tests Run on Sewer-Water Samples and Water and Soil Samples Taken from Los Alamos and Pueblo Canyons,"[23] LAMS-516, data on fluid and soil are presented for Absorption Beds 1 and 2.

Two-liter samples were taken for the fluid analysis and 50 g samples were taken for the soil analysis. Analytical procedures are given on pages 5-7 of the report; see Fig. T-7 for location of July, September and Oct-Nov 1946 soil and fluid samples.

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*Filter Building TA-21-12 was removed in 1973.

Fig. T-4.
Bucket auger in operation at Area T.

TABLE T-IV

DETAIL AT AREA T ON 2.4 m (8 ft.) AND 1.8 m (6 ft.)* DIAMETER SHAFT

Shaft Number	Date Completed	Date Filled	Approximate Depth	Substrate and Comments
Shaft 1	5-17-71	10-25-73	5.7 m (18.7 ft.) H-7 18.9 m (62.0 ft.) Zia	Dirt to 5.5 m (18 ft.) Tuff 5.5-19.8 m (18-65 ft.)
Shaft 2		10-14-70	6.4 m (21.0 ft.) H-7 7.0 m (23.0 ft.) Zia	Boulders at 6.1 m (20 ft.)
Shaft 3		4-10-69	8.2 m (27.0 ft.) H-7	
Shaft 5		9-9-71	18.8 m (61.8 ft.) H-7 19.5 m (64.0 ft.) Zia	Tuff
Shaft 6	3-20-75	8-4-75	8.2 m (26.8 ft.) H-7 6.7 m (22.0 ft.) Zia	1.0 m (3.0 ft.) pilot hole Boulders in tuff.
Shaft 8	6-o-74		20.4 m (66.8 ft.) H-7	
Shaft 9		2-16-70	19.2 m (63.0 ft.) H-7 19.5 m (64.0 ft.) Zia	0.9-12 m (3-4 ft.) Boulder at 5.5-6.1 m (18-20 ft.)
Shaft 10		7-20-71	7.1 m (23.2 ft.) H-7 7.9 m (26.0 ft.) Zia	Boulders at 7.6 m (25 ft.) Boulders on NE side
Shaft 11		11-19-69	8.5 m (28.0 ft.) H-7	
Shaft 13	9-18-73	7-2-74	19.8 m (65.0 ft.) Zia	Tuff at 4.6 m (15 ft.) Dirt to 4.6 m (15 ft.)
Shaft 17		4-10-69	15.2 m (50.0 ft.) H-7	
Shaft 18		11-6-69	18.0 m (59.0 ft.) H-7	
Shaft 19		9-5-68	19.8 m (65.0 ft.) H-7	
Shaft 20	11-25-70	2-11-71	19.2 m (63.0 ft.) H-7 18.9 m (62.0 ft.) Zia	Tuff. Hard from 3.0-6.2 m (10-20 ft.), easy on down.
Shaft 21		6-12-72	19.0 m (62.3 ft.) H-7 19.2 m (63.0 ft.) Zia	Tuff. Hard about 10.7 m (35 ft.)
Shaft 22	4-9-70	8-10-70	19.5 m (64.0 ft.) H-7 19.2 m (63.0 ft.) Zia	Tuff. Hard for 13.7 m (45 ft.) No boulders.
Shaft 23	12-1-70	5-25-71	19.1 m (62.7 ft.) H-7 19.2 m (63.0 ft.) Zia	Tuff to 5.5 m (18 ft.) 5.5-8.5 m (18-28 ft.) boulders. Tuff on down.
Shaft 24	3-13-70	5-6-70	18.6 m (61.0 ft.)	Boulders at 5.5-8.8 m (18-29 ft.) Boulder layer 0.6 m (2 ft.) thick on N side and 3.4 m (11 ft.) thick on SW side. Hot material 8.8-10 m (29-33 ft.)
Shaft 25	8-26-70	9-15-70	4.9 m (16.0 ft.) H-7 5.5 m (18.0 ft.) Zia	Boulders at 6.4 m (21 ft.)
Shaft 26		3-16-70	4.6 m (15.0 ft.) H-7	
Shaft 27		11-22-68	17.7 m (58.0 ft.) H-7	
Shaft 28	9-5-73	3-13-74	20.4 m (67.0 ft.) Zia	Tuff. Reamed to 19.5 m (64 ft.)

TABLE T-IV (Continued)

Shaft Number	Completed	Filled	Approximate Depth	Substrate and Comments
Shaft 29	4-19-71	6-12-72	18.5 m (60.7 ft.) H-7 19.8 m (65.0 ft.) Zia	Tuff.
Shaft 30	8-7-70	11-5-70	18.9 m (62.0 ft.) H-7 19.1 m (62.5 ft.) Zia	Tuff. Hard from 7.6-9.1 m (25-30 ft.)
Shaft 31	5-3-71	2-18-72	5.6 m (18.3 ft.) H-7 7.0 m (23.0 ft.) Zia	Boulders from 4.9-7.0 m (16-23 ft.)
Shaft 32	4-6-70	6-3-70	4.6 m (15.0 ft.)	Boulders about 1/4 of hole.
Shaft 33		8-14-69	19.5 m (64.0 ft.) H-7	
Shaft 34	5-6-71	2-7-72	18.4 m (60.3 ft.) H-7 18.3 m (60.0 ft.) Zia	Boulders from 4.9-9.8 m (16-32 ft.) Tuff to 18.3 m (60 ft.)
Shaft 35	6-2-72	8-10-72	19.0 m (62.3 ft.) H-7 18.9 m (62.0 ft.) Zia	Tuff. Easy
Shaft 36	4-22-71	3-2-72	18.7 m (61.3 ft.) H-7 19.8 m (65.0 ft.) Zia	Tuff hard to 9.1 m (30 ft.) easy on down.
Shaft 41	5-12-71	10-4-72	18.9 m (62.0 ft.)	
Shaft 42	8-28-70	12-8-70	6.4 m (21.0 ft.) H-7 7.0 m (23.0 ft.) Zia	Boulders at 7.0 m (23 ft.)
Shaft 43	8-22-74	4-3-75	18.9 m (62.0 ft.) Zia	Pilot hole 19.8 m (65 ft.) deep
Shaft 44	4-28-71	11-12-71	19.2 m (62.9 ft.) H-7 20.1 m (66.0 ft.) Zia	Hard tuff to 10.7 m (35 ft.)- Soft to 19.8 m (65 ft.)
Shaft 46	9-11-72	2-23-73	20.1 m (65.8 ft.) H-7 20.1 m (66.0 ft.) Zia	Boulders at 4.9-8.2 m (16-27 ft.) Hard tuff to 14.0 m (46 ft.). Tuff to 20.1 m (66 ft.).
Shaft 47	8-23-74	5-13-75	7.6 m (25.0 ft.) Zia	Boulders in bottom
Shaft 48	10-31-72	5-16-74	19.2 m (63.0 ft.)	Tuff. Hard from 4.6-10.7 m (15-35 ft.)
Shaft 49	9-12-74	12-5-74	18.9 m (62.0 ft.)	Pilot hole 20.1 m (66 ft.) deep tuff. Hard from 4.6-12.2 m (15-40 ft.)
Shaft 50	9-25-72	3-28-73	19.9 m (65.3 ft.) H-7 14.3 m (47.0 ft.) Zia	1.2 m (4 ft.) hole to 19.8 m (65 ft.) hot hole.
Shaft 51	8-20-73	4-5-74	9.1 m (30.0 ft.)	Tuff to 5.5 m (18 ft.). Boulders 5.5-9.1 m (18-30 ft.)
Shaft 52	8-31-72	2-23-73	7.1 m (23.3 ft.) H-7 7.0 m (23.0 ft.) Zia	Boulders at 5.2 m (17 ft.)
Shaft 53	8-24-73	12-6-73	4.8 m (15.8 ft.) H-7 14.8 m (48.5 ft.) Zia	Dirt to 5.2 m (17 ft.). Boulders to 7.6 m (25 ft.). Tuff to 19.8 m (65 ft.). Boulder in pilot hole.
Shaft 54	10-20-72	5-23-73	19.1 m (62.8 ft.) H-7 19.2 m (63.0 ft.) Zia	Tuff. Hard from 4.6-10.7 m (15-35 ft.)
Shaft 55	9-12-73	8-23-74	20.1 m (66.0 ft.) Zia 18.9 m (62.0 ft.) H-7	Dirt to 4.6 m (15 ft.). Tuff to 20.1 m (66 ft.)

TABLE T-IV (Continued)

Shaft Number	Date Completed	Date Filled	Approximate Depth	Substrate and Comments
56	10-6-72	6-22-73	19.2 m (63.0 ft.) Zia	Boulders 5.5-6.7 m (18-22 ft.) Tuff to 19.8 m (65 ft.)
57	8-23-74	4-22-75	7.6 m (25.0 ft.) Zia	Boulders in bottom
58	8-28-72	1-17-73	6.8 m (22.3 ft.) H-7 7.3 m (24.0 ft.) Zia	Boulders in 5.5-6.7 m (18-22 ft.)
59	9-17-74	2-7-75	16.5 m (54.0 ft.) Zia	Boulders 4.6-6.1 m (15-20 ft.)
60	10-16-72	8-3-73	5.8 m (19.1 ft.) H-7 19.4 m (63.5 ft.) Zia	Tuff. Hard 4.6-10.7 m (15-35 ft.)
70	8-20-75	12-11-75	20.7 m (67.8 ft.) H-7 19.4 m (63.5 ft.) Zia	Tuff. Hard 4.6-12.2 m (15-40 ft.)
75	3-25-75	7-2-75	20.3 m (66.5 ft.) H-7 19.2 m (63.0 ft.) Zia	Tuff. Hard 4.6-10.7 m (15-35 ft.)
76	8-15-75	10-9-75	20.5 m (67.3 ft.) H-7 19.2 m (63.0 ft.) Zia	Tuff. Hard 4.6-10.7 m (15-35 ft.)
78	12-1-75	5-12-76	19.7 m (64.7 ft.) H-7 18.3 m (60.0 ft.) Zia	Boulders 6.1-9.1 m (20-30 ft.)
80	10-30-75	2-20-76	20.1 m (66.0 ft.) H-7 19.2 m (63.0 ft.) Zia	Tuff. Hard 4.6-12.2 m (15-40 ft.)
82	9-30-75		19.5 m (64.0 ft.) H-7 18.7 m (61.5 ft.) Zia	Tuff. Hard 4.6-12.2 m (15-40 ft.)
83	10-15-75	12-16-75	7.3 m (24.0 ft.) H-7 6.6 m (21.5 ft.) Zia	Tuff. Hard 4.6-12.2 m (15-40 ft.) Hot material SW side
84	3-12-76	7-28-76	15.1 m (49.5 ft.) H-7 15.8 m (52.0 ft.) Zia	Boulders from 6.1-8.2 m (20-27 ft.)
87	10-10-75		20.0 m (65.5 ft.) H-7 19.1 m (62.5 ft.) Zia	Tuff. Hard 4.6-12.2 m (15-40 ft.)
91	9-17-76		7.9 m (26.0 ft.) H-7	
92	9-21-76		8.2 m (26.8 ft.) H-7	
94	9-23-76		6.6 m (21.7 ft.) H-7	
95	9-28-76		4.9 m (15.9 ft.) H-7	
100	3-19-76		20.2 m (66.3 ft.) H-7 19.4 m (63.5 ft.) Zia	Boulders on SW side at 7.3 m (24 ft.). Tuff on down.
101	3-17-76		7.0 m (23.0 ft.) Zia	Boulders at 5.5 m (18 ft.). Hole abandoned at 7.0 m (23 ft.) because encountered hot material. Filled with dirt.

This table is composed of data from the Zia Company and Group H-7.

* Shafts 1-60 are 2.4 m (8 ft.) diameter shafts; shafts 70-87 are 1.8 m (6 ft.) diameter shafts.

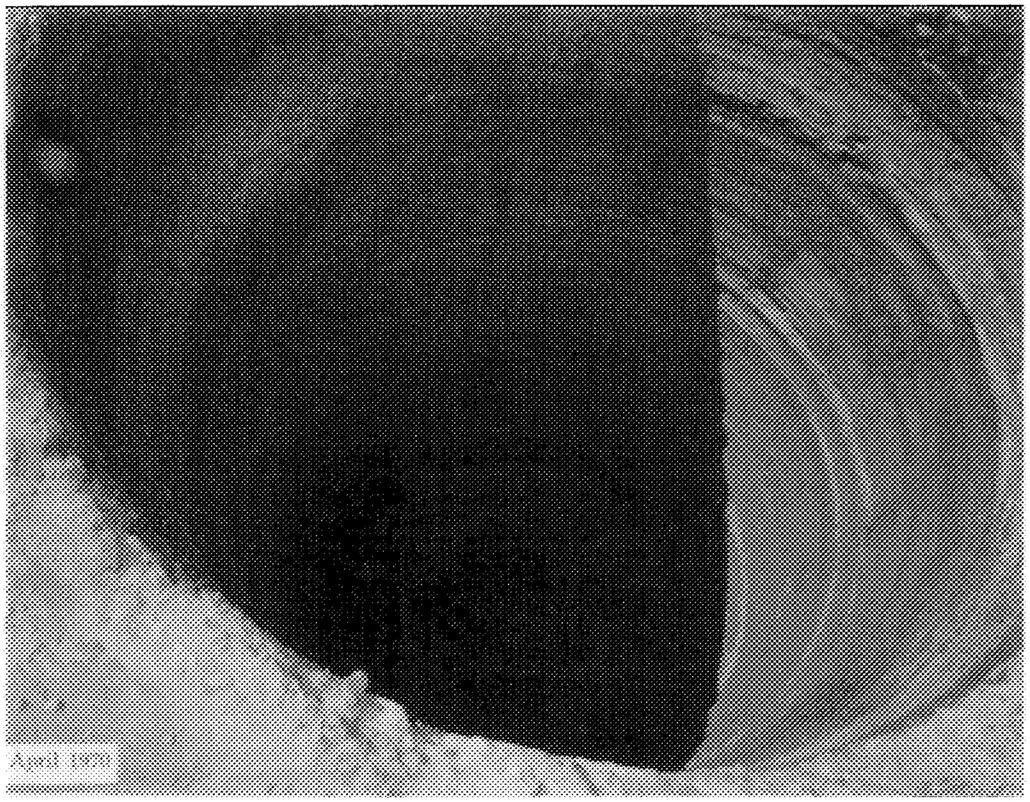


Fig. T-5.
Newly augered Shaft 32, Area T.

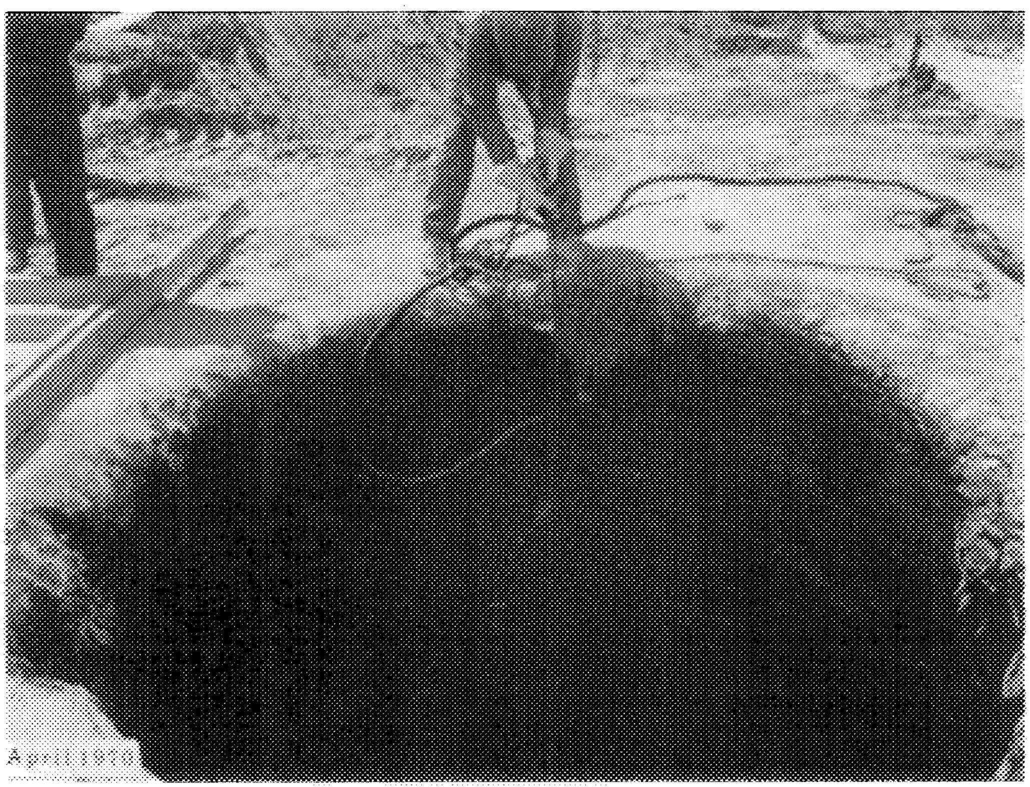


Fig. T-6.
Asphalt being applied to Shaft 32 before filling it with cement paste.

Absorption Bed 1[23]

Date	Sample Type	Direct Instru. Reading "Pee Wee" d/m	Po d/m/ℓ	Po d/m/50g	Pu d/m/ℓ	Pu d/m/50g	Pu microg./ℓ
July, 1946	fluid	*	200		6780		4.8×10^{-2}
Sept., 1946	fluid	*	65		97		69.2×10^{-5}
Oct.-Nov., 1946	soil	800		123		200	

Absorption Bed 2[23]

Date	Sample Type	Po d/m/50g	Pu d/m/50g	Pu microg./50g
July, 1946	soil	80	80	5.7×10^{-4}
Sept., 1946	soil	43	122	87.1×10^{-5}

* Not applicable

In April 1947 collection began of effluent samples from the DP-Site chemical sewer outlets, to be performed at 2-month intervals.[247] Samples were assayed for plutonium, polonium, and uranium. The first report was made October 20, 1947.[262]

"These water samples (a to e), in addition to being radioassayed, were submitted to the analytical group for a fluorine analysis. (Samples from the same sewer were taken at 3 different times of the day.)"*[262]

*"*a. DP West Laundry, seepage pit* [Area V]

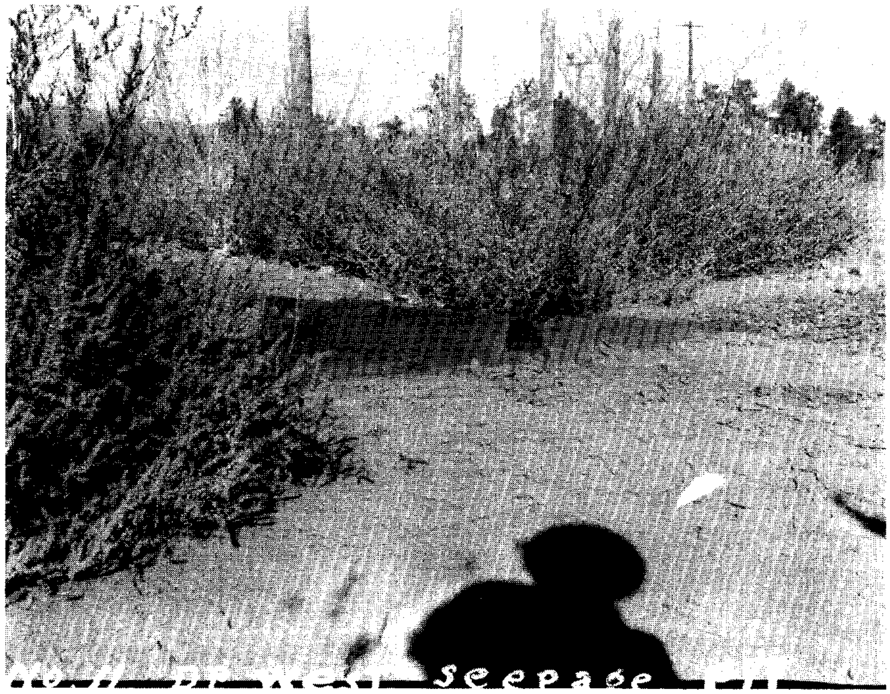
b. DP West seepage, main drain [Area T]

c. DP East seepage, main drain [Area U]

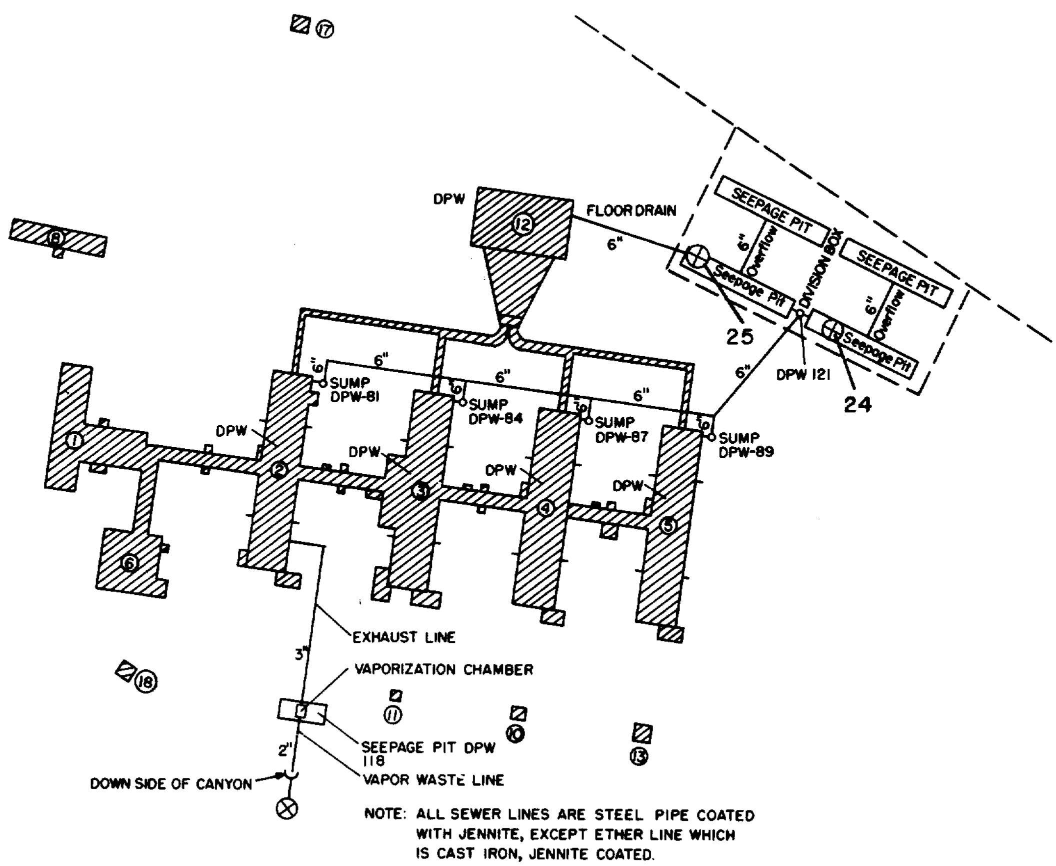
d. DP East drain from precipitron, actually carrying water from sprinkler system.

e. Tech Area acid sewer No. 3"

The result of the fluorine analysis for "DP West seepage, main drain," Area T, in mg of fluorine per 100 mc, was 4.2. *"As soon as repair work on the hood is finished, all water samples will be prepared for a spectrographic analysis and radioassay will be continued."*[262] The monthly report for October 21 to November 20, 1947,[263] gives a radioassay in c/m/ℓ as 29 836 for plutonium and 5.8 for polonium. Samples collected September 26-30, 1947, were reported January 2, 1948.[26] *"As expected the highest activity due to*



a. Pipe leading from TA-21-12 into Absorption Bed 1. Site of Oct-Nov 1946 soil sample.



b. #25 is location of July and Sept 1946 fluid samples.
#24 is location of July and Sept 1946 soil samples.

Fig. T-7.
Location of July, September and October-November 1946 fluid and soil samples.[23]

plutonium was found at DP-W Seepage Pit Main Drain ("B") with 65 639 d/m/l."[26] The January 2, 1948, report[26] also included the analytical procedures for (1) polonium in water samples and soil samples, (2) plutonium in water samples and soil samples, and (3) uranium.

Records on studies and monitoring at Area T from 1948 to 1953 are not available at this time. In 1953 the USGS conducted a study[264] at Los Alamos to determine *"the fate of plutonium contained in liquid wastes discharged onto or just below the surface of the earth."*[264] Area T was one of the sites chosen. Five test holes were drilled in and around the absorption beds (Fig. T-8). Effort was made to gather samples at 0.3-m (1-ft) intervals. All samples were analyzed for plutonium, while three were selected for determination of ion-exchange capacity (Tables T-V and T-VI).

> *"Despite the shortcomings of the sampling techniques, the patterns of plutonium concentrations from the various borings were reasonably good and each pattern may be considered as representative of the particular sample hole. Furthermore, certain characteristics concerning the travel of plutonium through the earth, sand, gravel, and rock media are indicated. These are:*
>
> *1. No appreciable horizontal movement of the plutonium occurs in the first 20 feet of depth.*
>
> *2. The plutonium is readily retained by the various earth media (sand, clay, gravel, and rock).*
>
> *3. Apparently retention of the plutonium is greater in the finer materials.*
>
> *4. Penetration of the plutonium into the underlying strata is not to be expected."*[264]

A joint USGS[160]/LASL[11] study to determine distribution of plutonium previously discharged to the absorption beds was begun in October 1959 with the construction of a caisson 9.1 m (30 ft) deep, 1.8 m (6 ft) wide, by 3.6 m (12 ft) long, on the northeast corner of Absorption Bed 1.

> *"Horizontal holes 3 inches in diameter were drilled at 2 foot depth intervals to a depth of 12 feet so as to terminate at about the center of the seepage pit. At each 2 foot interval two holes were drilled 2 feet apart horizontally. In one hole, a 2 1/4 inch diameter plastic pipe was inserted with the far end sealed; ground tuff was inserted in the area between the pipe and the solid tuff. This hole was used for measurements of moisture. The companion hole was used for collection of liquid samples. Detail of the collection cup system is shown in* [Fig. T-9]. *A porous ceramic cup was inserted to the end of the drilled hole; the hole was back filled with ground tuff. Clay was inserted and capped with a molded cement plug at the caisson face around the vacuum release tubes."*[11] (See Fig. T-10 and Table VII.)

A 17.8-cm (7-in.) long core sample for each 0.6 m (2 ft) of horizontal depth was taken when the holes were drilled. Part of each core was assayed for gross alpha (Table T-VIII).

In late 1960, after the first infiltration study, six deep holes were drilled at the periphery of Absorption Bed 1 ranging from 23.2 m to 30.2 m (76 ft to 99 ft) deep. They were lined with 6.4-cm (2.5-in.) plastic pipe. The holes were augered using compressed air to remove cuttings. Samples of cuttings were taken at 1.5-m (5-ft) intervals. *"This core sampling procedure leaves much to be desired but results did indicate gross variations."*[11] (See Fig. T-11 and Table T-IX.)

The infiltration study for 1960 was done in the summer. DP-West raw waste flowed directly to Absorption Bed 1 for one month at an average rate of 32.9 m^3 (8700 gal) per day. The following month tap water was applied at a rate of 25 m^3 (6600 gal.) per day. Moisture data were collected during and after these discharges. This was a preliminary study.

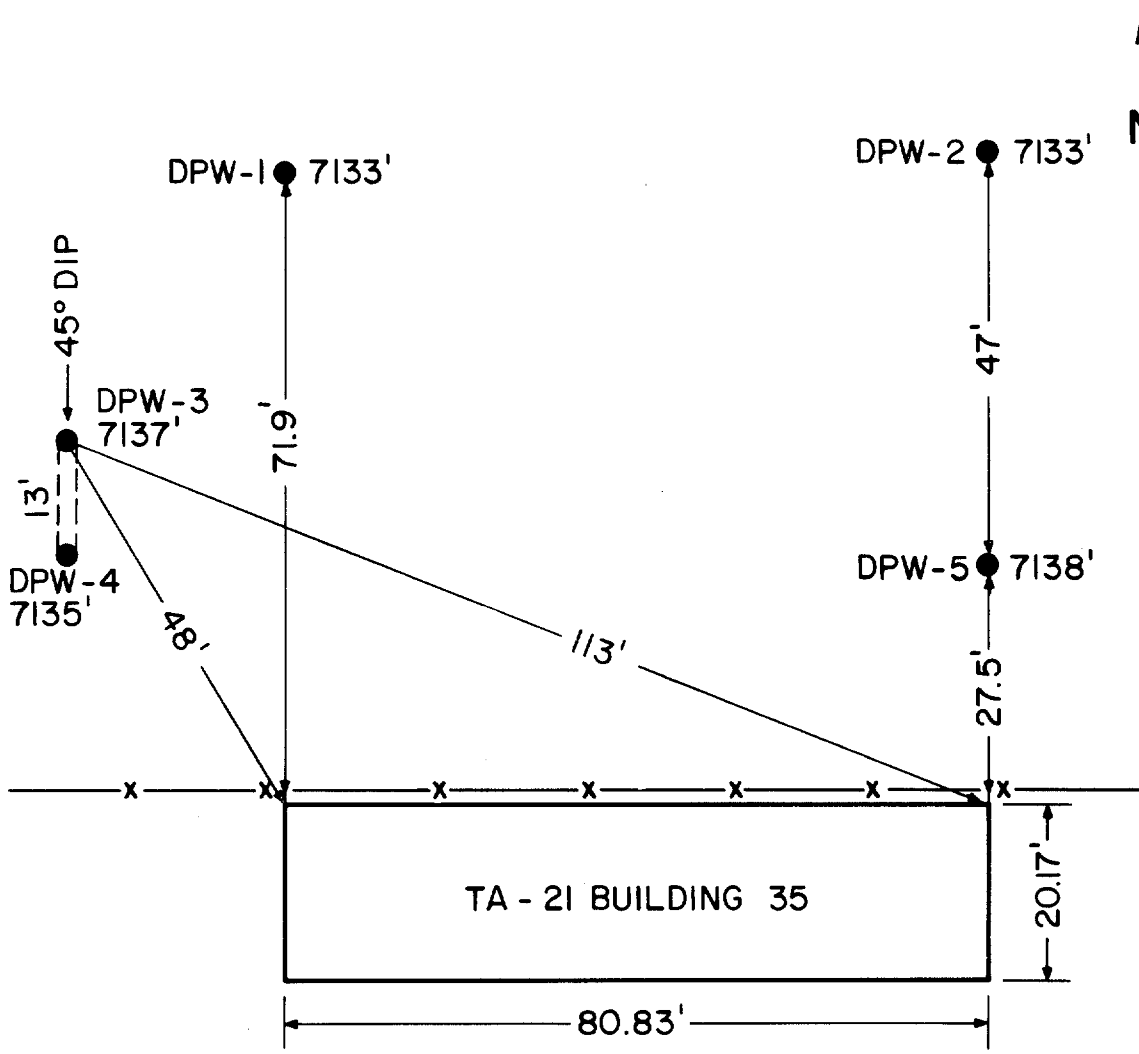


Fig. T-8.
Location of 1953 sampling points at Area T.[264]

The 1961 infiltration study was similar to the 1960 study. Twenty-four cubic meters (6400 gal) per day of raw waste went into Absorption Bed 1 from June 30 to August 1. From August 2 through August 26, 26.9 m^3 (7100 gal) per day of tap water was applied. Sampling continued for an additional week after the application of tap water.

> *"Samples were collected, at each sampling depth, continuously during each day until 50 mls was obtained or 8 hours had elapsed. Five daily samples were then composited and used as the weekly sample.*[11] [See Table T-X.] *The objectives of the present study were to determine if and where water moved beneath a disposal pit and to ascertain if waste products moved with the water."*[160]

TABLE T-V

PLUTONIUM CONCENTRATIONS IN SAMPLES FROM 1953 TEST HOLES

(Table modified from Hermann 1953[264])

Date	Depth Below Surface	Description	Plutonium dpm/dry g	Notes
		DPW-1		
August 25-27, 1953	Surface	Very fine sandy soil	70	
	1'	Very fine sandy soil	8	
	2'	Very sandy soil	4	
	3'	Sandy soil	8	
	4'	Coarse sand and clay	4	
	5'	Sand	4	
	6'	Sand	4	
	6' - 10'	Sand	2	
	10' - 14'	Sand	2	
	15'	Sand	4	
		DPW-2		
August 25-27, 1953	Surface	Very fine sandy soil	9	
	1'	Very fine sandy soil	4	
	2'	Sandy soil	3	
	3'	Sandy soil	1	
	4'	Sand	2	
	5'	Sand	3	
	6'	Sand	2	
	7'	Sand and clay soil	4	
	8'	Sand	1	
	9'	Sand	3	
	10'	Very coarse sand	4	
	11'	Fine sand, some gravel	4	
	12'	Fine sand	3	
	13'	Fine sand	3	
	14'	Sand	3	
	15'	Sand	2	
	16'	Sand	4	
	17'	Sand	3	
	18'	Sand	2	
	19'	Sand	3	
	20'	Sand	3	
		DPW-3		
August 28, 1953	Surface	Very fine sandy soil	32	Hole drilled on a 45° slant extending under adjacent absorption bed. Depths given are slant depths.
	1'	Very fine sandy soil	5	
	2'	Very fine sandy soil	9	
	3'	Very fine sandy soil	7	
	4'	Sandy soil	8	
	5'	Sand	6	
	6'	Very sandy soil	4	
	7'	Very sandy soil	7	
	8'	Very sandy soil	3	
	9'	Sand and clay	3	
	10'	Fine sand	2	
	11'	Sand	2	
	12'	Loose tufaceous sand	450*	*Point of intersection with absorption bed.
	12.5'	Loose tufaceous sand	1510	
	13'	Loose tufaceous sand	1330	

TABLE T-V (continued)

PLUTONIUM CONCENTRATIONS IN SAMPLES FROM 1953 TEST HOLES

(Table modified from Hermann 1953[264])

Date	Depth Below Surface	Description	Plutonium dpm/dry g	Notes
		DPW-4		
September 21, 24, 25, 30 and October 1, 1953	Surface	Sandy soil	8	
	1'	Sand and gravel, some clay	400	
	2'	Sand and gravel, some clay	36,100	
	3'	Sand and gravel, some clay	45,600	
	12'	Very fine loose tuff	1,400	
	15'	Fine sand	5,000	
	16'	Fine sand	5,100	
	17'	Loose tuff	720	
	18'	Sandy loose tuff	24	
	19'	Loose tuff	12	
	20'	Broken tuff core	12	
		DPW-5		
September 21, 24, 25, 30 and October 1, 1953	Surface	Sand and clay soil	410	
	1'	Sand and clay soil	600	
	2'	Sand and clay soil	10	
	3'	Sand and gravel	80	
	4'	Sand and gravel	3,400	
	5'	Solid tuff core from a boulder	530	
	6'	Solid tuff core from a boulder	80	
	7'	Friable tuff core	1,800	
	8'	Fine sand and clay	40	
	9'	Fine sand and clay	380	
	15'	Fine sand	2,400	

The 1961 study was reported by both the USGS and LASL. The USGS report[160] stated

> *"[1] ...that waste water movement may have changed some of the physical properties of the tuff, such as pore and particles sizes. [2] Some of the wastes discharged in the east end of the disposal pit may have moved laterally through the sand material* [Bed A on Sketch C and D, Fig. T-10] *along the sloping top of the tuff and then vertically into the tuff. [3] The lower moisture values...seem to coincide with areas of tuff in which the greatest amount of staining had occurred. The stained areas may indicate a different stage of weathering than that at the clay layer due to alternate wetting and drying cycles... [4] The tuff is extensively jointed* [Fig. T-10], *and the tendency for a liquid to move through the joints is indicated by higher gross alpha count of a 1000 per minute per dry gram at the 20' depth... [5]* [There were] *several open joints...below a depth of 25 ft. Waste water had penetrated the fineline joints to depth of at least 22 feet and subsequently altered the tuff adjacent to the joint as much as one-quarter inch. Clays developed locally and impeded drainage so that the joints retained water to the extent that the moisture content of the tuff was locally as much as 35%... [6] ...Water in the low moisture range apparently moved to depths greater than 90 feet. Water in unknown quantities moves through open joints or joints enlarged by solvents in the waste. [7] ...Below a depth of about 15-20 feet the alpha activity was low, except for local areas of high alpha activity where water carried the activity along the joints. Rapid movement of water through joints was substantiated during infiltration studies..."*[160]

TABLE T-VI

ION EXCHANGE CAPACITY OF SAMPLES

FROM THREE OF THE 1953 TEST HOLES

(Table modified from Hermann 1953[264])

Sample Depth	Megascopic Description	Minerals Present (parts in ten)			Ion Exchange Capacity (me/kg)
DPW-3 at 12 ft. (slant)	Sandy to silty clay and gravel composed of gray pumiceous Bandelier tuff (probably Tshirege member). Due to 45° dip of hole, vertical depth of sample is 8.5 ft.	Clay <2 μ	Feldspar	4	17
			Montmorillonite	3	
			Hydrous mica	2	
			Kaolin		
			Cristobalite		
			Tridymite		
			Quartz		
		Silt 2-62 μ	Feldspar	4	
			Cristobalite	4	
			Tridymite	1	
			Quartz		
DPW-4 at 19 ft.	Gray tuff of Tshirege member of Bandelier tuff. Contains some bit-broken fine particles.	Clay <2 μ	Feldspar	4	7
			Cristobalite	4	
			Tridymite		
			Quartz		
		Silt 2-62 μ	Feldspar	5	
			Cristobalite	4	
			Tridymite	1	
			Quartz		
DPW-5 at 5 ft.	Dark gray to white pumiceous tuff. Apparently cored from a boulder.	Clay <2 μ	Feldspar	5	32
			Montmorillonite	2	
			Cristobalite		
		Silt 2-62 μ	Feldspar		
			Tridymite		
			Cristobalite		

The LASL report[11] stated (1) a high concentration of potassium salts affects the movement of plutonium. (2) A low concentration of aluminum and silicon in the samples of liquid removed indicates that plutonium was not being transported on colloidal clay of such a size as to escape filtration by the tuff.

"[3] ...total hardness and total solids may be correlated with alpha activity. [4] That both total solids and total hardness tend to increase with depth... suggests solution or resolution of previously deposited material... [5] There is some indication of an inverse relationship between gross alpha content and pH... [6] ...It has been deduced from the irregularity of the curves obtained from data for holes 1, A-1, and 2, that percolating groundwater may be perched, ... or may travel rapidly along fissures as seen by a sudden decrease in percent moisture which indicates rapid drainage from the area. These two factors will exert a marked influence on the accumulation and sorption of radionuclides in the areas involved... [7] ...Under field conditions, plutonium species have been

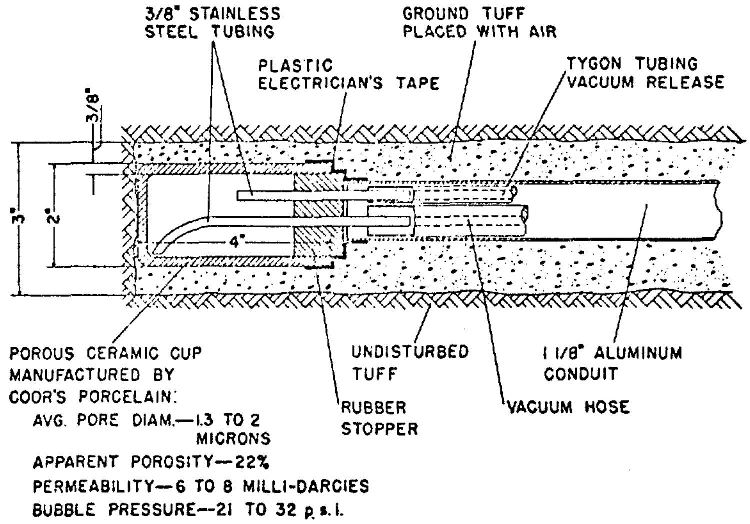


Fig. T-9.
Vacuum cup system for the joint 1959 through 1961 USGS-LASL study at Area T.[11]

shown to penetrate to at least 28 feet. That this penetration takes place along fissures is indicated by moisture data, rates of flow of liquid and by physical inspection... [8] ...It is apparent that one cannot extrapolate from laboratory studies on intact core sample to conditions which prevail in the field..."[11]

Before the excavation of the shaft field at Area T, a reconnaissance study[246] was made of the absorption beds, in January 1967. Water samples were collected for radiochemical analysis from DPW-1A, DPW-3, the caisson (see Fig. T-11), and a sample of weathered tuff beneath the gravel fill of Absorption Bed 1 near the caisson. The water samples showed only background amounts of gross alpha and gross beta-gamma and no plutonium or uranium. Tritium analysis of the water samples gave approximations for DPW-1A as 462 DPM, for DPW-3 as background, and for the caisson as 2000 DPM. The sample of weathered tuff had a gross alpha count of 978 c/min/g (1956 dis/min). Observations in January 1967 are as follows:

"*Effluents from DP-East have at times partially filled the shaft* [caisson] near Pit 1 [Absorption Bed 1] *thus creating a more localized point for infiltration for liquids. Test holes DPW-1A and DPW-3 contained some effluent at the time of observation. It is supposed that the water in DPW-3 moved down the outside of the casing from water ponded in the pit.*"[245]

Moisture contents of the tuff were logged in holes DPW-1, DPW-2, and DPW-5 at selected depths.

"*A comparison of the moisture content with previous moisture measurements (March 1961 prior to the addition of 389 thousand gallons of tap water and effluents in August 1961 during the study) is shown in* [Table T-XI].

The January 1967 measurements at hole DPW-1 show the effect of the 1.9 million gallons of effluent from DP-East in which the maximum concentrations of water have moved from the depth of 12 feet (40 percent August 1961) to 40 feet (41 percent, January 1967). The hole is next to the shaft [caisson].

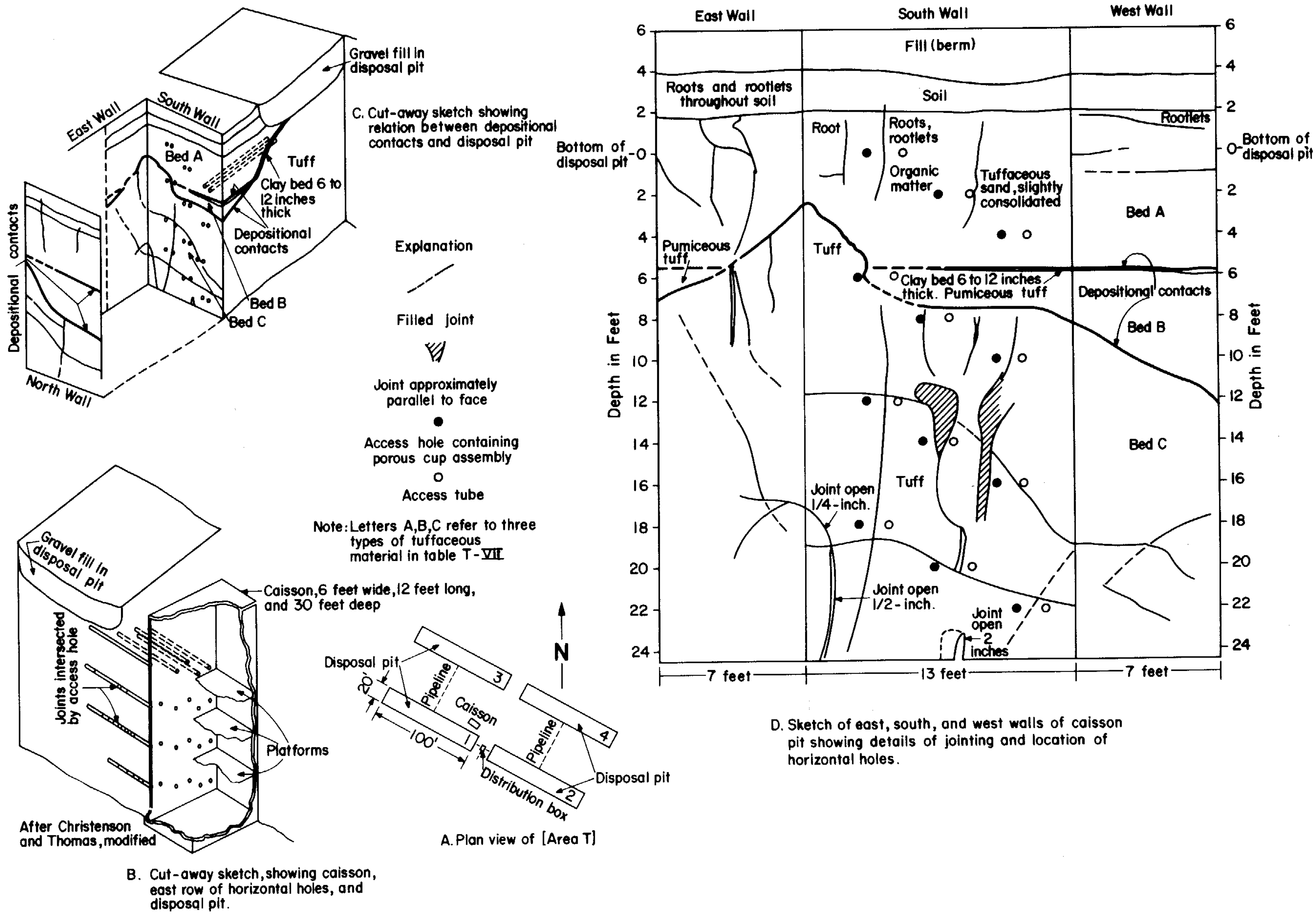


Fig. T-10.

Diagrammatic sketches of installations and caisson pit [Area T]. (Joint 1959 through 1961 USGS-LASL study at Area T.)[11]

TABLE T-VII

DESCRIPTION OF MATERIAL IN CAISSON PIT AT [AREA T]

Position on Figure T-10	Description*
A	Sand, light orange-brown, weathered yellowish; consists of subround to to subangular silt to coarse grains of quartz, sanidine, pumice, and minor amounts of mafic minerals, some grains pitted.
B	Tuff, light orange-gray, weathered throughout; much clay present.
C	Tuff, light gray, weathered yellowish around devitrified pumice fragments and adjacent to joints, locally weathered into clay, weathering more intense in bottom of pit; consists of ash and some mafic minerals.

* by William D. Purtymun

Abrahams, 1963[160]

TABLE T-VIII

CORE RECORD

Depth (ft)	No. Cores	Average Gross α (c/m/dry gram)	Gross α - All Cores (Max.)	(Min.)
6	10	3003	6613	4
8	7	1306	2850	11
10	8	1143	1872	12
12	6	821	1729	414
14	9	749	2094	1
16	9	732	1305	8
18	4	517	923	141
20	7	183	506	45
22	4	15	20	11
24	8	402	1038	175
26	10	13	88	2
28	6	28	156	2

Ref: 11

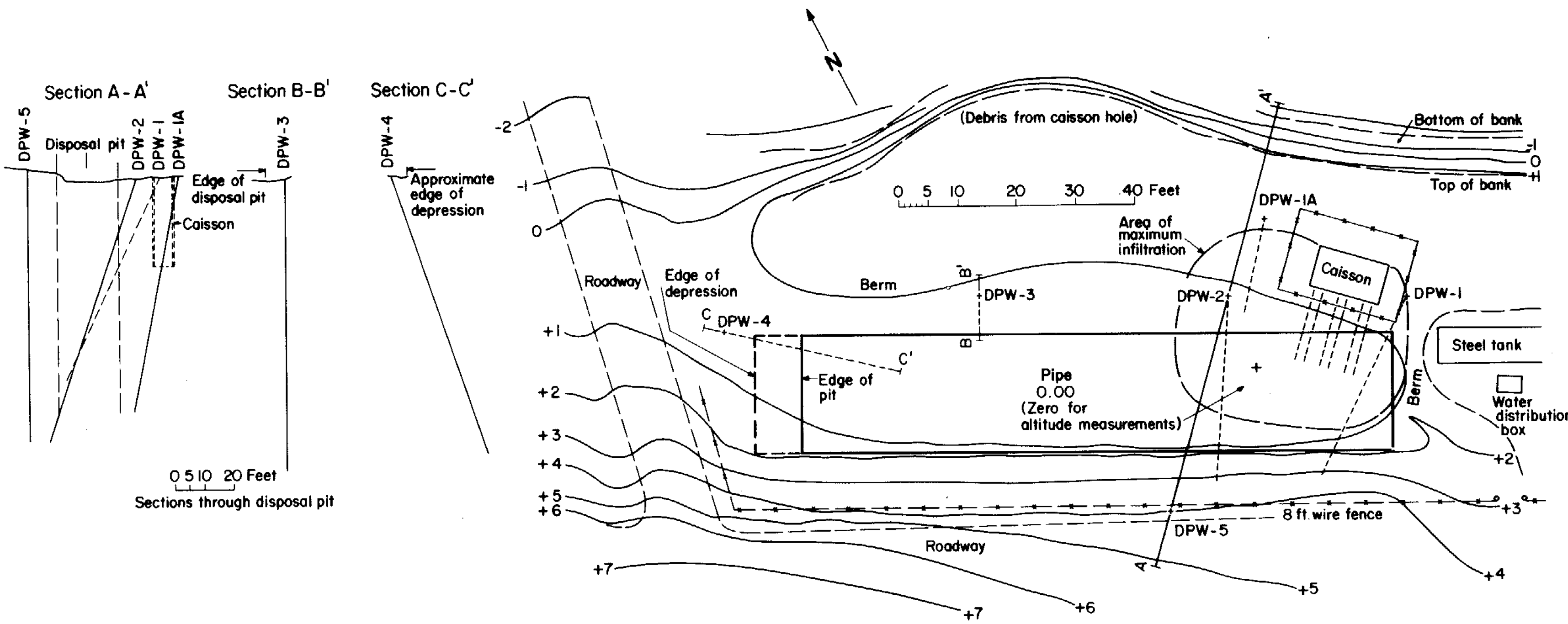


Fig. T-11.
Planview showing location of deep access tubes and sections through disposal pit at [Area T]. (Joint 1959 through 1961 USGS-LASL study at Area T.)[11]

TABLE T-IX

DEEP HOLE CORE RECORDS

(Samples from "Wagon Drill" - Air Blown to Surface)

Hole No.	No. Cores	Depth (ft.)	Gross α (c/m/dry gram)		
			(Avg.)	(Max.)	(Min.)
1	10	76	2	3	1
A-1	10	83	24	34	9
2	11	93	698	3722	142
3	11	99	3	7	2
4	13	99	1.5	2	1
5	7	92	3	6	1

Ref: 11

The moisture measurements in DPW-2 and DPW-5 show a general decrease in moisture content of the tuff from August 1961 to January 1967. The indication is that most of the effluents released into Pit 1 [Absorption Bed 1] *have moved down in the area of the shaft, a focal point for collection and infiltration of effluents into the tuff.*"[245]

On the basis of previous studies and this reconnaissance, it was concluded that

"*...the movement of the effluents in the tuff underlying the seepage pits* [absorption beds] *is mostly downward beneath the pits. The plutonium moves with the effluents and the data indicate that most of the plutonium is retained by absorption in the upper 20 feet of the tuff. Some, however, may move to greater depths through open joints.*"[245]

An average of 10 cuttings samples per shaft have been taken from most of the shafts augered at Area T. These samples are analyzed for tritium and plutonium. Most of these data are unpublished to date.

In March 1974[265] a survey to gather surface and subsurface data for the proposed location of the retrievable waste storage facility was begun. The retrievable waste storage facility is a pit dug between Absorption Beds 1 and 3, west of the shaft field. The pit is dug to within 4.6 m (15 ft) of Absorption Bed 3 and to within approximately 6 m (20 ft) of Absorption Bed 1, and extends several meters west of both of them.

March 22, 1974, the plutonium-americium surface contamination and external radiation survey[266] was completed. Three monitoring stations were over Absorption Bed 1; six monitoring stations were over the proposed pit; and one monitoring station was over Absorption Bed 3. A LAFPHA/FIDLER (Los Alamos Field Pulse Height Analyzer/Field Instrument For The Detection Of Low Energy Radiation) system was used to measure the plutonium-americium surface contamination. External radiation levels were measured by a calibrated Reutor Stokes high-pressure ionization chamber dosimetry system, Model RSS-111. The basic conclusions of the survey were:

TABLE T-X
ANALYSES OF 1961 SAMPLES

		Filt. Gross α c/m/ml	Milli-pore Filter Gross α c/m/ml	pH Un-Filt. / Filt	Phen. Alk.	Tot. Alk.	Total Hard-ness	Ca	Mg	Cl^-	NO_3^-	$SO_4^=$	Filt. Total Solids	Filt. Vol. Solids 400°C	Filt. Vol. Solids 600°C	F^-	Na	K	Surface Tension Dynes/cm	C.O.D.
Avg F	Wkly Raw Comp*	584		6.0 / 6.0	45	186	170	57	7	70	139	36	17,036	316	10,596	200	197	1245	54.5	73
Avg F	Comp. #6	48		11.0	714	1381	161	32	20	102	146	44	11,808		2,605	230	942	2927	42.3	322
Avg W		6		8.6	22	261	190	52	14	17	9	18	3,868	2,012	3,619	76	138	118	52.7	50
Avg T		24		9.7	329	759	177	43	17	66	70	29	7,838	2,012	3,168	144	494	1366	48.1	171
Avg F	Comp. #8	14		4.3	0	0	359	49	57	61	305	227	4,467	1,056	2,359	33	801	112	52.3	353
Avg W		14		6.4	0	175	510	64	84	77	356	272	6,286	1,912	4,048	36	1127	84	51.0	705
Avg T		14		5.5	0	97	443	57	72	70	333	252	5,477	1,769	3,297	34	982	96	51.6	548
Avg F	Comp. #10	28		4.3	0	0	1820	74	393	73	350	288	8,417	752	2,351	48	1878	271	52.2	273
Avg W		10		7.0	0	223	420	88	48	63	292	140	5,992	2,569	6,218	52	790	104	51.8	392
Avg T		18		5.8	0	124	1042	82	201	67	318	206	7,070	2,266	4,500	50	1273	156	52.0	339
Avg F	Comp. #12	9		9.2							290		7,504		2,940	220				
Avg W		6		8.9	440	1720	325	70	36	180	363	140	9,768	1,988	2,772	280				
Avg T		7		9.0	440	1720	325	70	36	180	345	140	8,636	1,988	2,856	265				
Avg F	Comp. #14	165	148	3.7	0	0	4161	344	793	1112	436	355	34,622	8,548	17,175	233	3620	1005	53.2	67
Avg W		126	108	4.0	0	0	4190	256	852	838	406	413	32,340	7,131	16,478	228	3825	1203	53.2	219
Avg T		143	122	3.8	0	0	4177	295	826	960	419	387	33,386	7,367	16,768	230	3734	1115	53.2	152
Avg F	Comp. #16	11		7.2	35	390	994	80	191	60	310	47	5,156	552	1,769	153	1005	709	51.5	136
Avg W		6		8.8	72	855	310	80	33	102	208	73	7,822	1,491	2,916	280	1099	2518	46.1	461
Avg T		8		8.1	56	648	614	80	99	83	253	61	6,637	1,335	2,406	223	1057	1714	48.5	271
Avg F	Comp. #18	79	70	3.8	0	0	7375	625	1335	1526	446	603	52,232	14,036	24,017	245	5900	1631	56.0	76
Avg W		36		5.4	0	84	3290	284	619	610	432	343	34,616	12,874	24,630	220	3274	1468	54.2	208
Avg T		55		4.7	0	47	5106	436	964	1017	438	460	42,445	13,068	24,357	231	4441	1551	54.8	158
Avg F	Comp. #20	6		4.7	0	15	2948	254	555	202	410	96	13,999	2,808	5,789	123	1610	477	53.2	52
Avg W		15		4.4	0	0	3580	346	653	132	419	167	20,013	5,213	9,647	228	2216	920	56.9	99
Avg T		11		4.5	0	7	3299	304	609	158	415	141	17,340	4,812	7,932	181	1989	747	55.5	81
Avg F	Comp. #22	8		3.9	0	0	6168	431	1186	370	464	543	40,733	11,152	18,541	245	4794	896	52.1	358
Avg W		10		3.9	0	0	5510	436	1061	212	470	341	34,127	11,097	18,770	280	3682	895	57.1	308
Avg T		9		3.9	0	0	5802	436	1116	282	467	431	37,063	11,106	18,680	264	4176	895	54.9	327
Avg F	Comp. #24	127	107	4.0	0	0	3103	244	598	160	468	399	20,958	3,968	8,565	173	3729	675	54.3	242
Avg W		47		4.7	0	13	3300	252	641	159	451	310	20,951	5,553	9,813	188	2645	898	53.3	470
Avg T		83		4.4	0	7	3212	248	622	160	459	350	20,956	5,289	9,289	181	3127	799	53.7	368
Avg F	Comp. #26	20		4.5	0	0	4775	346	939	204	463	342	31.430	7,120	15,268	240	3472	628	52.0	291
Avg W		4		4.5	0	2	4610	408	862	167	455	219	24,748	7,691	14,086	208	2642	704	57.5	201
Avg T		11		4.5	0	1	4683	380	896	181	459	266	27,718	7,596	14,612	222	2953	675	56.0	227
Avg F	Comp. #28	19		5.5	8	150	5470	239	1170	169	457	271	22,344	7,464	10,608	175	3083	371	55.1	302
Avg W		1		7.7	2	137	900	112	149	65	330	115	8,036	2,388	5,161	76	1008	1260	55.7	85
Avg T		9		6.7	4	143	2931	168	602	111	386	184	14,395	3,234	7,583	120	2391	851	55.3	258

Code: F = Waste: W = Water: T = Total

***Unfilt. Gross α (c/m/ml) - 565: Unfilt. Tot. Solids - 5454**
Unfilt. Vol. Solids (400°C) - 396:
Unfilt. Vol. Solids (600°C) -1368

Ref. 11

TABLE T-XI

MOISTURE CONTENT OF TUFF ADJACENT TO TEST HOLES

DPW-1				DPW-2				DPW-5			
Depth (ft.)	Percent Moisture (by volume)			Depth (ft.)	Percent Moisture (by volume)			Depth (ft.)	Percent Moisture (by volume)		
	3-17-61	8-23-61	1-30-67		3-18-61	8-23-61	1-30-67		3-19-61	8-25-61	1-30-67
1	22	28	34	1	26	34	39	1	20	20	36
5	24	34	37	4	25	38	40	5	16	16	26
8	18	38	39	8	30	24	30	10	19	20	26
12	13	40	22	12	25	>50	30	15	20	25	29
16	14	34	22	16	22	>50	28	20	17	22	25
20	16	35	40	20	16	>50	18	25	13	19	18
24	18	30	34	24	24	>50	28	30	12	16	15
28	16	27	36	28	25	>50	>50	35	13	18	20
32	28	36	39	32	22	>50	>50	40	13	20	18
36	18	29	41	36	20	>50	47	45	11	16	16
40	14	23	41	40	10	44	16	50	13	21	20
44	14	27	36	44	10	46	16	55	12	19	20
48	14	29	30	48	10	42	17	60	12	14	16
52	16	34	30	52	12	44	22	65	12	15	17
56	14	28	19	56	14	40	25				
60	13	23	16	60	15	28	22				
64	13	22	26	64	12	24	17				

Note: Water level DPW-1A 1-30-67 24.2 feet
Water level DPW-3 1-30-67 50.3 feet
DPW-4 Destroyed
Depth of DPW-a, 76 ft; DPW-2, 93 ft; DPW-5, 92 ft.
Logging length of cable - 65 feet in 1967.

Purtymun, 1967[245]

"1. There is no Pu surface contamination (less than approx. 1.2μCi/m²) within the boundaries of the fenced site. *

2. Americium-241 was detected in Pit #1 [Absorption Bed 1], *but at a level of only 1.1 Ci/m² assuming surface contamination.*

3. No significant levels of external radiation could be attributed to the radioactivity with the waste pits, 1 and 2 of Area T."[266]**

Seven holes (numbered 7-13) were augered in April 1974, within the boundaries of the proposed pit (see Fig. T-12). The depth of the holes was 12 m (40 ft). Samples were collected at 0.8-m (2.5-ft) intervals from 0.3 to 3 m (1-10 ft) and at 1.5-m (5-ft) intervals from 3 to 12 m (10-40 ft). Samples were analyzed for moisture content, gross alpha, gross beta, ^{137}Cs and tritium. In 1974 minimum detection limits for routine analyses of radioactivity in typical solids were 1 pCi/g for gross alpha, 2 pCi/g for gross beta, 0.2 pCi/g for ^{137}Cs, and 0.6 nCi/ℓ for ^{3}H.[63] The sampling results for Area T showed a range of 1.6 ± 0.3† to 20.9 ± 0.8 pCi/g for gross alpha, 21.0 ± 0.8 to 46.7 ± 0.7 pCi/g for gross beta, 0.0 ± 0.1 to 1.2 ± 0.2 pCi/g for ^{137}Cs, and 0.6 ± 0.5 to 28.0 ± 0.9 nCi/ℓ for ^{3}H (see Table T-XII). The analyses results were in general slightly elevated compared to those of surface soil samples in northern New Mexico where radioactive fallout is the only source of contamination (see Table T-XIII).

Six holes (numbered 1-6) were augered in the shaft field in May 1974 (see Fig. T-12). They were located so as to encounter a "boulder bed" which occurs at a depth of 4.5-7.6 m (15-25 ft) below the surface. The samples were collected at the same intervals and analyzed for the same things as those from the seven holes augered in April. No analyses are available (see Table T-XII).

During excavation of the Retrievable Waste Storage Area pit, samples were taken from the north and south walls of the excavation, on October 30, 1974 (see Fig. T-13). Samples were analyzed for ^{3}H, ^{238}Pu, ^{239}Pu, and gross alpha. In 1974 minimum detection limits for routine analyses of radioactivity in typical solids were 5 fCi/g for both ^{238}Pu and ^{239}Pu.[63] In the samples ^{3}H ranged from 8.0 ± 0.5 to 374. ± 1.1 pCi/ℓ, ^{238}Pu ranged from 0.000 ± 0.002 to 2.50 ± 0.08 pCi/g, ^{239}Pu ranged from 0.011 ± 0.003 to 368 ± 8 pCi/g, and gross alpha ranged from ≃0 to ≃253 pCi/g (see Tables T-XIV and T-XIII).

In March 1976 four holes were augered through Absorption Beds 3 and 4 with a 15 cm (6 in.) hollow-stem auger (see Fig. T-14). Core samples were taken of the tuff beneath the beds by inserting a 46 cm (18 in.) long, 3.8 cm (1.5 in.) I.D. split-spoon sampler through the hollow-stem auger and driving the sampler with the drop hammer. At the end of each core-run, 46 cm (18 in.) in.), the auger was advanced to the bottom of the core hole before the next core was taken. Cores were cut into 15 cm (6 in.) pieces and placed in polyethylene, screw-top bottles.[284,285]

"This sampling program is being conducted in cooperation with Argonne National Laboratory. Workers there are performing laboratory experiments on migration of plutonium in tuff, and desire field validation of their results. Our program is interested in the depth distribution of plutonium as it relates to the absorptive properties of the tuff."[284]

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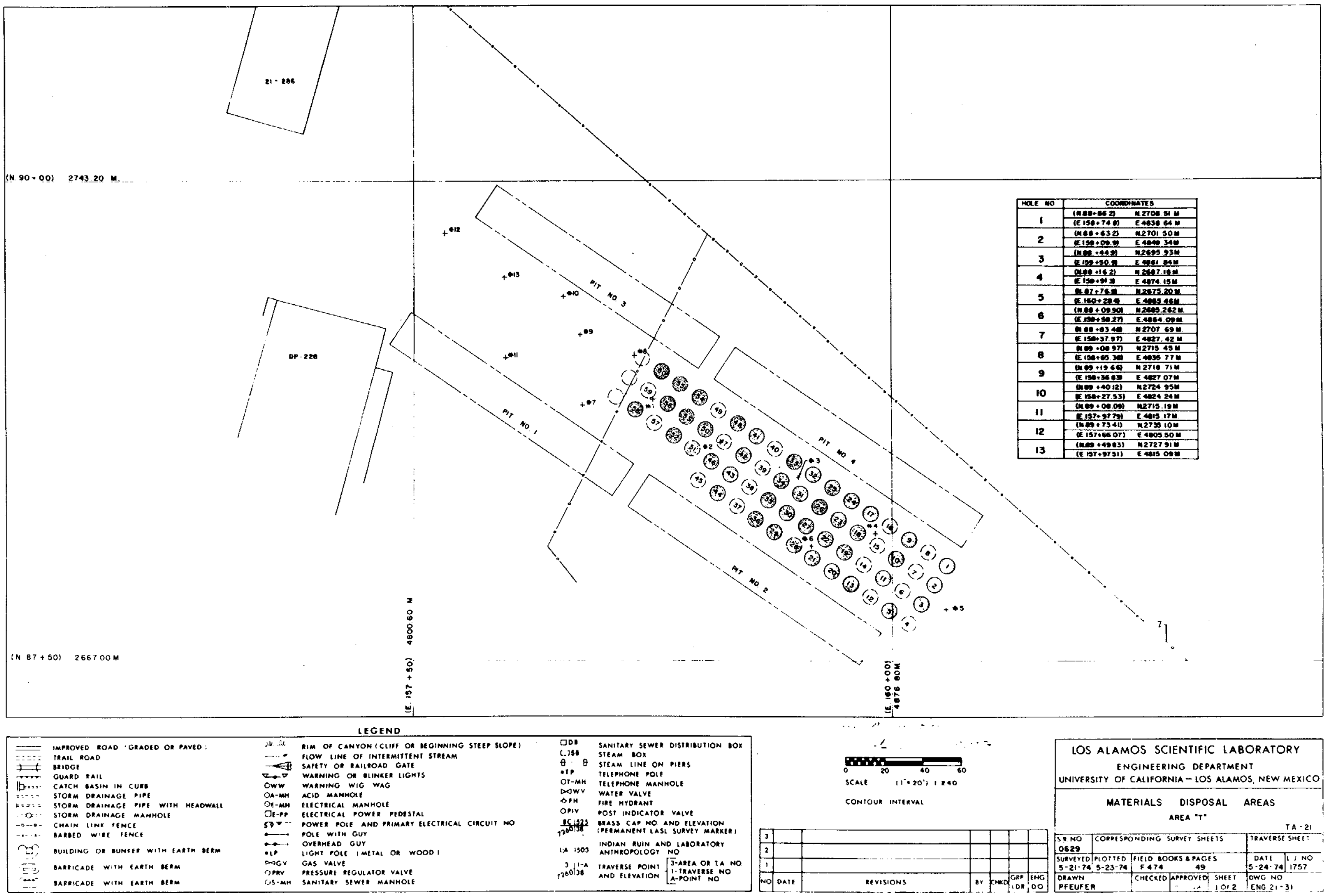
*The "fenced site" is the part of Area T which does not include the shaft field.

**Typographical error. Should read Absorption Beds 1 and 3.

†This number is one standard deviation.



HOLE NO	COORDINATES	
1	(N 88+86.2)	N 2708.51 M
	(E 158+74.0)	E 4838.64 M
2	(N 88+63.2)	N 2701.50 M
	(E 159+09.9)	E 4849.34 M
3	(N 88+44.9)	N 2695.93 M
	(E 159+50.9)	E 4861.84 M
4	(N 88+16.2)	N 2687.18 M
	(E 159+91.3)	E 4874.15 M
5	(N 87+76.9)	N 2675.20 M
	(E 160+28.4)	E 4885.46 M
6	(N 88+09.90)	N 2685.262 M
	(E 159+58.27)	E 4864.09 M
7	(N 88+83.48)	N 2707.69 M
	(E 158+37.97)	E 4827.42 M
8	(N 89+08.97)	N 2715.45 M
	(E 158+65.36)	E 4835.77 M
9	(N 89+19.66)	N 2718.71 M
	(E 158+36.83)	E 4827.07 M
10	(N 89+40.12)	N 2724.95 M
	(E 158+27.53)	E 4824.24 M
11	(N 89+08.09)	N 2715.19 M
	(E 157+97.79)	E 4815.17 M
12	(N 89+73.41)	N 2735.10 M
	(E 157+66.07)	E 4805.50 M
13	(N 89+49.83)	N 2727.91 M
	(E 157+97.51)	E 4815.09 M

Fig. T-12.
Location of augered holes (1 through 13) for April-May 1974 studies at Area T.

TABLE T-XII

SOIL SAMPLE ANALYSES RESULTS FOR 1974 SURVEY OF AREA T, TA-21

	Depth in feet	% H_2O	Gross alpha (pCi/g)	Gross beta (pCi/g)	Cs (pCi/g)	^3H (nCi/ℓ)
HOLE 1	0-5					
	5-10					
(5/9/74)	10-15		NO	ANALYSES		
	15-20					
	20-25					
	25-30					
	30-35					
HOLE 2	0-5					
	5-10					
(5/9/74)	10-15		NO	ANALYSES		
	15-20					
	20-25					
	25-30					
	30-35					
	35-40					
HOLE 3	0-5					
	5-10					
(5/9/74)	10-15		NO	ANALYSES		
	15-20					
HOLE 4	0-5					
	5-10					
(5/9/74)	10-15		NO	ANALYSES		
	15-20					
HOLE 5	0-5					
	5-10					
(5/10/74)	10-15		NO	ANALYSES		
	15-20					
	20-25					
	25-30					
	30-35					
	35-40					
HOLE 6	0-5					
	5-10					
(5/15/74)	10-15					
	15-20		NO	ANALYSES		
	20-25					
	25-30					
	30-35					
	35-04					
HOLE 7	0-2-1/2	15.7	1.8 ± 0.3	34.6 ± 1.0	0.3 ± 0.1	No analysis
	2-1/2-5	17.9	2.7 ± 0.3	21.0 ± 0.8	0.0 ± 0.1	0.6 ± 0.5
(4/18/74)	5-7-1/2	23.0	9.4 ± 0.6	31.0 ± 1.0	0.3 ± 0.1	11.4 ± 0.6
	7-1/2-10	17.0	2.2 ± 0.3	33.5 ± 1.0	0.2 ± 0.1	3.7 ± 0.5
	10-15	17.8	2.7 ± 0.3	39.9 ± 1.1	0.2 ± 0.1	No analysis
	15-20	14.8	2.2 ± 0.3	34.1 ± 1.0	0.6 ± 0.1	No analysis
	20-25	12.5	1.9 ± 0.3	39.1 ± 1.0	0.3 ± 0.1	No analysis
	25-30	12.7	2.7 ± 0.3	42.5 ± 1.1	0.3 ± 0.1	No analysis
	30-35	12.5	3.9 ± 0.4	39.2 ± 1.1	0.3 ± 0.1	No analysis
	35-40	10.2	3.9 ± 0.4	39.6 ± 1.1	0.2 ± 0.1	No analysis
	40-47	4.4	2.9 ± 0.3	31.6 ± 1.0	0.3 ± 0.1	No analysis

TABLE T-XII (continued)

	Depth in feet	% H_2O	Gross alpha (pCi/g)	Gross beta (pCi/g)	Cs (pCi/g)	^3H (nCi/ℓ)
HOLE 8	0-2-1/2	8.0	2.2 ± 0.2	36.2 ± 0.6	0.8 ± 0.2	12.4 ± 0.6
	2-1/2-5	10.0	2.3 ± 0.3	33.2 ± 1.0	0.4 ± 0.1	8.6 ± 0.6
(4/17/74)	5-7-12	7.4	2.8 ± 0.2	48.6 ± 0.7	0.2 ± 0.1	4.6 ± 0.5
	7-1/2-10	7.6	2.4 ± 0.3	38.7 ± 1.1	0.5 ± 0.1	5.2 ± 0.6
	10-15	8.0	2.7 ± 0.2	46.7 ± 0.7	0.1 ± 0.1	13.5 ± 0.7
	15-20	8.2	3.0 ± 0.2	36.7 ± 0.7	0.1 ± 0.1	19.2 ± 0.8
	20-25	7.5	2.6 ± 0.3	37.9 ± 1.0	0.2 ± 0.1	7.5 ± 0.6
	25-30	7.5	2.3 ± 0.3	35.1 ± 1.0	0.2 ± 0.1	2.6 ± 0.5
	30-35	No analysis	2.9 ± 0.2	38.2 ± 0.7	0.3 ± 0.1	3.3 ± 0.5
	35-40	8.6	3.3 ± 0.2	38.1 ± 0.7	0.3 ± 0.1	1.9 ± 0.5
HOLE 9	0-2-1/2	14.8	2.5 ± 0.3	27.8 ± 0.9	0.3 ± 0.1	7.5 ± 0.6
	2-1/2-5	10.6	4.5 ± 0.4	39.0 ± 1.1	0.3 ± 0.1	7.1 ± 0.6
(4/17/74)	5-7-1/2	11.6	3.3 ± 0.4	36.5 ± 1.0	0.3 ± 0.1	10.3 ± 0.6
	7-1/2-10	8.2	3.3 ± 0.4	39.7 ± 1.1	0.4 ± 0.1	11.7 ± 0.6
	10-15	8.0	4.1 ± 0.4	45.0 ± 1.1	0.1 ± 0.1	15.9 ± 0.7
	15-20	9.1	3.8 ± 0.4	37.1 ± 1.0	0.2 ± 0.1	25.6 ± 0.9
	20-25	8.7	3.4 ± 0.4	37.4 ± 1.0	0.1 ± 0.1	17.5 ± 0.7
	25-30	9.0	2.8 ± 0.3	38.8 ± 1.1	0.4 ± 0.1	10.6 ± 0.6
	30-35	9.5	20.9 ± 0.8	41.2 ± 1.1	0.2 ± 0.1	11.5 ± 0.6
	35-40	11.4	12.7 ± 0.7	39.2 ± 1.0	0.2 ± 0.1	15.2 ± 0.7
HOLE 10	0-2-1/2	29.6	2.5 ± 0.2	32.6 ± 0.5	0.2 ± 0.1	10.9 ± 0.6
	2-1/2-5	17.8	5.0 ± 0.3	34.5 ± 0.6	0.3 ± 0.1	8.0 ± 0.6
(4/18/74)	5-7-1/2	22.3	3.7 ± 0.2	37.9 ± 0.7	0.4 ± 0.1	7.8 ± 0.6
	7-1/2-10	13.3	4.0 ± 0.2	31.2 ± 0.6	0.4 ± 0.1	9.6 ± 0.6
	10-15	14.6	4.3 ± 0.4	35.4 ± 1.0	1.2 ± 0.2	7.2 ± 0.6
	15-20	13.8	3.7 ± 0.4	36.7 ± 1.0	0.2 ± 0.1	13.2 ± 0.7
	20-25	14.6	2.6 ± 0.3	39.5 ± 1.1	No analysis	10.1 ± 0.6
	25-30	9.4	3.7 ± 0.2	40.7 ± 0.7	0.3 ± 0.1	28.0 ± 0.9
	30-35	8.4	2.9 ± 0.2	40.2 ± 0.7	0.4 ± 0.1	16.4 ± 0.7
	35-40	8.3	4.3 ± 0.3	35.0 ± 0.6	0.1 ± 0.1	19.0 ± 0.8
HOLE 11	0-2-1/2	16.8	1.6 ± 0.3	25.2 ± 0.9	0.2 ± 0.1	12.9 ± 0.7
	2-1/2-5	16.2	2.8 ± 0.3	25.7 ± 0.9	0.0 ± 0.1	4.4 ± 0.5
(4/18/74)	5-7-1/2	18.6	2.0 ± 0.2	28.7 ± 0.6	0.1 ± 0.1	10.4 ± 0.6
	7-1/2-10	17.6	1.6 ± 0.3	37.7 ± 1.0	0.3 ± 0.1	3.5 ± 0.5
	10-15	14.8	2.0 ± 0.2	35.7 ± 0.6	No analysis	4.9 ± 0.6
	15-20	14.0	1.7 ± 0.2	39.8 ± 0.7	0.3 ± 0.1	9.8 ± 0.6
	20-25	10.8	1.8 ± 0.2	36.6 ± 0.7	0.1 ± 0.1	5.6 ± 0.6
	25	13.0	1.8 ± 0.3	34.5 ± 1.0	0.1 ± 0.1	3.5 ± 0.5
	25-30	9.2	1.7 ± 0.2	32.2 ± 0.6	0.2 ± 0.1	9.0 ± 0.6
HOLE 12	0-2-1/2	13.0	3.1 ± 0.3	32.4 ± 1.0	0.2 ± 0.1	6.4 ± 0.6
	2-1/2-5	10.7	2.9 ± 0.3	36.5 ± 1.0	0.2 ± 0.1	8.3 ± 0.6
(4/18/74)	5-7-1/2	9.3	2.9 ± 0.3	35.4 ± 1.0	1.2 ± 0.2	5.4 ± 0.6
	7-1/2-10	6.4	2.8 ± 0.3	34.1 ± 1.0	0.2 ± 0.1	7.3 ± 0.6
	10-15	5.6	3.7 ± 0.4	43.3 ± 1.1	No analysis	9.1 ± 0.6
	15-20	5.8	3.1 ± 0.3	34.5 ± 1.0	0.0 ± 0.1	2.1 ± 0.5
	20-25	6.8	3.5 ± 0.4	45.3 ± 1.1	0.3 ± 0.1	2.0 ± 0.5
	25-30	6.7	2.7 ± 0.3	29.8 ± 0.9	0.3 ± 0.1	No analysis
	30-35	7.2	2.4 ± 0.3	41.1 ± 1.1	0.2 ± 0.1	No analysis
	35-40	7.3	3.1 ± 0.3	35.0 ± 1.0	0.2 ± 0.1	1.0 ± 0.5
HOLE 13	0-2-1/2	10.9	2.1 ± 0.3	29.2 ± 0.9	No analysis	No analysis
	2-1/2-5	11.3	2.5 ± 0.3	35.3 ± 1.0	0.2 ± 0.1	10.6 ± 0.6
	5-7-1/2	9.6	3.1 ± 0.3	41.0 ± 1.1	0.2 ± 0.1	11.0 ± 0.6
	7-1/2-10	7.9	3.0 ± 0.3	35.0 ± 1.0	0.3 ± 0.1	10.6 ± 0.6
	10-15	10.2	3.3 ± 0.4	43.0 ± 1.1	0.2 ± 0.1	9.7 ± 0.6
	15-20	9.3	3.8 ± 0.4	42.7 ± 1.1	0.5 ± 0.1	8.6 ± 0.6
	20-25	8.7	2.8 ± 0.3	35.3 ± 1.0	0.2 ± 0.1	6.8 ± 0.6
	20-30	No analysis	1.6 ± 0.3	36.9 ± 1.0	No analysis	8.2 ± 0.6
	30-35	7.6	2.0 ± 0.2	23.8 ± 0.6	0.1 ± 0.1	13.3 ± 0.7
	35-40	14.0	2.2 ± 0.3	39.0 ± 1.1	0.3 ± 0.1	3.0 ± 0.5

TABLE T-XIII

NORTHERN NEW MEXICO REFERENCE LOCATIONS FOR SURFACE SAMPLING*

Contaminant	Units	Number of Samples	Range	Median	Average
Gross alpha	pCi/g	7	1.8 to 1.0	2.6	2.6
^{239}Pu	pCi/g	7	0.010 to 0.034	0.025	0.024
^{137}Cs	pCi/g	7	1.2 to 2.5	1.7	1.8
Gross beta	pCi/g	7	17.3 to 32.4	20.0	21.3
^{3}H	pCi/mℓ		2 to 13		

*Personal communication from A. J. Ahlquist, H-8, 1976.

TABLE T-XIV

SOIL SAMPLES FROM WALLS OF RETRIEVABLE WASTE STORAGE AREA PIT

Sample Number	Sample Letter	Sample Description	Date	^{3}H (nCi/ℓ)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (Ludlum alpha probe)* Counts/Min	pCi/g
T-SS-1								
	A	From weathered tuff or soil approximately 0.3 m above non-weathered tuff	10/30/74	29.0 ± 0.9	0.000 ± 0.006	0.023 ± 0.004		
	B	0.6 m below Sample A in fracture zone	10/30/74	20.0 ± 0.7	0.000 ± 0.002	0.032 ± 0.003		
	C	0.6 m below Sample A, adjacent to Sample B, in unaltered tuff	10/30/74	21.0 ± 0.8	0.000 ± 0.006	0.011 ± 0.003		
	D	1.5 m below Sample A in fracture zone	10/30/74	16.4 ± 0.7	0.001 ± 0.003	0.021 ± 0.003		
T-SS-2								
	A	Fracture filling near surface of tuff	10/30/74	11.2 ± 0.6	0.005 ± 0.003	0.838 ± 0.018		
	B	Unaltered tuff adjacent to Sample A	10/30/74	8.0 ± 0.5	0.000 ± 0.006	0.247 ± 0.011		
T-SS-3		From sidewall of ditch holding overflow pipe	10/30/74				41.8	≈253
T-SS-4		From exposed dirt face approximately 6 m north of Absorption Bed 1 edge and 4.6 m west of present (1974) east fence	10/30.74				9.3	≈30
T-SS-5		From exposed dirt face approximately 6 m north of Absorption Bed 1 and 12 m west of overflow pipe	10/30/74				9.5	≈30
T-SS-6		From excavated tuff in northeast corner of area	10/30/74				3.7	<20 (background)
T-SS-7		From excavated tuff in northwest	10/30/74				6.4	<20 (background)
T-SS-8		From exposed south wall in "weathered tuff" approximately 9 m west of Hole 8 and 24 m from ground level		13.4 ± 0.6	No analysis	0.41 ± 0.02		
T-SS-9		9 m west of Sample T-SS-8 and 24 m from ground level		22.0 ± 0.8	0.001 ± 0.002	0.095 ± 0.005		

TABLE T-XIV (continued)

Sample Number	Sample Letter	Sample Description	Date	^3H (nCi/ℓ)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (Ludlum alpha probe)* Counts/Min	pCi/g
T-SS-10								
	A	Fracture filling		37.4 ± 1.1	0.36 ± 0.02	52.6 ± 1.0		
	B	Rock adjacent to fracture, estimated 1 cm thick zone		33.9 ± 1.0	0.172 ± 0.012	23.1 ± 0.4		
T-SS-11		Approximately 9 m west and 1.8 m north of Hole 8 on north wall about 1 m below ground level						
	A	"Weathered material" in horizontally layered zone		18.0 ± 0.7	>100**			
	B	Rock beneath Sample A, estimated 5 cm thick zone		21.0 ± 0.8	0.38 ± 0.02	49.2 ± 0.9		
T-SS-12		Fracture zone on north wall approximately 4.6 m west of east end of pit						
	A	Fracture filling about 1.2 m off floor of pit		18.3 ± 0.7	2.50 ± 0.08	368 ± 8		
	B	Rock adjacent to Sample A		16.5 ± 0.7	0.128 ± 0.019	18.1 ± 0.5		
	C	Scrapings of filling from "hot rock" removed by monitor from Site T-SS-12		11.0 ± 0.6	>3500**			
	D	"Hot rock" described in Sample C		14.8 ± 0.6	0.81 ± 0.03	117 ± 2		
T-SS-13		Fracture zone on north wa.1 approximately 12 m west of T-SS-12						
	A	Fracture filling		19.6 ± 0.7	0.014 ± 0.006	2.15 ± 0.07		
	B	Approximately 28 m layer rock adjacent to filling		19.0 ± 0.7	1.57 ± 0.05	0.94 ± 0.04		

*Rough calibration: $\text{pCi/g} = \frac{\text{counts/min} - 5}{0.145}$

**No isotope differentiation. Average $^{239}Pu/^{238}Pu$ ratio for samples T-SS-2A, T-SS-9, T-SS-10A & B, T-SS-11B, T-SS-12A, B & D, and T-SS-13A is 142.

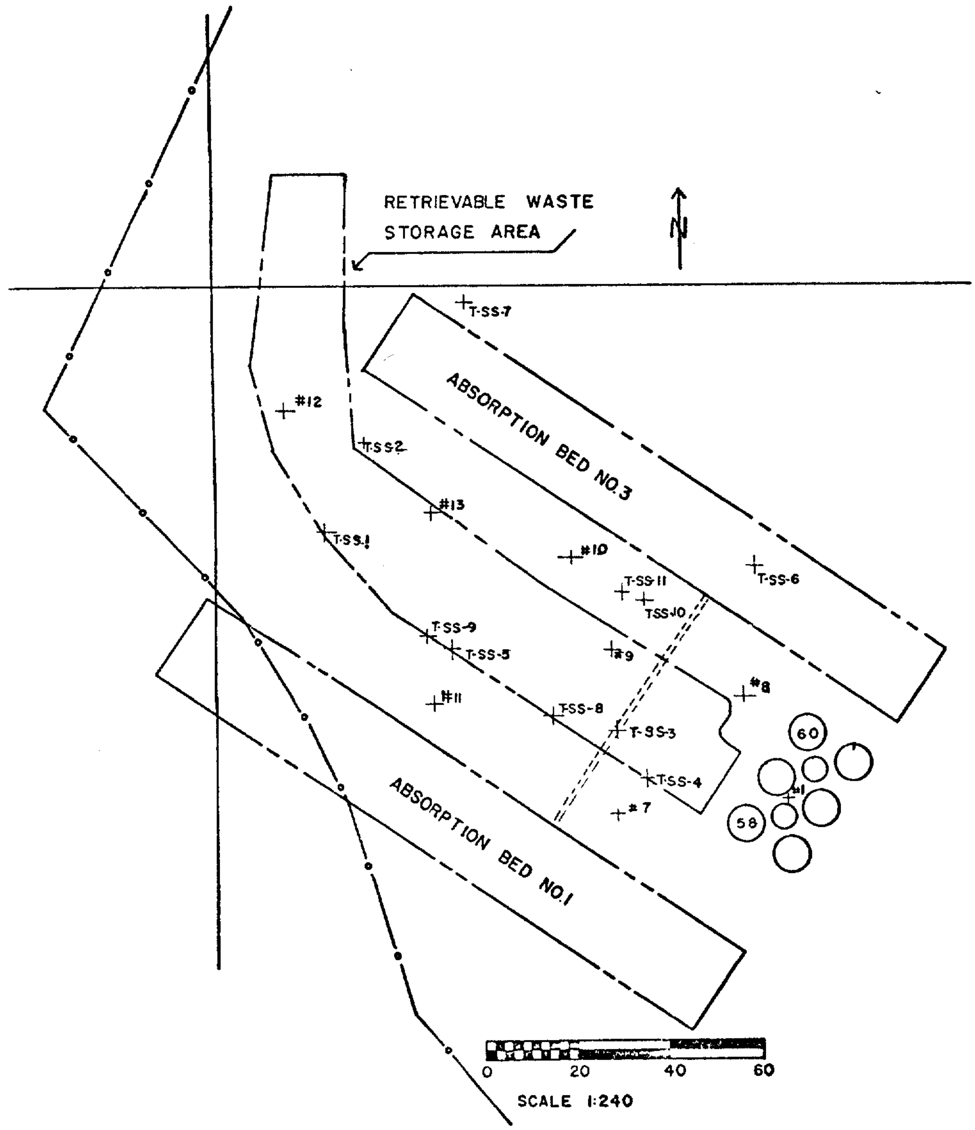


Fig. T-13.
Location of samples taken during excavation of the Retrievable Waste Storage Area pit, Area T, October 30, 1974.

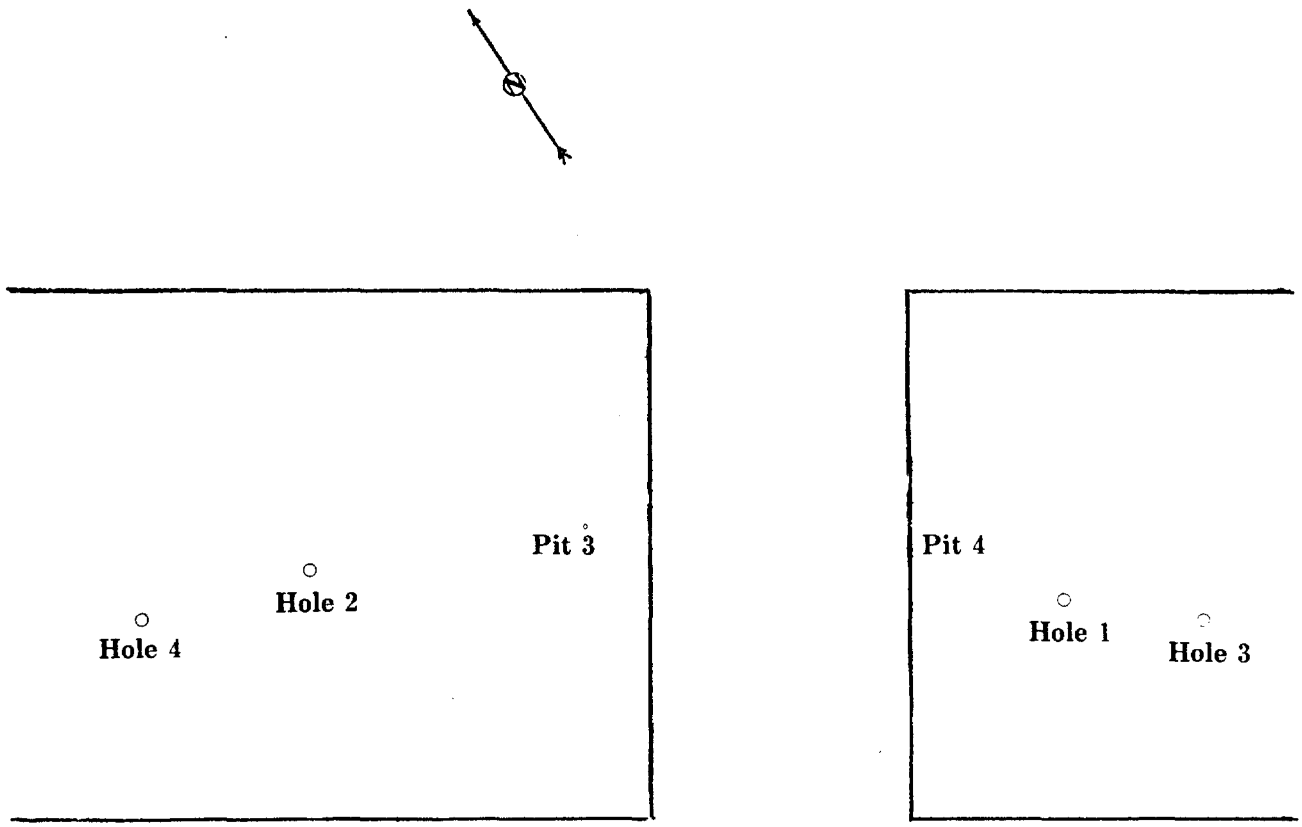


Fig. T-14.
Core sample holes, Area T absorption beds.[285]

TABLE T-XV

ZINC-SULFIDE SCINTILLATION DETECTOR ANALYSES OF CORES FROM BENEATH ABSORPTION BEDS 3 AND 4, AREA T[285]

Hole No. 1 Depth, in.	Bed 4 pCi/g	Hole No. 2 Depth, in.	Bed 3 pCi/g	Hole No. 3 Depth, in.	Bed 4 pCi/g	Hole No. 4 Depth, in.	Bed 3 pCi/g (Est)
0 - 6	950	0 - 6	2895	0 - 6	185	0 - 6	300
6 - 12	195	6 - 12	1850	6 - 12	105	6 - 12	170
12 - 18	1100	12 - 30	150	12 - 18	60	12 - 18	100
NOTE: Hole was abandoned because of caving.		30 - 35	75	18 - 24	45	18 - 24	80
		36 - 42	15	24 - 30	5	24 - 30	60
		42 - 48	20	30 - 36	50	30 - 36	55
		48 - 54	460	36 - 42	65	36 - 42	55
		54 - 66	Background	42 - 48	30	42 - 48	45
		66 - 72	40	48 - 54	15	48 - 54	30
		72 - 84	Background	54 - 60	30	54 - 60	10
				60 - 66	570	60 - 66	Background*
				66 - 72	25	66 - 72	230
				72 - 138	Background*	72 - 78	60
						78 - 84	50
						84 - 90	70
						90 - 96	70
						95 - 102	65
						102 - 108	50
						108 - 114	55
						114 - 120	35
						120 - 126	60
						126 - 132	55
						132 - 138	65
						138 - 144	50
						144 - 150	50
						150 - 156	50
						156 - 162	50
						162 - 168	50
						168 - 174	20
						174 - 240	Background

*Less than 10 pCi/g