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Ground-Water Monitoring Waiver Demonstration For Surface Impoundments At Technical Area 53

Los Alamos National Laboratory
Environmental Protection Group, EM-8
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RESPONSIVE TO THE NEEDS OF ENVIRONMENTAL MANAGEMENT

GROUND-WATER MONITORING WAIVER DEMONSTRATION FOR SURFACE IMPOUNDMENTS AT TECHNICAL AREA 53

FINAL

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1.0 INTRODUCTION

This document provides information necessary to demonstrate a variance from 1990 Code of Federal Regulations Title 40 (40 CFR) Part 264, Subpart F, in accordance with 40 CFR 264.90(b)(4), for three surface impoundments at Los Alamos National Laboratory (LANL). The surface impoundments are located in Technical Area (TA) 53. Subpart F requires ground-water monitoring unless it can be demonstrated that there is no potential for migration of liquid from the waste management facility via the uppermost aquifer to water supply wells or to surface water. However, because demonstrating that no potential for migration exists is not feasible under the best of circumstances, this document demonstrates that the migration potential is low.

Information presented in this document demonstrates the low potential for migration of hazardous waste or hazardous waste constituents to the uppermost aquifer because:

(1) the unsaturated characteristics of the vadose zone below the TA-53 surface impoundments on Mesita de Los Alamos demonstrate low gravimetric moisture content (typically less than 10 percent) with depth, similar to the field measurements obtained for TA-54; and

(2) the annual evapotranspiration equals or exceeds the annual mean precipitation, resulting in a negative annual infiltration at TA-53.

Additionally, the closest water supply well (PM-3) is located in the Pajarito well field, approximately 3,000 feet down gradient from the TA-53 facility. At an approximate rate of ground-water flow in the uppermost aquifer near TA-53 of 20 feet per year (ft/yr) to 250 ft/yr, any hazardous waste or hazardous waste constituents reaching the uppermost aquifer would require a travel time to this water supply of 12 years or more.

2.0 FACILITY DESCRIPTION

2.1 FACILITY LOCATION

LANL is located in Los Alamos County in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1). The LANL facilities occupy an area of 43 square miles. TA-53 is one of 34 developed technical areas operated at LANL. The TA-53 surface impoundments are located on Mesita de Los Alamos, approximately 1,200 to 1,600 feet north of East Jemez Road (Figure 2).

The communities nearest LANL are Los Alamos, located approximately three miles northwest of TA-53, and White Rock, located approximately four miles southeast of TA-53. The total population of Los Alamos County is approximately 19,000. Most of Los Alamos County, as well as adjoining portions of neighboring Sandoval, Rio Arriba, and Santa Fe Counties, is undeveloped. The only significant land developments in Los Alamos County are the LANL facilities and the associated residential communities. Large tracts of land in the Jemez Mountains, which lie to the north, west, and south of Los Alamos, are held by the U.S. Forest Service and the National Park Service. This land is largely occupied by pine, fir, and aspen forests. Agriculture in the vicinity of LANL is limited to home gardens and some cattle grazing. In the river valleys to the east, agriculture is limited to the cultivation of relatively small, irrigated plots.

2.2 GEOLOGIC SETTING

LANL is located on the Pajarito Plateau, which is comprised of volcanic and sedimentary rocks along the east-central flank of the Jemez Mountains. The plateau is aligned approximately north-south and is about 20 to 25 miles long and five to ten miles wide. The plateau, which slopes

gently eastward from the mountains toward the Rio Grande, has been dissected into a number of narrow finger-like mesas by southeast-trending intermittent streams. One of these mesas, Mesita de Los Alamos, is the site of TA-53. This mesa is bounded on the north by Los Alamos Canyon and on the south by Sandia Canyon.

The stratigraphy of Mesita de Los Alamos is a series of unconsolidated sediments and volcanic extrusive rocks and is typical of a terrain produced by concurrent sedimentation and volcanism. In ascending order, the following rock units are present at Mesita de Los Alamos: the Tesuque Formation, the Puye Formation, basaltic rocks of Chino Mesa, and the Bandelier Tuff (IT Corporation, 1987). The Tesuque Formation, consisting of siltstone and sandstone with conglomerate lenses and basalt layers, is overlain by conglomerates and sandstones of the Puye Formation. Overlying and interfingering with the Puye Formation are the dense basalt flows and scoria of the basaltic Chino Mesa rocks. The Bandelier Tuff, which consists of numerous ashfall and ashflow units and overlies the Puye Formation and Chino Mesa flows, caps the mesa (IT Corporation, 1987).

The Bandelier Tuff at Mesita de Los Alamos consists of the Tshirege, Tsankawi, Otowi, and Guaje Members (Appendix A). The Tshirege Member has been broken out into distinct units, which include, in descending order, Tshirege 2B, 2A, 1B, and 1A. The thicknesses of these units at Mesita de Los Alamos are approximately 65, 45, 20, and 23 feet, respectively (Appendix A). Underlying the Tshirege Member is a 19-foot-thick section of the Tsankawi Member (Appendix A). The Otowi Member of the Bandelier Tuff, which is overlain by the Tsankawi Member, varies from about 120 to 180 feet thick. The thickness of the lowest member of the Bandelier Tuff, the Guaje Member, is approximately 35 feet (Purtymun, 1975). Underlying the Bandelier Tuff are the Puye Formation and basaltic rocks of Chino Mesa which, near TA-53, have a combined thickness

of at least 680 feet (Purtymun, 1975). Together, the Bandelier Tuff and upper Puye Formation form a vadose zone approximately 1,000 feet thick between the Pajarito Plateau and uppermost aquifer.

2.3 SURFACE WATER HYDROLOGY

2.3.1 Proximity to Surface Water

The nearest perennial navigable stream is the Rio Grande, located approximately five miles southeast of TA-53. The surface impoundments are bordered on the north by Los Alamos Canyon and on the south by Sandia Canyon. Sandia Canyon has a smaller drainage area than Los Alamos Canyon, and both are subject to high runoff during periods of localized, high-intensity summer thunderstorms. Perennial flow is maintained in sections of Los Alamos and Sandia Canyons by the release of effluent from industrial waste treatment plants, sewage plants and cooling water from the power plant and may occur up to a mile downstream of the points of discharge (Purtymun, 1975). Stream loss due to infiltration into the underlying alluvium and evapotranspiration typically prevents surface flow in these canyons from discharging across the eastern boundary of LANL. In periods of excessive storm runoff or snowmelt, surface flow may reach the Rio Grande (Abeele et al., 1981). Hydrogeologic investigations of the perched zones within the canyon alluvial systems indicate that there is no hydrologic connection to the deeper regional aquifer (IT Corporation, 1987; Purtyman and Stoker, 1990; Stoker, et al., 1991). A conceptual diagram of the geologic and hydrologic relationships in the vicinity of LANL is shown in Figure 3.

2.3.2 Flooding Potential of Site

The surface impoundments are not subject to flooding from overland flow because natural drainage flows away from the impoundments into the deep canyons adjacent to Mesita de Los

Alamos. The surface elevation of the mesa is 6,900 feet or higher. The elevation in the adjacent southern Sandia Canyon floor is 6,700 feet or lower. In Los Alamos Canyon to the north, the canyon floor elevation is 6,600 feet or lower. Additionally, overland flow to the surface impoundments is diverted by the impoundment berms.

The TA-53 surface impoundments are not located within the 100-year floodplain boundary. LANL has mapped all 100-year floodplain boundaries within the LANL complex (Figure 4). The mapping procedure utilized techniques that comply with 40 CFR 270.14 (b) (11) (iii). A report documenting these floodplain mapping procedures is currently in press (McLin, 1992). Actual floodplain boundary location maps, currently being finalized, will supplement the floodplain report.

2.4 GROUND-WATER HYDROLOGY

The main aquifer in the Los Alamos area is the only aquifer capable of producing a municipal and industrial water supply. The upper surface of the main aquifer slopes eastward from west of the Pajarito Plateau to the Rio Grande (Purtymun, 1984).

In the area of TA-53, the upper surface of the main aquifer is contained in the conglomerates and sandstones of the Puye Formation. The direction of ground-water flow in the uppermost aquifer in this region is to the east-southeast, and the velocity ranges from 20 to 250 feet/year (Figure 5). The transmissivity of the main aquifer at the PM-3 well in Sandia Canyon, 3,000 feet southeast of the impoundments, is approximately 320,000 gallons per day per foot (IT Corporation, 1987) (Figure 2). The main aquifer was encountered at a depth of about 750 feet below the land surface at the Otowi-4 well location in Los Alamos Canyon, just northwest of the TA-53 surface impoundments (Figure 2). The depth to the uppermost aquifer at the TA-53 site is approximately 1,000 feet.

3.0 DESCRIPTION OF TA-53 SURFACE IMPOUNDMENTS

The surface impoundments are identified with LANL Structure No. TA-53-166. Each impoundment is further identified in this document as TA-53-166 Northeast (NE), TA-53-166 Northwest (NW), and TA-53-166 South (S). The largest impoundment, TA-53-166 S, was constructed in 1985 and is approximately 305 feet in length by 148 feet in width and is six feet deep. It is lined with Hypalon (36 mil thick) and has a liquid storage capacity of 2,580,000 gallons. TA-53-166 NE and TA-53-166 NW were constructed in 1969. These two impoundments are 210 feet in length by 210 feet in width and are six feet deep. Both impoundments have Gunite sides and bentonite clay bottoms. TA-53-166 NE and NW have liquid storage capacities of 1,629,144 gallons each.

The waste of concern in the surface impoundments is the sludge located at the bottoms of the impoundments. The sludge may contain metals, organic compounds, and low-level radionuclides. The TA-53-166 NE and NW impoundments have received sanitary waste since their construction in 1969; they also received radioactive and industrial waste until 1989. The TA-53-166 S impoundment received sanitary, industrial and radioactive waste from the time of its construction in 1985 until 1989, at which time the influent to the impoundment was modified so that it became the only impoundment to receive radioactive waste. It periodically may receive sanitary waste from the other impoundments to maintain appropriate liquid levels and weigh down the Hypalon liner as well as to avoid concentrating radioactive compounds in the liquid.

4.0 POTENTIAL FOR MIGRATION

4.1 POTENTIAL MIGRATION DUE TO PRECIPITATION

Potential migration of hazardous waste or hazardous waste constituents due to infiltration at TA-53 may be computed using a water balance equation provided in the U.S. Environmental Protection Agency Manual SW-921 (1981). The equation is as follows:

$$=P - ET - R$$

where I =Infiltration

P=Precipitation

ET=Evapotranspiration

R=Runoff

Precipitation

The annual mean precipitation at TA-53 is approximately 15 inches (Bowen, 1989). For a return period of 100 years, the average annual precipitation for Los Alamos has been estimated to range from approximately 24 inches (TA-54) to 34 inches (TA-59) (Bowen, 1989).

Evapotranspiration

Potential evapotranspiration in the Los Alamos area may range between 24 and 36 inches annually (Daughty et al., 1975). However, ET is constrained by the actual amount of precipitation. Therefore, a conservative estimate of potential ET equal to 15 inches, or the annual mean precipitative, has been selected for purposes of this ground-water monitoring waiver demonstration. This ET value is consistent with the range of ET values (12.67 to 18.56 inches) calculated by NMED (NMED, 1984).

Runoff

Maximum runoff due to a 24-hour, 100-year precipitation event is calculated to range from about 1.7 to 2.6 inches, using the Soil Conservation Service curve number method (U.S. Department of Agriculture, 1973) (Appendix B). The conservative runoff calculation assumes that the surface impoundments act as a soil surface with 20 percent vegetative cover. These values agree closely with actual runoff values measured at Frijoles Canyon in Bandelier National Monument (Purtymun and Adams, 1980).

Infiltration

From the above estimates of precipitation, evapotranspiration, and runoff, a reasonable scenario for annual infiltration at TA-53 becomes:

$$I = P - ET - R$$

$$I = 15 \text{ inches} - 15 \text{ inches} - 1.7 \text{ inches}$$

$$I = -1.7 \text{ inches}$$

Worst-case infiltration scenarios calculated by NMEID (1984) ranged from zero (0) inches to 5.61 inches (high antecedent moisture content). However, the conclusion that average annual infiltration is essentially zero has been observed by field experimentation at TA-54. A moisture content study showed that precipitation and seasonal variations did not influence the vadose zone tuffs below a depth of approximately 22 feet (IT Corporation, 1987; Bendix Field Engineering Corporation, 1986, 1985). Gravimetric moisture content measured for samples collected at TA-53 are comparable to values obtained for TA-54. Gravimetric moisture content at TA-53 typically ranges from 5 to 10 percent with some intervals ranging from 10 to 20 percent (Appendix C).

4.2 POTENTIAL MIGRATION DUE TO SURFACE IMPOUNDMENT LEAKAGE

For the purposes of evaluating the potential migration due to surface impoundment leakage at TA-53, the worst case scenario will be examined. The two north impoundments TA-53-166 (NE) and TA-53-166 (NW) have the largest relative potential for leakage because the bentonite clay liners have a greater hydraulic conductivity than the Hypalon liner at the south impoundment TA-53-166 (S). The four-inch-thick bentonite clay liners at the north impoundments would be expected to have a saturated hydraulic conductivity of approximately 10^{-10} centimeters per second (cm/s) or lower while the Hypalon liner (36-mil thick) has a typical saturated hydraulic conductivity of 10^{-11} cm/s. Based on the relative hydraulic conductivity the worst case scenario to be evaluated is that of leakage through the bentonite liners at the north impoundments. Leakage, in terms of infiltration through the bentonite clay liners may be calculated from the Darcy flow equation (Davis and DeWiest, 1966):

$$Q = KA(dh/dl)$$

where Q = Flow Rate

K = Saturated Hydraulic Conductivity

A = Cross Sectional Area

dh = Hydraulic Head

dl = Distance Dissipating Active Head

Saturated Hydraulic Conductivity

For bentonite/sand mixtures where the percentage of bentonite is 30 percent or greater, the saturated hydraulic conductivity is 10^{-10} centimeters per second (cm/s) or lower (Fernandez et al., 1987).

Cross Sectional Area

The surface area for both TA-53-166 NE and NW is 210 feet by 210 feet, or 44,100 square feet.

Hydraulic Head

The hydraulic head required to produce leakage at the bottoms of the impoundment liners, assuming a liquid depth of six feet, is the liquid depth plus the liner thickness. The total hydraulic head, therefore, equals six feet plus 1/3 foot (the four-inch liner thickness), or 19/3 feet.

Distance Dissipating Active Head

The distance over which the hydraulic head is absorbed is the thickness of the impoundment liner, which is 1/3 foot.

Flow Rate

The flow rate of leakage through the bottoms of the two north impoundments becomes:

$$Q = 2KA(dh/dl)$$

$$Q = (2)(10^{-10}\text{cm/s})(1\text{ in}/2.54\text{ cm})(1\text{ ft}/12\text{ in})(44{,}100\text{ ft}^2)(19/3\text{ ft})/(1/3\text{ ft})$$

$$Q = 54{,}980(10^{-10})\text{ ft}^3/\text{sec} = 0.055(10^{-4})\text{ ft}^3/\text{sec}$$

The volume of liquid leaking through the two north impoundments in one day becomes:

$$V_L = Q(t) = 0.055(10^{-4})\text{ ft}^3/\text{sec}(60\text{ sec}/1\text{ min})(60\text{ min}/1\text{ hr})(24\text{ hr}/1\text{ day})$$

$$V_L = 0.475\text{ ft}^3/\text{day}$$

$$V_L = (0.475\text{ ft}^3/\text{day})(7.48\text{ gal}/\text{ft}^3) = 3.553\text{ gal/day}$$

The leakage through the bentonite clay bottom of each surface impoundment per year in terms of infiltration per square foot of impoundment bottom becomes:

$I_P = V_L/A$

$I_P = (1/2)(3.55\ gal/day)(365\ day/yr)(0.1337\ ft^3/gal)/(44{,}100\ ft^2) = 1.96(10^{-3})\ ft/yr$

$I_P = (0.00196\ ft/yr)(12\ in/ft) = 0.024\ in/yr$

The estimated total for each impoundment-induced infiltration becomes:

$I_T = (I_p)$ (Total number of years of impoundment existence)

$I_T = (0.024\ in/yr)(22\ yr) = 0.53$ inches.

To establish whether or not leakage from the impoundments occurred, eight boreholes were drilled at locations near the surface impoundments as shown in Figure 6. One background borehole (B) was drilled to a depth of 50 feet approximately 500 feet west of the NW impoundment to establish background moisture levels. Four boreholes (#1-4) were placed adjacent to the impoundments to a depth of 50 feet. These boreholes were completed as neutron-moisture access wells. Borehole 5 was drilled between the three impoundments to a depth of 100 feet and completed with a pore-gas monitoring system. Borehole 6 was drilled to a depth of 150 feet between the NW and NE impoundments and the final borehole (#7) was drilled near the head of a small canyon south-west of the impoundments to identify impact from the impoundments at depths beyond Boreholes 1-6 and "B". Borehole 7 was completed as a neutron-moisture access well with a cup lysimeter. Gravimetric and volumetric moisture contents were obtained from the boreholes at selected intervals below the mesa surface (Appendix C). Gravimetric and volumetric moisture content typically vary between five and ten percent with a few samples peaking to 21 percent in the Tshirege member of the Bandelier Tuff (Table 1) . Moisture content, both gravimetric and volumetric, increase in the Tsankawi Tuff, ranging between 9 to 20 percent with peaks of 33 percent (volumetric) at the base of the unit (Borehole 7).

Moisture content decreases significantly in the underlying Otowi member, ranging from 12 to 16 percent, with peaks of 18 percent.

In comparison, the volumetric moisture content is slightly lower in the Tshirege member of the Bandalier Tuff at TA-54 (where there are no surface impoundments) and varies between two and four percent, with a few samples peaking to the 20 percent range (IT Corporation, 1987; Bendix Field Engineering Corporation, 1986, 1985). Therefore, the TA-53 samples may indicate that some leakage from the impoundments has taken place. However, the overall moisture content at both TA-53 and TA-54 is too low to support saturated flow in the Bandelier Tuff. This is confirmed in that no saturated zones or perched water bodies were encountered during the borehole drilling at either site.

The Bandelier Tuff is very porous, averaging 50 percent porosity, and has high moisture retention properties. While the investigation of the hydrologic properties of tuff at the TA-54 site is much more extensive than for the TA-53 site, the average characteristics are expected to be very similar. The preliminary results from the TA-53 hydrogeologic investigations seem to substantiate these expectations. Average hydraulic properties for moderately-welded Bandelier Tuff are useful in estimating the potential of hazardous waste migration in the solute phase. For example, volumetric moisture contents below four percent result in no migration; from four to eight percent, moisture is distributed by diffusion; from eight to 23 percent, moisture is distributed by capillary action; and above 23 percent, the movement of moisture is by capillary action and gravity drainage (Purtymun and Stoker, 1987). Based on the moisture levels exhibited, there is very low potential for hazardous waste or hazardous waste constituents to migrate through the vadose zone at TA-53 to the uppermost aquifer located approximately 1,000 feet below the site.

Vertical and near-vertical fractures (formed during cooling of the volcanically deposited material) are common in the Bandelier Tuff, although the degree of openness or pervasiveness of individual fractures is not well characterized. Field evidence indicates that fractures can be either a capillary barrier to saturated flow, or preferential paths for infiltration (Abeele et.al., 1981). Further fracture characterization at TA-53 would be necessary to model the transport mechanism role in the vadose zone.

4.3 POTENTIAL MIGRATION WITHIN THE UPPERMOST AQUIFER

The uppermost aquifer beneath the TA-53 site is located within the Puye Formation and the Tesuque Formation at a depth of approximately 1,000 feet. In the unlikely event that hazardous waste or hazardous waste constituents reach the uppermost aquifer there is high potential for migration within the aquifer. The direction of potential migration would be southeast toward the Rio Grande. Hydraulic conductivity varies between different hydrostratigraphic units and typically ranges from $1x10^{-4}$ to $5x10^{-3}$ cm/s at the major well fields (Purtymun and Stoker, 1987; Purtymun, 1984).

The velocity of ground water in five locations at LANL have been calculated by Purtymun (1984), and are shown on Figure 5. The potential migration rate of hazardous waste or hazardous waste constituents in the uppermost aquifer nearest the TA-53 surface impoundments might range from 20 to 250 feet per year.

4.4 POTENTIAL MIGRATION TO THE NEAREST WATER SUPPLY

Three major well fields have been developed in the uppermost aquifer to support Los Alamos County; Los Alamos, Guaje, and Pajarito well fields. The Pajarito well field near TA-53 is located down gradient from the surface impoundments. Two supply wells in the Pajarito well field have

been constructed in Sandia Canyon (Figure 2). Well PM-3 is located approximately 3,000 feet down gradient from the impoundments and has a high potential to intercept hazardous waste or hazardous waste constituents that might migrate in the uppermost aquifer. The depth to ground water at this well is 762 feet. In the unlikely event that hazardous waste or hazardous waste constituents reached the uppermost aquifer they could potentially reach the location of well PM-3 in approximately 12 years assuming a maximum ground-water velocity of 250 feet per year.

5.0 SUMMARY

The surface impoundments at TA-53 have a very low potential for affecting ground water in the uppermost aquifer, which is approximately 1,000 feet below the surface. Only infiltration, followed by migration through several hundred feet of unsaturated tuffaceous materials, could potentially contaminate local ground water. Samples from boreholes in the immediate vicinity of the surface impoundments indicate that, after more than 20 years of operation, the gravimetric moisture content of the underlying tuffs remains unsaturated. In the Tshirege member of the Bandelier Tuff underlying the surface impoundments gravimetric moisture content typically ranges from five to ten percent, with an occasional moisture spike reaching 20 percent of the sample by weight. Similarly, at TA-54, (where there are no surface impoundments) the moisture content of the underlying tuffs typically varied from two to four percent with an occasional moisture spike of 20 percent by volume. The moisture content at either site is insufficient to support saturated flow to the uppermost aquifer. Although perched water is found in the adjacent canyons, no perched water has been found in the unsaturated tuffs below the impoundments at TA-53. The perched water in the alluvium of Los Alamos and Sandia Canyons appears to be hydrologically isolated from the uppermost aquifer by a thick sequence of unsaturated tuff and sediment (Purtymun and Stoker, 1990; Purtymun and Stoker, 1987; Devaurs and Purtymun, 1985). If, in the unlikely event that hazardous waste or hazardous waste constituents reach the uppermost aquifer there is high potential for migration within the uppermost aquifer to nearby water-supply wells within a relatively short time (12 years).

6.0 CERTIFICATION STATEMENT

I, Devon E. Jercinovic, a certified professional geologist, certified by the American Institute of Professional Geologists, do hereby certify that, in my best professional opinion, the contents of this document are correct and that the current operational practices meet the intent of controlling migration from hazardous waste management facilities.

Name of Geologist

4/8/92

Date

7823

Certificate Number

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TABLE 1

Summary of Gravimetric and Volumetric Moisture Contents for Lithologic Units in the Bandelier Tuff at TA-53

Lithologic Units of the Bandelier Tuff	Depth Interval (Ft.)	Gravimetric Moisture Range (%)	Maximum Gravimetric Moisture (%)	Volumetric Moisture Range (%)	Maximum Volumetric Moisture (%)
Tshirege 2B	0-68	1-21	21	5-10	20
Tshirege 2A	68-113	2-20	20	No measurement	No measurement
Tshirege 1B	113-133	8-14	14	No measurement	No measurement
Tshirege 1A	133-156	2-19	19	8-18	20
Tsankawi	156-175	9-20	20	16-28	33
Otowi	175-2122	12-16	16	14-16	18

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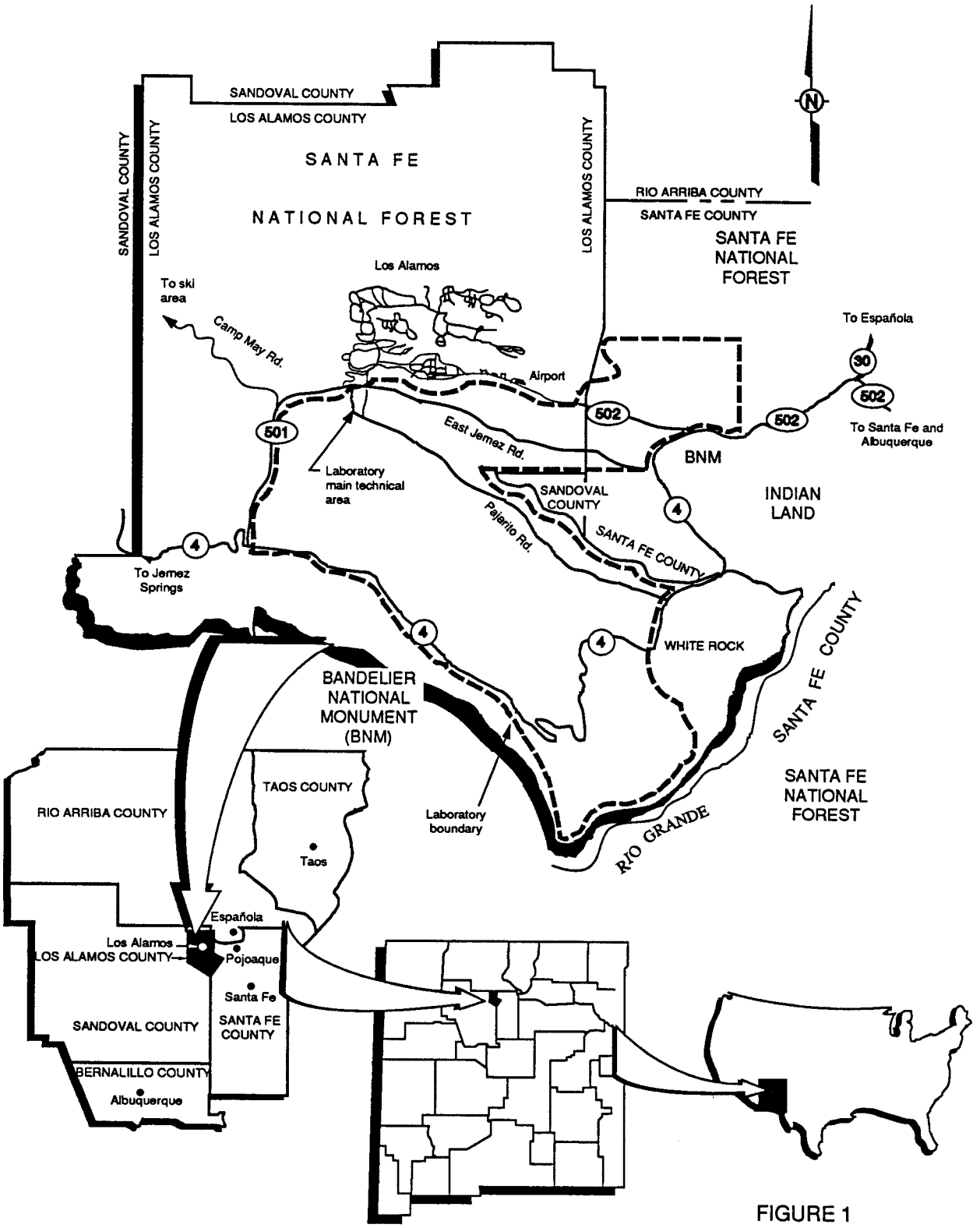


FIGURE 1

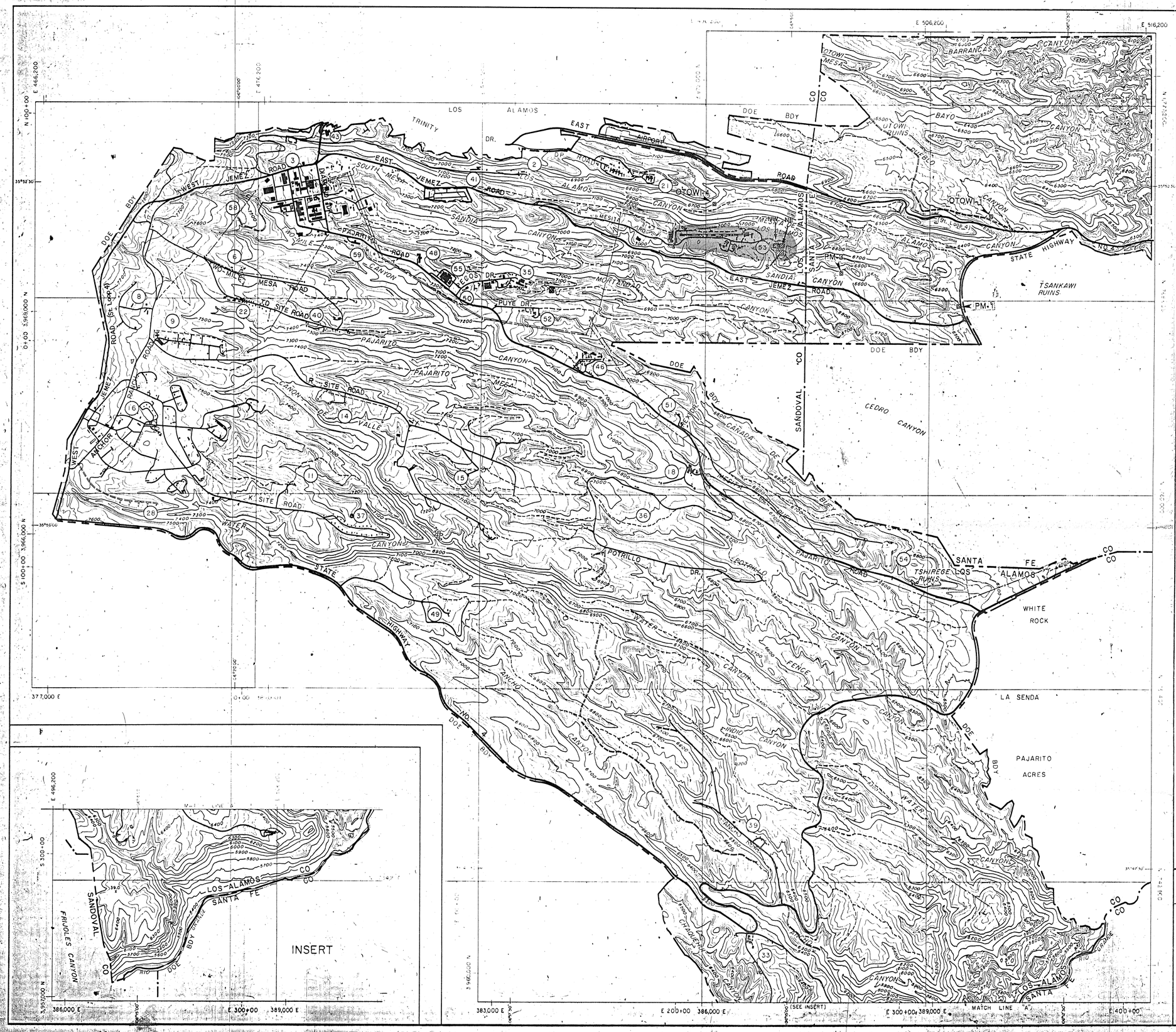
REGIONAL LOCATION OF LOS ALAMOS

PREPARED FOR

LOS ALAMOS NATIONAL LABORATORY

REFERENCE: ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1989, LANL

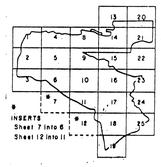
INTERNATIONAL TECHNOLOGY CORPORATION

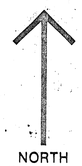


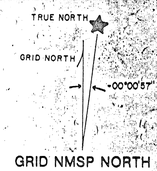
LEGEND

X 93.0	SPOT ELEVATION	N 1,768,000 NMSP GRID
6900	INDEX CONTOUR	3,989,000 N UTM GRID
	INTERMEDIATE CONTOUR 20ft.	N 240+00 LASL GRID
	SUPPLEMENTARY CONTOUR 10ft.	
	CONTOURS THROUGH HEAVY VEGETATION	
	COUNTY LINES – TRANSFERRED FROM USGS 1:24,000 QUADRANGLES.	
	DOE BOUNDARY – X & Y COORDINATE DATA PROVIDED BY LASL.	
	DOE BOUNDARY – SURVEY DESCRIPTIONS OR RECORD PLATS PROVIDED BY LASL.	
	DOE BOUNDARY – TRANSFERRED FROM USGS 1:24,000 QUADRANGLES BASED ON PROJECTED COUNTY LINES.	
35	TECHNICAL AREA NO.	
	BUILDING	
	PAVED ROAD	
	DIRT ROAD	
	JEEP TRAIL	
	TUNNEL	
	EARTHEN BUNKERS	
	POWER LINE	
	TANK	
	POND	

SHEET LAYOUT







MAPPING COMPLETED BY PHOTOGRAMMETRIC METHODS, UTILIZING 1:30,000, 1:12,000 & 1:13,200 PHOTOGRAPHY, OBTAINED IN NOV. 1976 & JUNE 1980 WITH ZEISS RMK A 15/23 CAMERAS OF 153.42 & 152.43mm C.F.L. RESPECTIVELY, MAPPING BASED ON CONTROL SURVEYS TIED TO THE NEW MEXICO STATE PLANE COORDINATE SYSTEM (CENTRAL ZONE). MAPPING COMPLETED IN ACCORDANCE WITH NATIONAL MAP ACCURACY SPECIFICATIONS.

3000 2000 1000 0 2000 4000 6000 8000 FEET

.5 0 2 KILOMETER

GRAPHIC SCALE: 1 in.=2000 ft.

CONTOUR INTERVAL 20 ft.

4272-A

LOS ALAMOS SCIENTIFIC LABORATORY

FIGURE 2

CONTOUR MAP SHOWING TECHNICAL AREAS (TAs) AND ROAD SYSTEM AT LOS ALAMOS NATIONAL LABORATORY (LANL)

LAB JOB NO. 5662

1"=2000' SCALE

PLAN / TOPO

SHEET 1 OF 1

DRAWING NUMBER	301215.01.09 LA9
CHECKED BY	APPROVED BY
GLC	9/2/91
DRAWN BY	

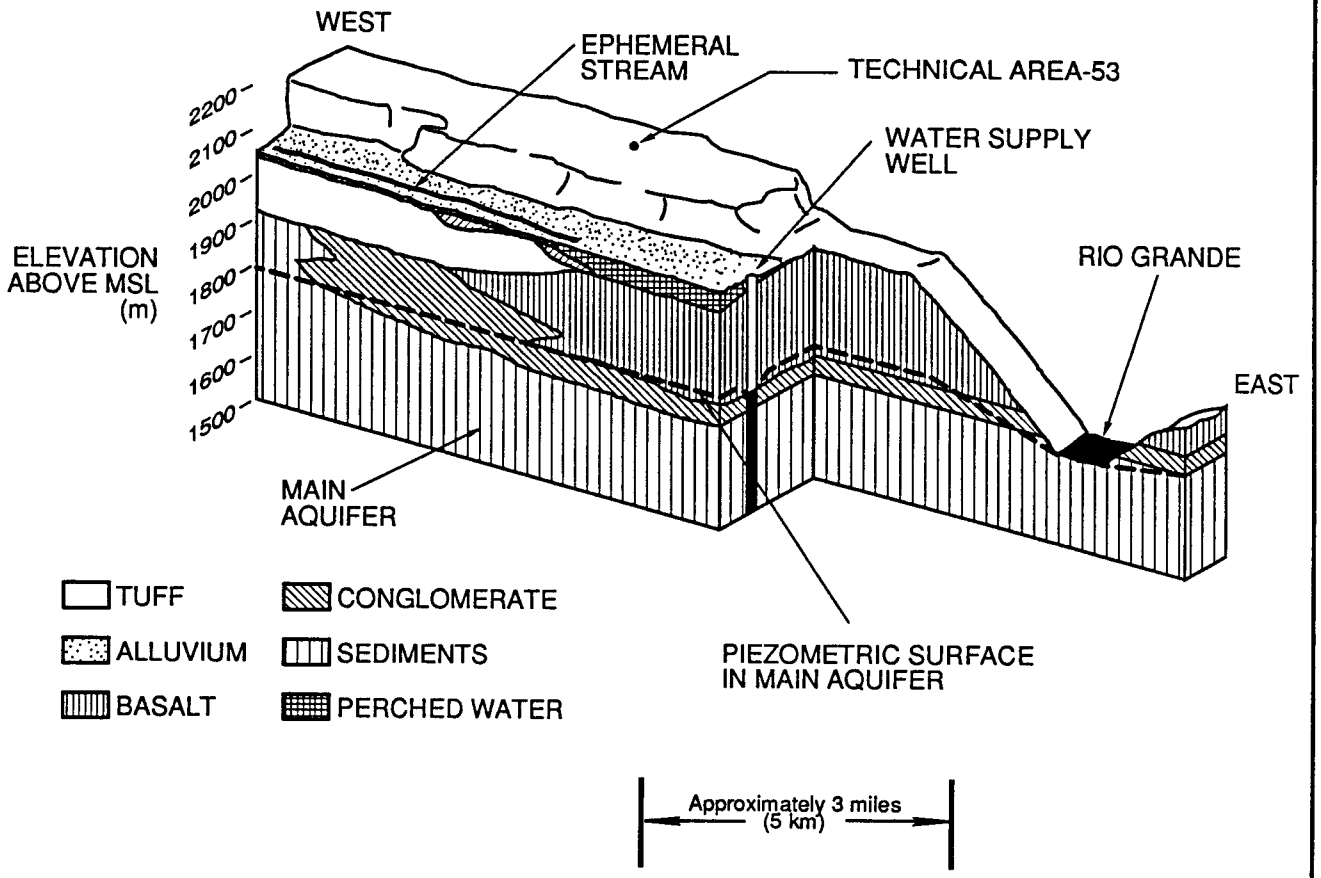


FIGURE 3

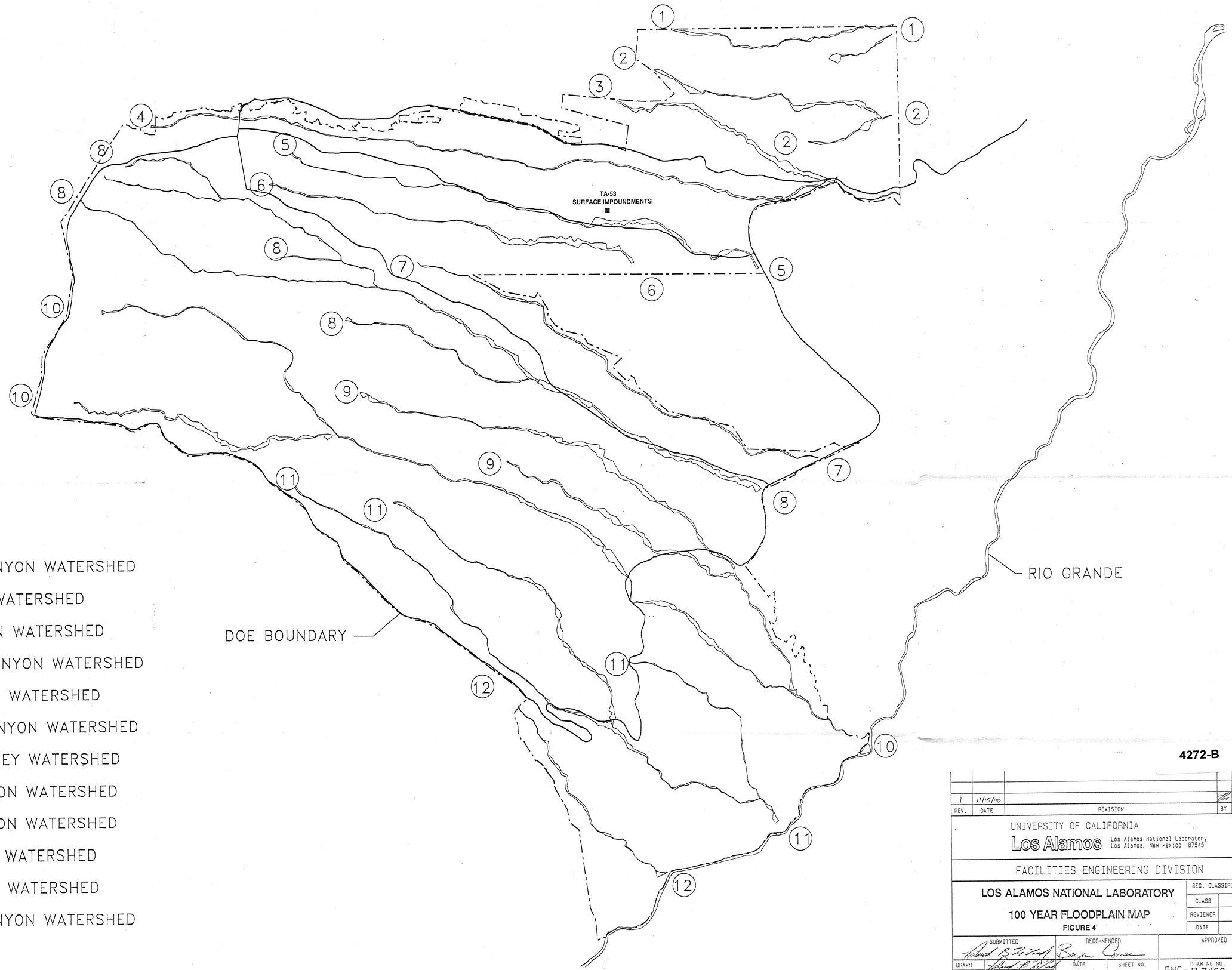
CONCEPTUAL ILLUSTRATION OF GEOLOGIC-HYDROLOGIC RELATIONSHIPS IN THE LOS ALAMOS AREA

PREPARED FOR

LOS ALAMOS NATIONAL LABORATORY

REFERENCE: EXTENT OF SATURATION IN MORTANDAD CANYON,LANL,1991

INTERNATIONAL TECHNOLOGY CORPORATION



LEGEND

1. BARRANCAS CANYON WATERSHED
2. BAYO CANYON WATERSHED
3. PUEBLO CANYON WATERSHED
4. LOS ALAMOS CANYON WATERSHED
5. SANDIA CANYON WATERSHED
6. MORTANDAD CANYON WATERSHED
7. CANADA DEL BUEY WATERSHED
8. PAJARITO CANYON WATERSHED
9. POTRILLO CANYON WATERSHED
10. WATER CANYON WATERSHED
11. ANCHO CANYON WATERSHED
12. CHAQUEHUI CANYON WATERSHED

4272-B

REV.	DATE	REVISION	BY	CKD.	APP
1	11/15/90				

UNIVERSITY OF CALIFORNIA
Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

FACILITIES ENGINEERING DIVISION

LOS ALAMOS NATIONAL LABORATORY

100 YEAR FLOODPLAIN MAP

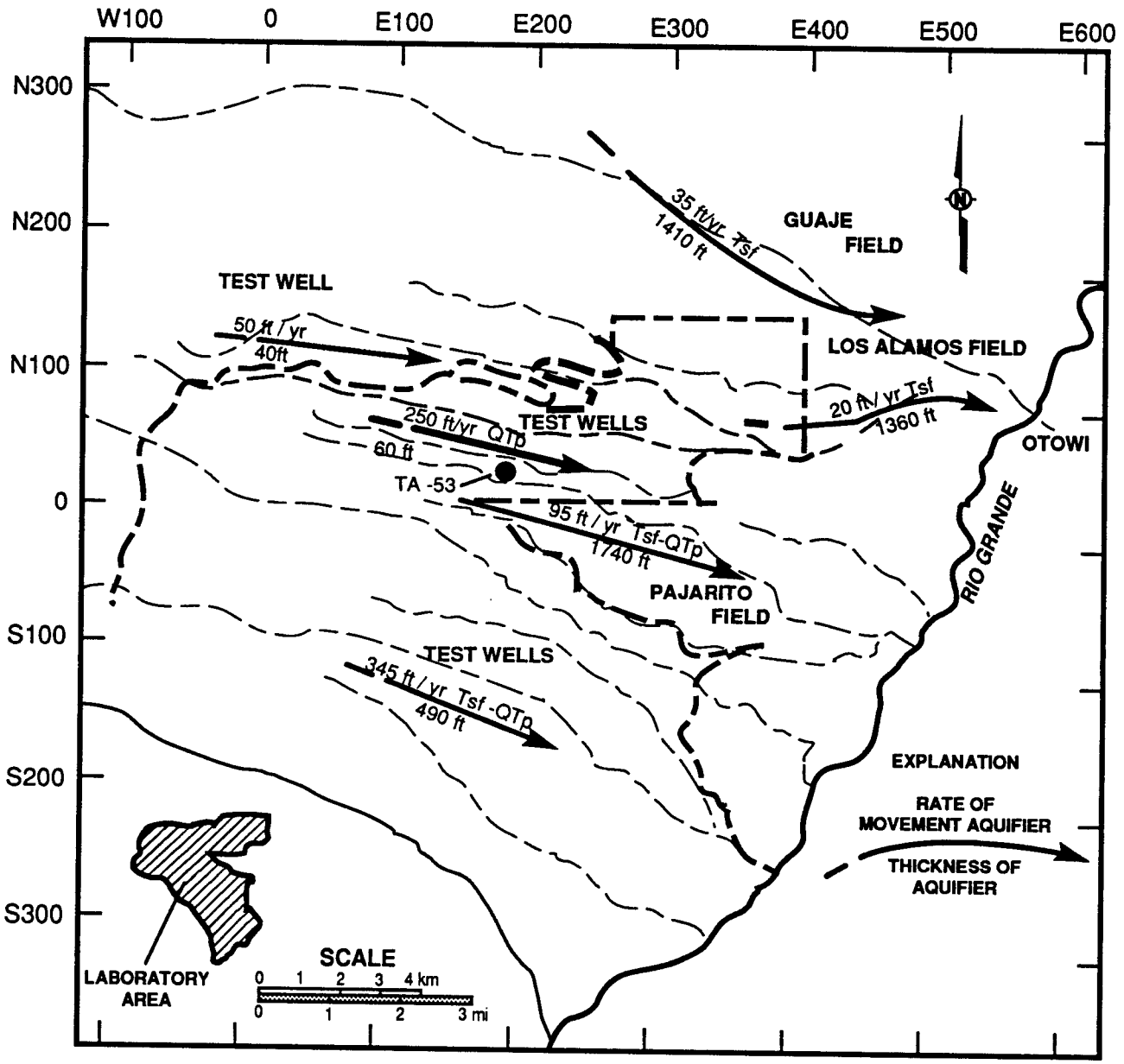
FIGURE 4

SEC. CLASSIFICATION
CLASS
REVIEWER
DATE

SUBMITTED
RECOMMENDED
APPROVED

DRAWN
CHECKED
DATE 11-15-90
SHEET NO. 1 OF 1
DRAWING NO. ENG-R 7160

DRAWN BY	GLC	CHECKED BY			DRAWING NUMBER 301215.01.09 LA12
	9/2/91	APPROVED BY	BH	4/7/93	



QTp
PUYE CONGLOMERATE
Tt
TSCHICOMA FORMATION
Tsf
TESUQUE FORMATION

FIGURE 5

RATE OF MOVEMENT OF WATER IN THE MAIN AQUIFIER

PREPARED FOR

LOS ALAMOS NATIONAL LABORATORY

REFERENCE: LANL Report, LA-9957-MS, 1984

INTERNATIONAL TECHNOLOGY CORPORATION

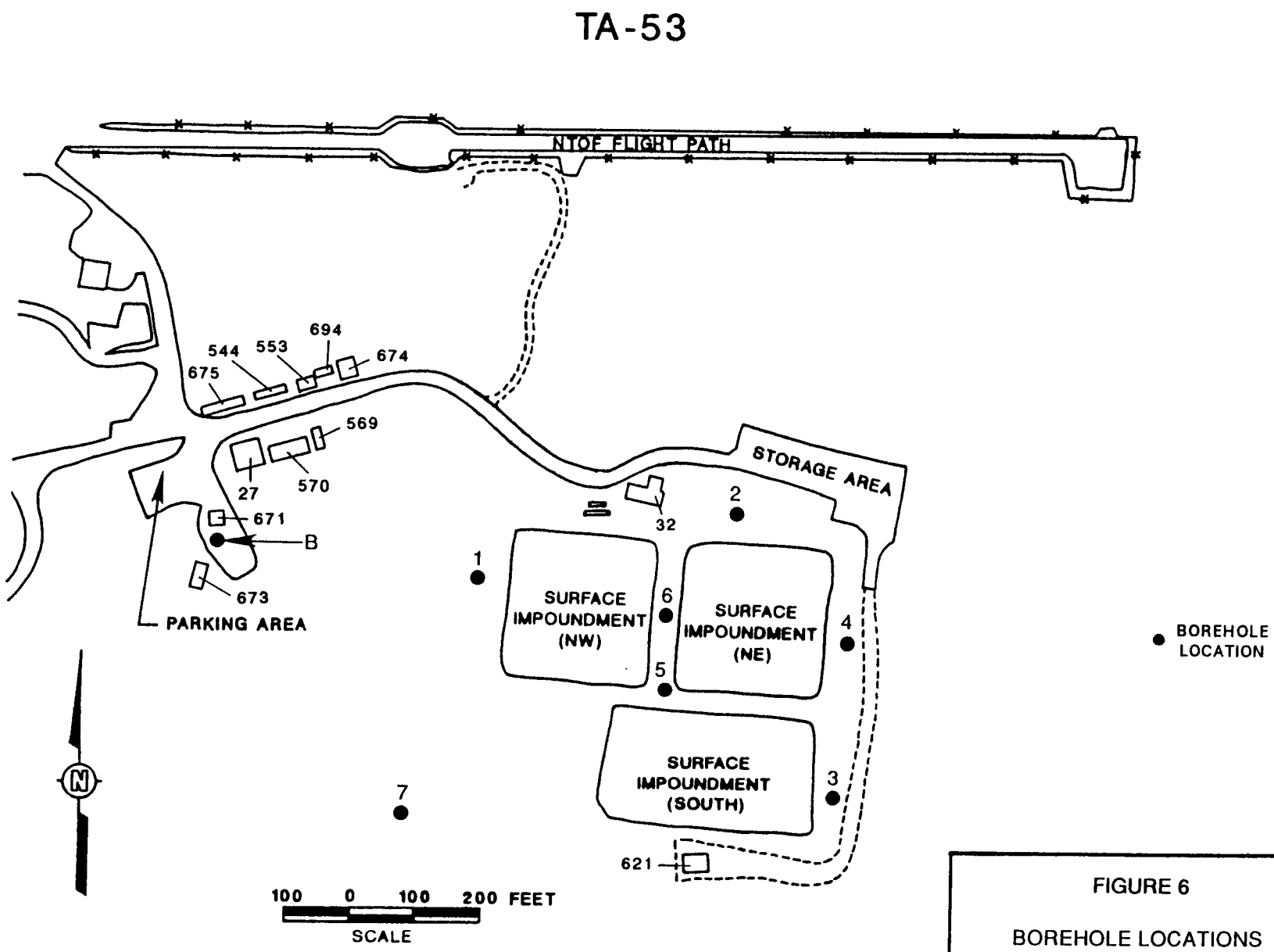


FIGURE 6

BOREHOLE LOCATIONS NEAR THE TA-53-166 SURFACE IMPOUNDMENTS

APPENDIX A

DRILLING LOGS FOR TA-53 MONITORING WELLS

DRILLING LOG

BOREHOLE	: B-53	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Stoker & Gallaher	**TOTAL DEPTH**	: 50 feet
DATE DRILLED	: June 20, 1991	**DIAMETER**	: 4.00 in Auger
LOCATION	: TA-53 Impoundments	**CASING MATERIAL**	: Aluminum

DEPTH	**DESCRIPTION** (all depths in feet below ground surface)
0- 1	Surface fill materials
1-50	Tuff; Tshirege Unit 2b; low moisture; not cored

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->LBA|X|<-- 1 FT OF TOPSOIL COVER
0.5 FT BENTONITE PELLETS ---->SA| |<-- TSHIREGE 2B TUFF AT 1 FT
ANNULUS FILLED WITH SAND ---->SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA|X|<-- COMPLETION DEPTH AT 44.9 FT
                                 |C|<-- TOTAL DEPTH AT 50 FT
```

COMPLETION DIAGRAM IS NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP............L
ALUMINUM CASING, 2 in ID....A
CEMENT GROUT SEAL............B
MEDIUM GRAIN SILICA SAND....S
END-CAP PLUG.................X
HOLE CAVED IN................C
-----------------------------
```

DRILLING LOG

BOREHOLE	: 1-53	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Stoker & Gallaher	**TOTAL DEPTH**	: 50 feet
DATE DRILLED	: June 17, 1991	**DIAMETER**	: 4.00 in Auger
LOCATION	: TA-53 Impoundments	**CASING MATERIAL**	: Aluminum

DEPTH	**DESCRIPTION** (all depths in feet below ground surface)
0- 1	Surface fill materials
1-50	Tuff; Tshirege Unit 2b; low moisture; not cored

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->LBA|X|<-- 1 FT OF TOPSOIL COVER
0.5 FT BENTONITE PELLETS ---->SA| |<-- TSHIREGE 2B TUFF AT 1 FT
ANNULUS FILLED WITH SAND ---->SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA|X|<-- COMPLETION DEPTH AT 45.8 FT
                                |C|<-- TOTAL DEPTH AT 50 FT
```

COMPLETION DIAGRAM IS NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP............L
ALUMINUM CASING, 2 in ID....A
CEMENT GROUT SEAL............B
MEDIUM GRAIN SILICA SAND....S
END-CAP PLUG................X
HOLE CAVED IN...............C
-----------------------------
```

DRILLING LOG

BOREHOLE	: 2-53	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Stoker & Gallaher	**TOTAL DEPTH**	: 50 feet
DATE DRILLED	: June 17, 1991	**DIAMETER**	: 4.00 in Auger
LOCATION	: TA-53 Impoundments	**CASING MATERIAL**	: Aluminum

DEPTH	**DESCRIPTION** (all depths in feet below ground surface)
0- 1	Surface fill materials
1-50	Tuff; Tshirege Unit 2b; low moisture; not cored

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->LBA|X|<-- 1 FT OF TOPSOIL COVER
0.5 FT BENTONITE PELLETS ---->SA| |<-- TSHIREGE 2B TUFF AT 1 FT
ANNULUS FILLED WITH SAND ---->SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA|X|<-- COMPLETION DEPTH AT 46.0 FT
                                 |C|<-- TOTAL DEPTH AT 50 FT
```

COMPLETION DIAGRAM IS NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP............L
ALUMINUM CASING, 2 in ID....A
CEMENT GROUT SEAL...........B
MEDIUM GRAIN SILICA SAND....S
END-CAP PLUG................X
HOLE CAVED IN...............C
-----------------------------
```

DRILLING LOG

BOREHOLE	: 3-53	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Stoker & Gallaher	**TOTAL DEPTH**	: 50 feet
DATE DRILLED	: June 18, 1991	**DIAMETER**	: 4.00 in Auger
LOCATION	: TA-53 Impoundments	**CASING MATERIAL**	: Aluminum

DEPTH	**DESCRIPTION** (all depths in feet below ground surface)
0- 1	Surface fill materials
1-50	Tuff; Tshirege Unit 2b; low moisture; not cored

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->LBA|X|<-- 1 FT OF TOPSOIL COVER
0.5 FT BENTONITE PELLETS ---->SA| |<-- TSHIREGE 2B TUFF AT 1 FT
ANNULUS FILLED WITH SAND ---->SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA|X|<-- COMPLETION DEPTH AT 47.5 FT
                                |C|<-- TOTAL DEPTH AT 50 FT
```

COMPLETION DIAGRAM IS NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP............L
ALUMINUM CASING, 2 in ID....A
CEMENT GROUT SEAL............B
MEDIUM GRAIN SILICA SAND....S
END-CAP PLUG................X
HOLE CAVED IN...............C
-----------------------------
```

DRILLING LOG

BOREHOLE	: 4-53	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Stoker & Gallaher	**TOTAL DEPTH**	: 50 feet
DATE DRILLED	: June 18, 1991	**DIAMETER**	: 4.00 in Auger
LOCATION	: TA-53 Impoundments	**CASING MATERIAL**	: Aluminum

DEPTH	**DESCRIPTION** (all depths in feet below ground surface)
0- 1	Surface fill materials
1-50	Tuff; Tshirege Unit 2b; low moisture; not cored

NEUTRON ACCESS WELL COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->LBA|X|<-- 1 FT OF TOPSOIL COVER
0.5 FT BENTONITE PELLETS ---->SA| |<-- TSHIREGE 2B TUFF AT 1 FT
ANNULUS FILLED WITH SAND ---->SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA| |
                               SA|X|<-- COMPLETION DEPTH AT 47.3 FT
                                 |C|<-- TOTAL DEPTH AT 50 FT
```

COMPLETION DIAGRAM IS NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP............L
ALUMINUM CASING, 2 in ID....A
CEMENT GROUT SEAL............B
MEDIUM GRAIN SILICA SAND....S
END-CAP PLUG................X
HOLE CAVED IN...............C
-----------------------------
```

DRILLING LOG

BOREHOLE	: 5-53	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Stoker & Gallaher	**TOTAL DEPTH**	: 100 feet
DATE DRILLED	: June 18, 1991	**DIAMETER**	: 4.00 in Auger
LOCATION	: TA-53 Impoundments	**CASING MATERIAL**	: Pore Gas Well

DEPTH	**DESCRIPTION** (all depths in feet below ground surface)
0- 3	Surface fill materials
3- 68	Tuff; Tshirege Unit 2b; low moisture; not cored
68-100	Tuff; Tshirege Unit 2a; low moisture; not cored

PORE GAS MONITORING SYSTEM COMPLETION SUMMARY

```
LOCKING STEEL CAP/2 FT CEMENT>LB| |
4 FT ALUMINUM CASING TO 1 FT->AS| |<-- TSHIREGE 2B TUFF AT 3 FT
2 FT BENTONITE PELLETS -------->S| |
ANNULUS FILLED WITH SAND ----->S| |
                               S| |
                               S| |
PORE GAS SAMPLE PORT 20 FT -->GS| |
                               S| |
                               S| |
                               S| |
PORE GAS SAMPLE PORT 40 FT -->GS| |
                               S| |
                               S| |
                               S| |
PORE GAS SAMPLE PORT 60 FT -->GS| |
                               S| |
                               S| |<-- TSHIREGE 2A CONTACT AT 68 FT
                               S| |
                               S| |
PORE GAS SAMPLE PORT 80 FT -->GS| |
                               S| |
                               S| |
                               S| |
PORE GAS SAMPLE PORT 93.5 FT->GS| |
                               S| |<-- COMPLETION DEPTH AT 94 FT
                                |C|<-- TOTAL DEPTH AT 100 FT
```

COMPLETION DIAGRAM IS NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP............L
CEMENT GROUT SEAL............B
ALUMINUM SURFACE CASING.....A
MEDIUM GRAIN SILICA SAND....S
PORE GAS SAMPLE PORT........G
HOLE CAVED IN...............C
-----------------------------
```

DRILLING LOG

BOREHOLE	: 6-53	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Stoker & Gallaher	**TOTAL DEPTH**	: 150 feet
DATE DRILLED	: July 10, 1991	**DIAMETER**	: 6.875 in Core
LOCATION	: TA-53 Impoundments	**CASING MATERIAL**	: Open Hole

DEPTH **DESCRIPTION** (all depths in feet below ground surface)

0- 3 Surface fill materials

3- 68 Tuff; Tshirege Unit 2b; low moisture; cored

68-113 Tuff; Tshirege Unit 2a; low moisture; cored

113-133 Tuff; Tshirege Unit 1b; low moisture; cored

133-150 Tuff; Tshirege Unit 1a; low moisture; cored

SUBSURFACE SUMMARY

```
NO WELL COMPLETION TO DATE ---->|X|<-- 3 FT OF FILL COVER
(OPEN HOLE WITH TOP COVER)      | |<-- TSHIREGE 2B TUFF AT 3 FT
                                | |
                                | |
                                | |
                                | |
                                | |
                                | |<-- TSHIREGE 2A TUFF AT 68 FT
                                | |
                                | |
                                | |
                                | |
                                | |
                                | |<-- TSHIREGE 1B TUFF AT 113 FT
                                | |
                                | |
                                | |<-- TSHIREGE 1A TUFF AT 133 FT
                                | |
                                | |
                                |C|<-- TOTAL DEPTH AT 150 FT
```

COMPLETION DIAGRAM IS NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP............L
ALUMINUM CASING, 2 in ID....A
CEMENT GROUT SEAL............B
MEDIUM GRAIN SILICA SAND....S
END-CAP PLUG................X
HOLE CAVED IN...............C
-----------------------------
```

DRILLING LOG

BOREHOLE	: 7-53	**ELEVATION**	: Not Surveyed
GEOLOGIST	: Stoker & McLin	**TOTAL DEPTH**	: 80 feet
DATE DRILLED	: July 17, 1991	**DIAMETER**	: 6.875 in Core
LOCATION	: TA-53 Impoundments	**CASING MATERIAL**	: Al+Lysimeter

DEPTH	**DESCRIPTION** (all depths in feet below ground surface)
0- 1	Light brown sandy soil cover
1-24	Tuff; Tshirege Unit 1a; low moisture; cored
24-43	Tuff; Tsankawi; low moisture; cored
43-80	Tuff; Otowi; low moisture; cored

NEUTRON ACCESS WELL & LYSIMETER COMPLETION SUMMARY

```
LOCKING STEEL CAP IN CEMENT->LBA|X|<-- 1 FT OF TOPSOIL COVER
0.5 FT BENTONITE PELLETS ---->SA| |<-- TSHIREGE 1A TUFF AT 1 FT
ANNULUS FILLED WITH SAND ---->SA| |
                              SA| |
                              SA| |<-- TSANKAWI TUFF AT 24 FT
                              SA| |
BENTONITE SEAL 35-37 FT ----->BA| |
                              FA| |
LYSIMETER PORT AT 38 FT ---->FVA| |
 (Lysimeter in Annulus)       FA| |
BENTONITE SEAL 39-40 FT ----->BA| |
                              SA| |<-- OTOWI TUFF AT 43 FT
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA| |
                              SA|X|<-- COMPLETION DEPTH AT 77 FT
                                |C|<-- TOTAL DEPTH AT 80 FT
```

COMPLETION DIAGRAM IS NOT TO SCALE

```
-----------------------------
STEEL LOCKING CAP............L
ALUMINUM CASING, 2 in ID....A
CEMENT GROUT SEAL............B
MEDIUM GRAIN SILICA SAND....S
PRESSURE-VACUUM LYSIMETER...V
FINE SILICA FLOUR............F
END-CAP PLUG.................X
HOLE CAVED IN................C
-----------------------------
```

APPENDIX B

ESTIMATION OF RUNOFF AT TA-53

FOR THE

24-HOUR 100-YEAR PRECIPITATION EVENT

ESTIMATION OF RUNOFF AT TA-53 FOR THE

24-HOUR 100-YEAR PRECIPITATION EVENT

Method Used: Soil Conservation Service, Peak Rates of Discharge For Small Watersheds, Chapter 2, Revised for New Mexico, Engineering Field Manual for Conservation Practices.

Rainfall Depth (in inches) Associated With The 24-Hour 100-Year Precipitation Event

---

EXHIBIT 2-2	4 in.
Observed Data 1911-1988 (Bowen, 1989)	3 in.

Runoff Curve Number for a C-hydrologic soil group - Rock Outcrop (mesic) and Hackroy Sandy Loam (Nyhan et al., 1978)

Assume juniper and grass cover

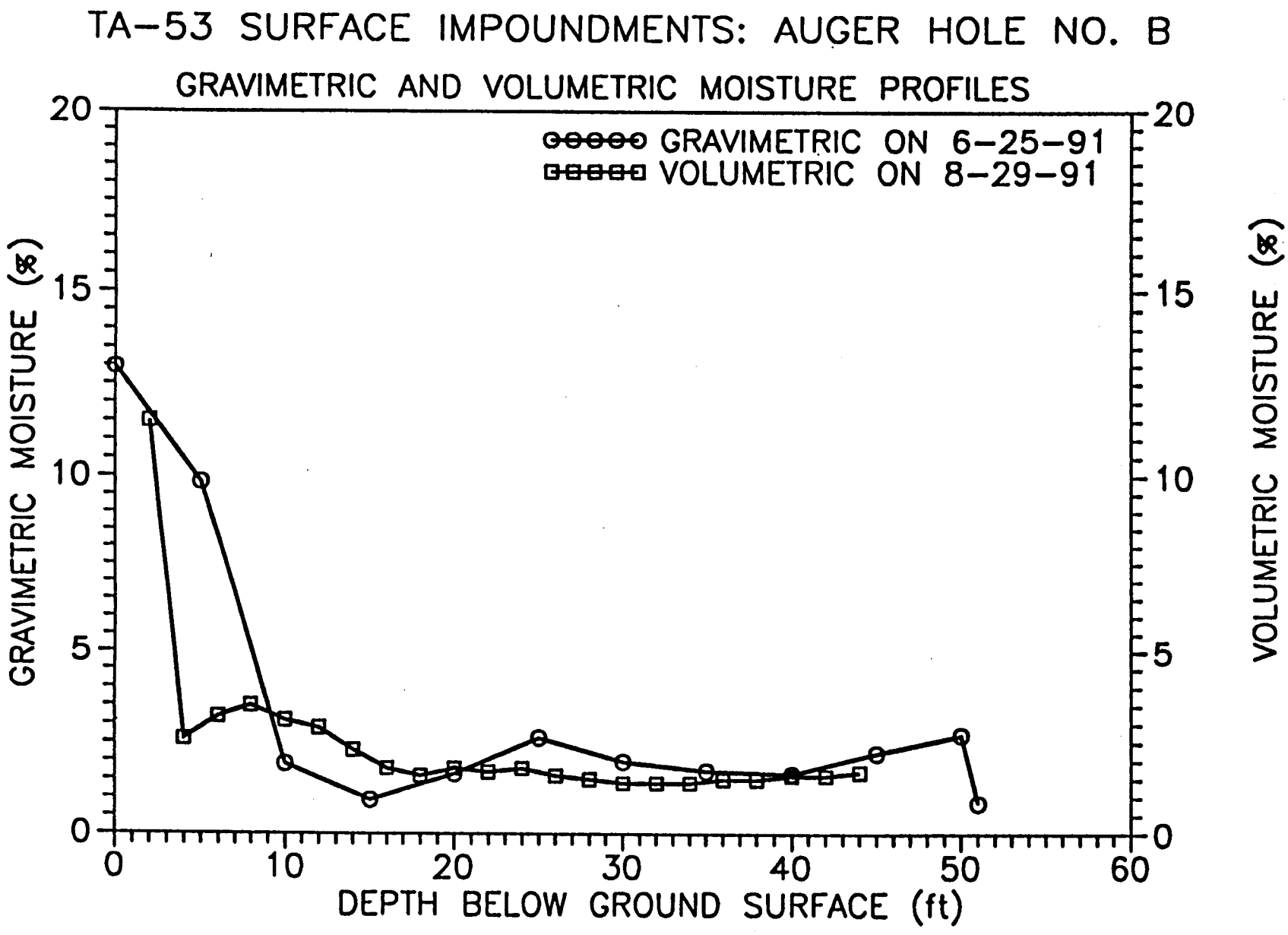
20% cover CN=86

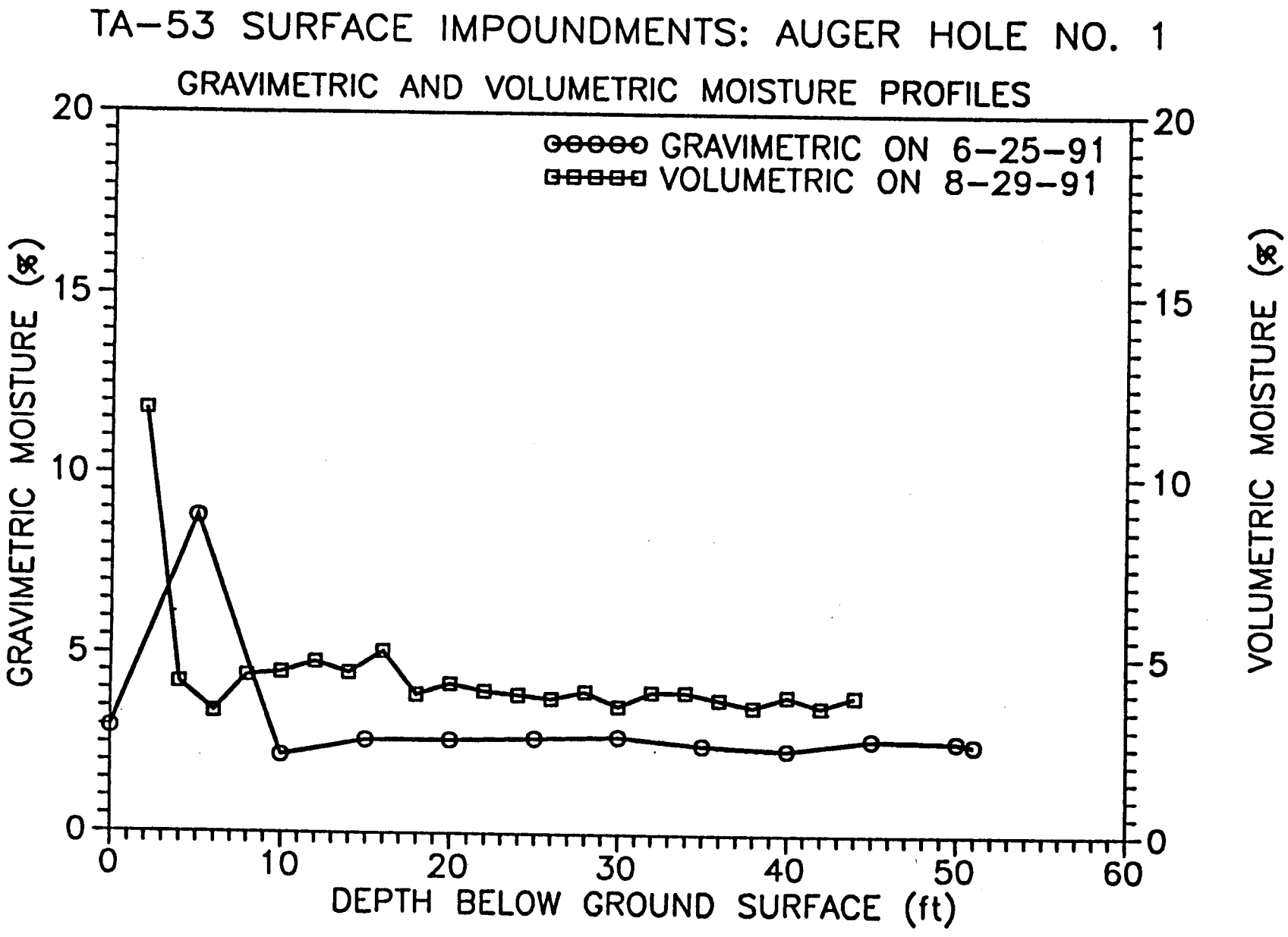
Rainfall	Curve Number	Runoff Depth (inches over basin)
4	86	2.6
3	86	1.7

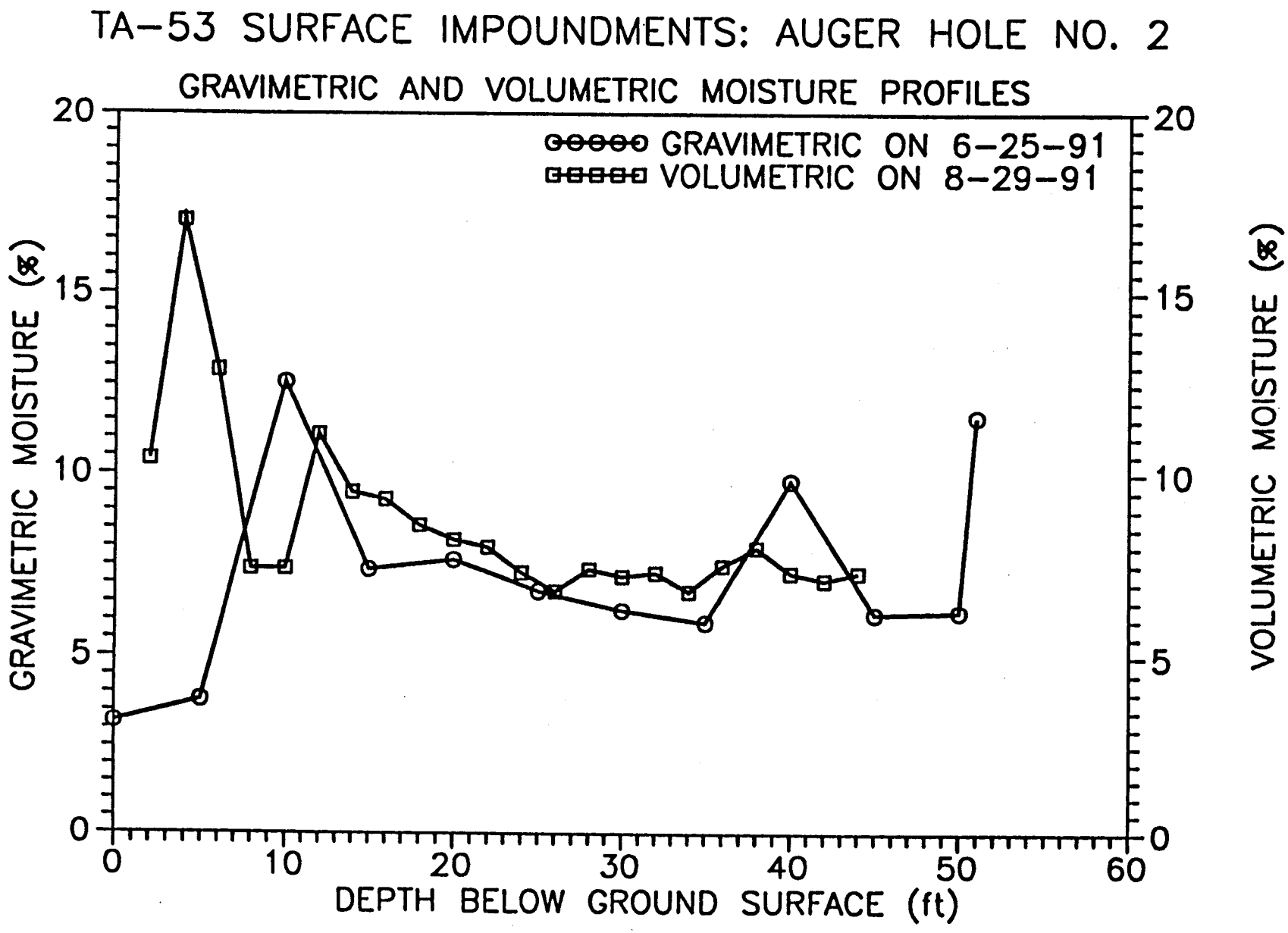
APPENDIX C

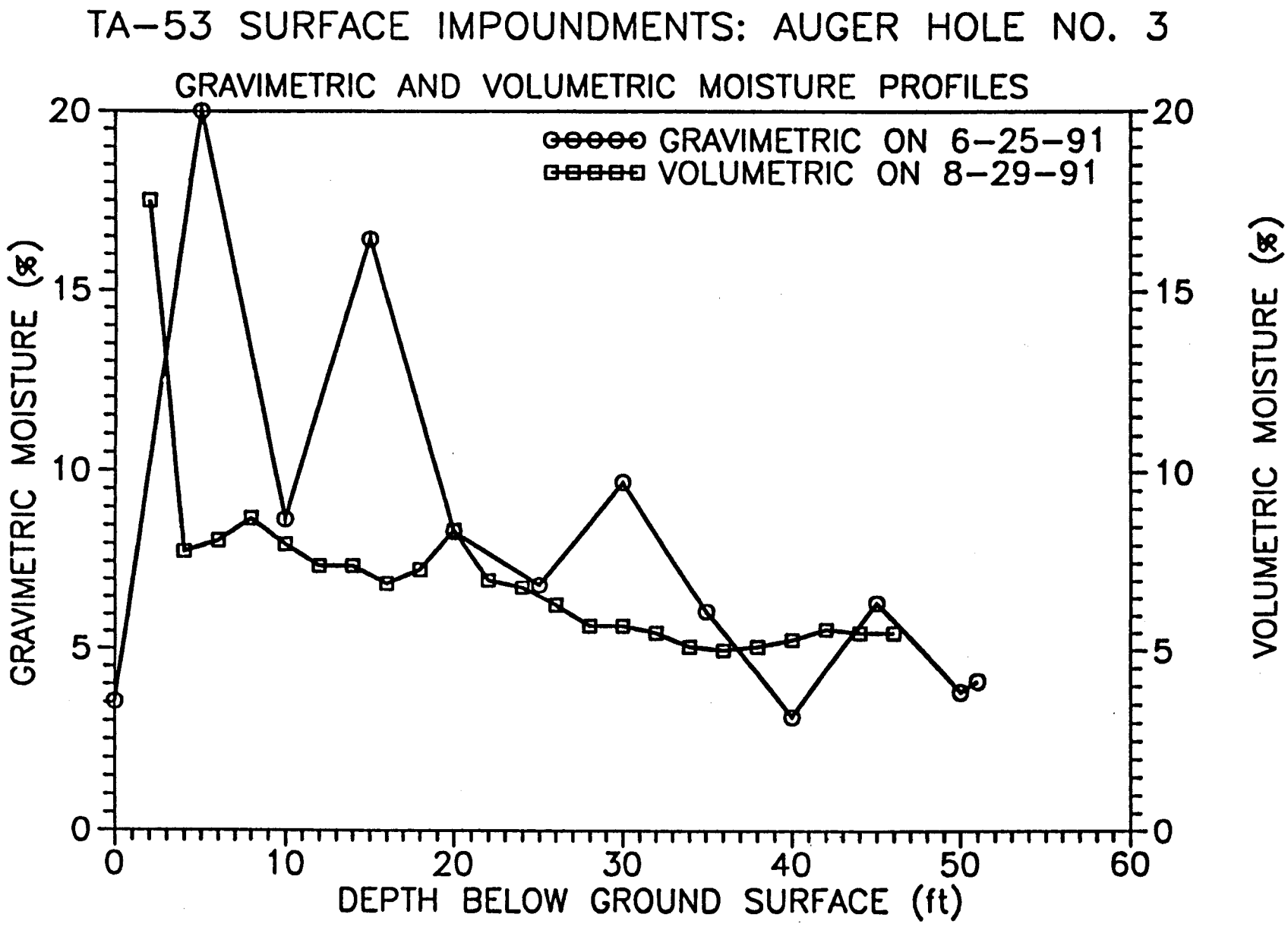
GRAVIMETRIC AND VOLUMETRIC MOISTURE PROFILES

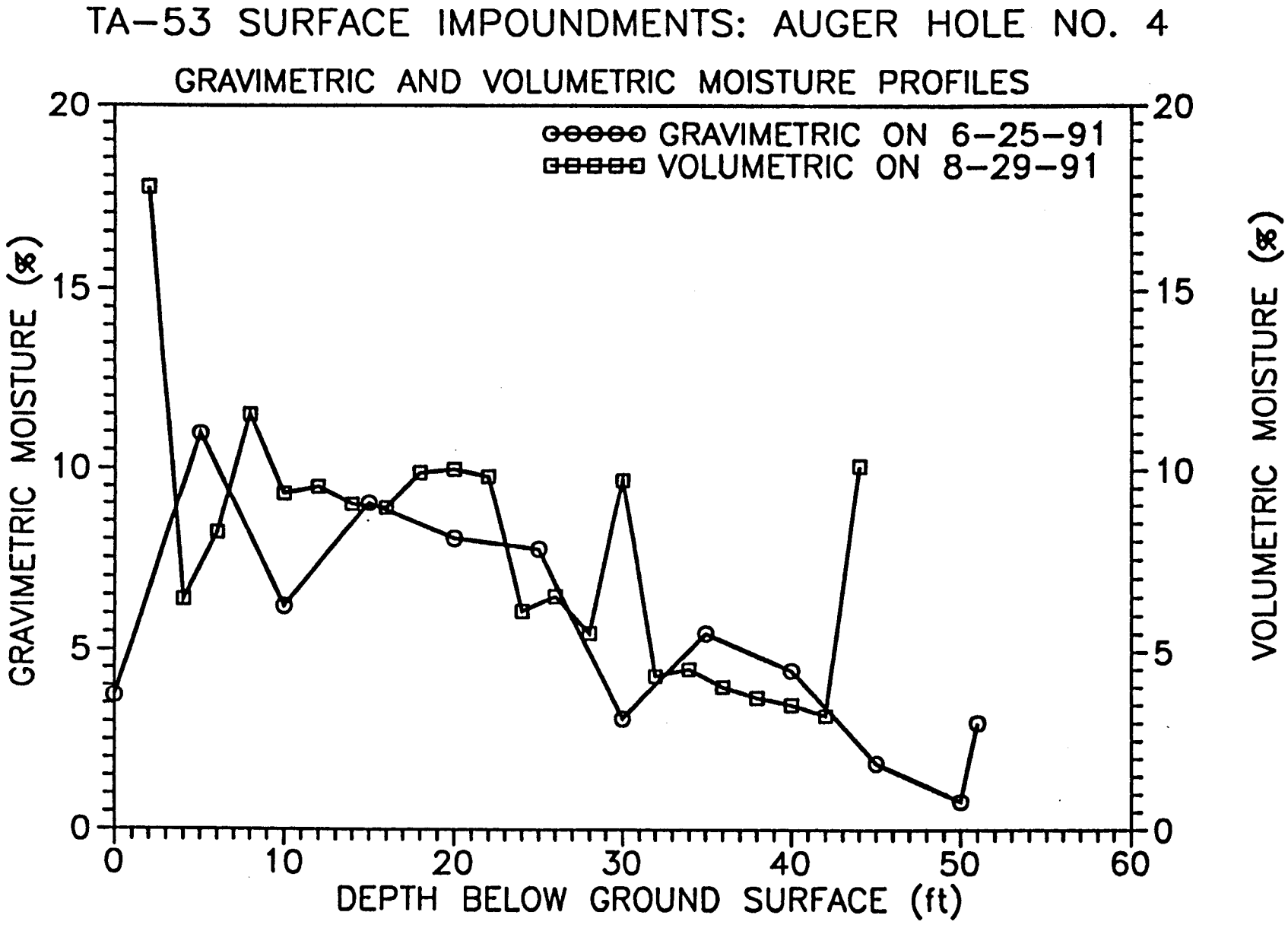
FOR TA-53 MONITORING WELLS

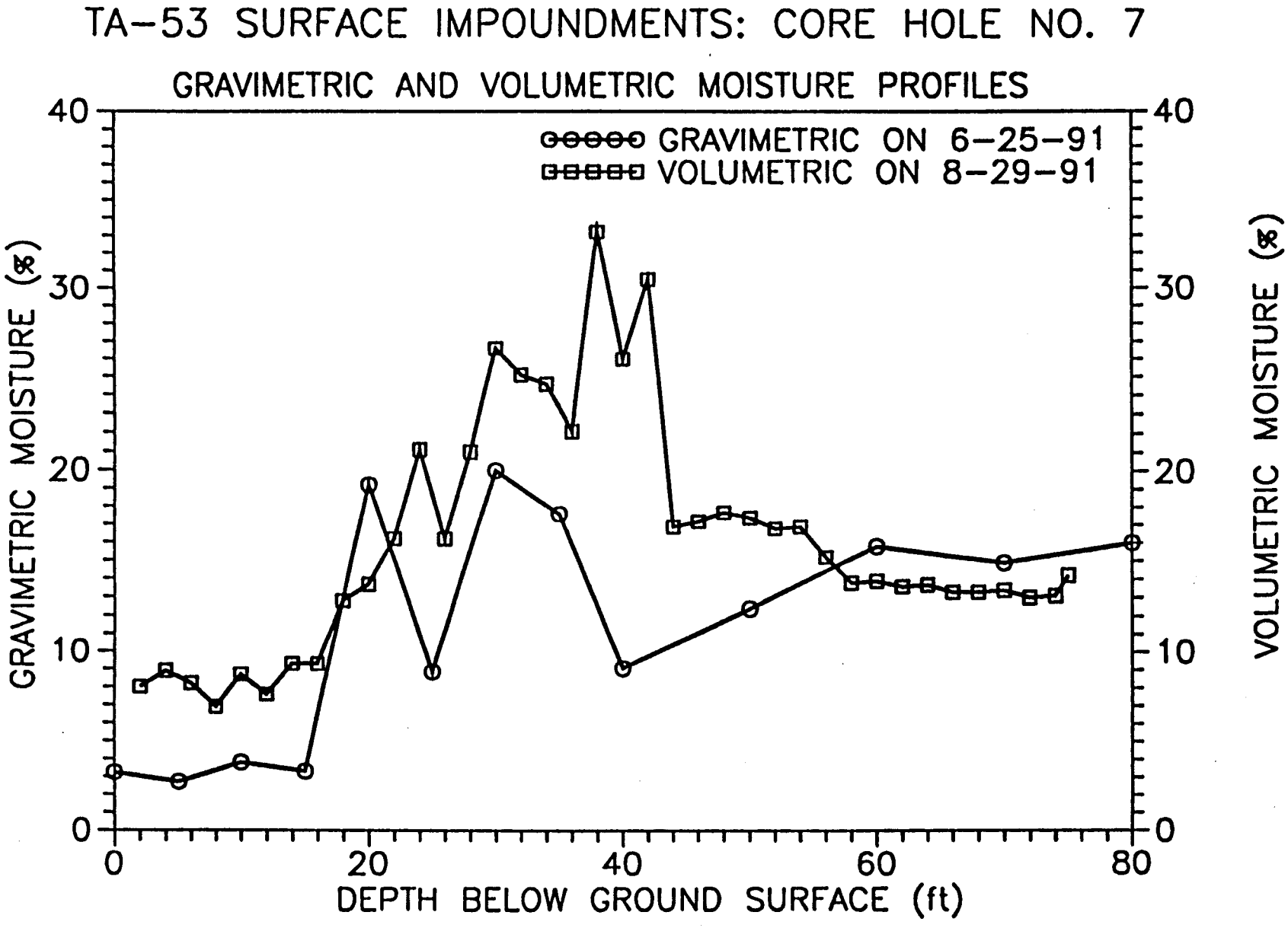

TA-53 SURFACE IMPOUNDMENTS: AUGER HOLE NO. B
GRAVIMETRIC AND VOLUMETRIC MOISTURE PROFILES
GRAVIMETRIC ON 6-25-91
VOLUMETRIC ON 8-29-91
GRAVIMETRIC MOISTURE (%)
VOLUMETRIC MOISTURE (%)
DEPTH BELOW GROUND SURFACE (ft)
0
5
10
15
20
0
10
20
30
40
50
60

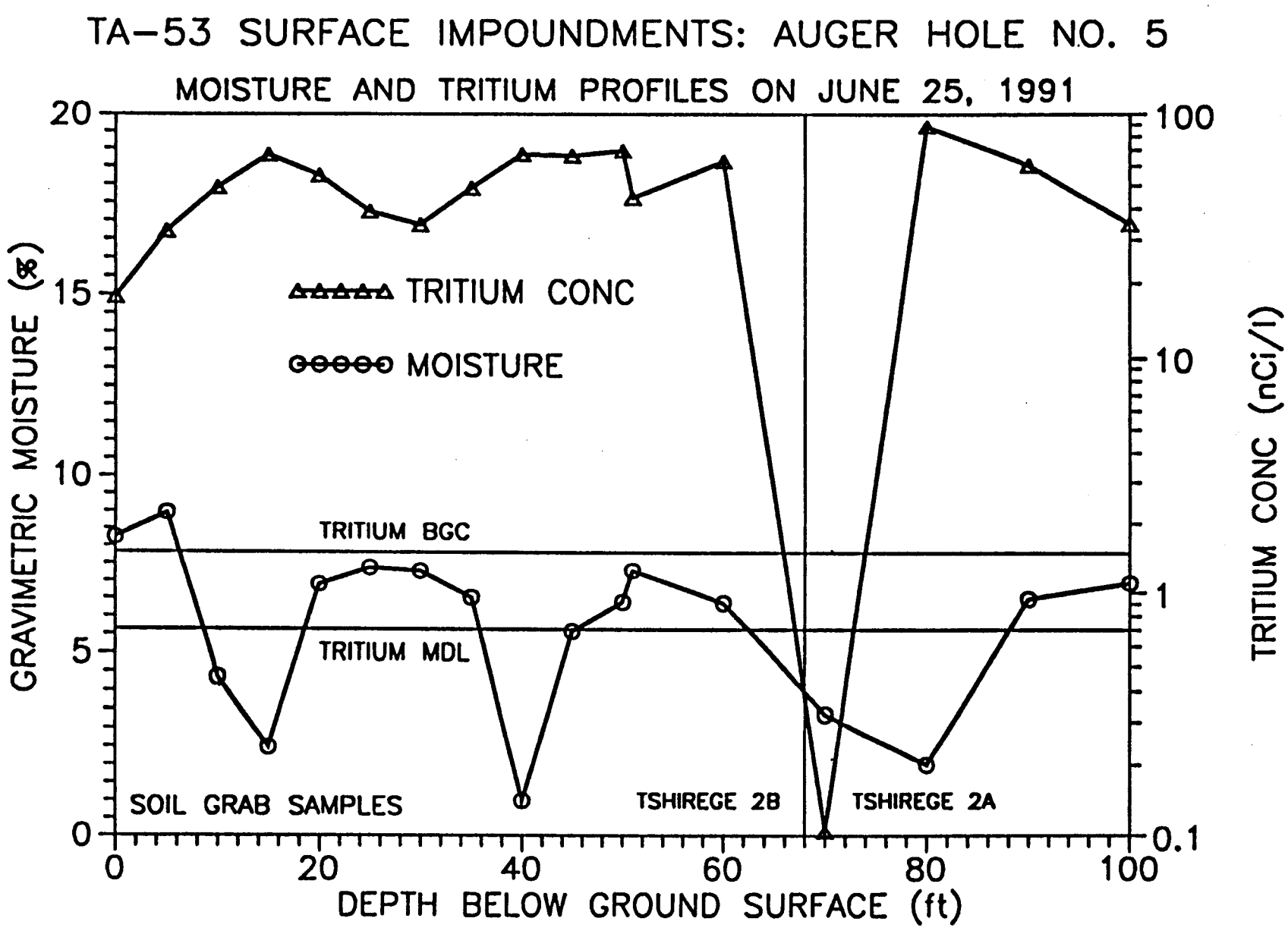

TA-53 SURFACE IMPOUNDMENTS: AUGER HOLE NO. 1
GRAVIMETRIC AND VOLUMETRIC MOISTURE PROFILES
GRAVIMETRIC ON 6-25-91
VOLUMETRIC ON 8-29-91
GRAVIMETRIC MOISTURE (%)
VOLUMETRIC MOISTURE (%)
DEPTH BELOW GROUND SURFACE (ft)
0
5
10
15
20
0
10
20
30
40
50
60

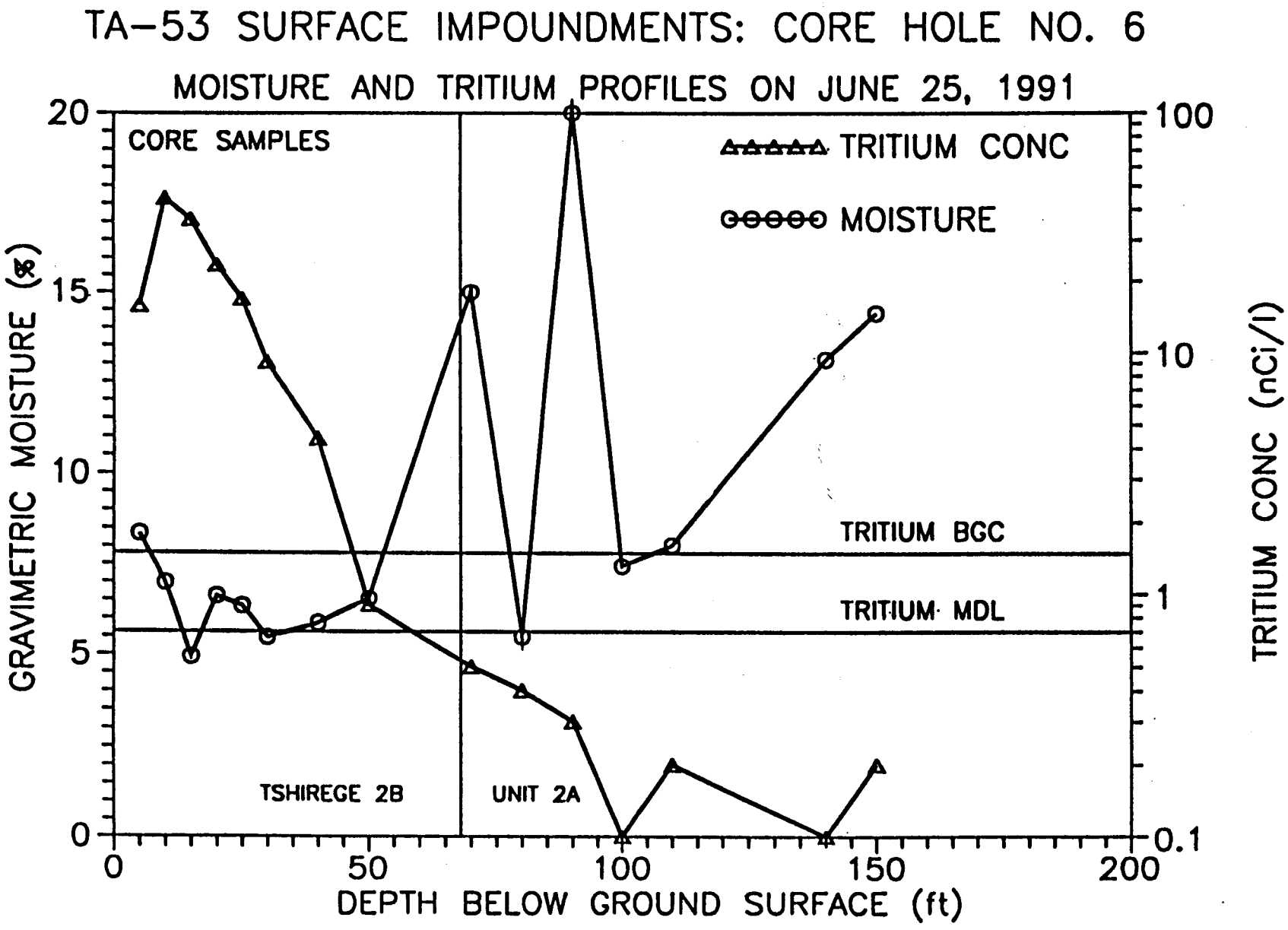

TA-53 SURFACE IMPOUNDMENTS: AUGER HOLE NO. 2
GRAVIMETRIC AND VOLUMETRIC MOISTURE PROFILES
GRAVIMETRIC ON 6-25-91
VOLUMETRIC ON 8-29-91
GRAVIMETRIC MOISTURE (%)
VOLUMETRIC MOISTURE (%)
DEPTH BELOW GROUND SURFACE (ft)
0
5
10
15
20
0
10
20
30
40
50
60

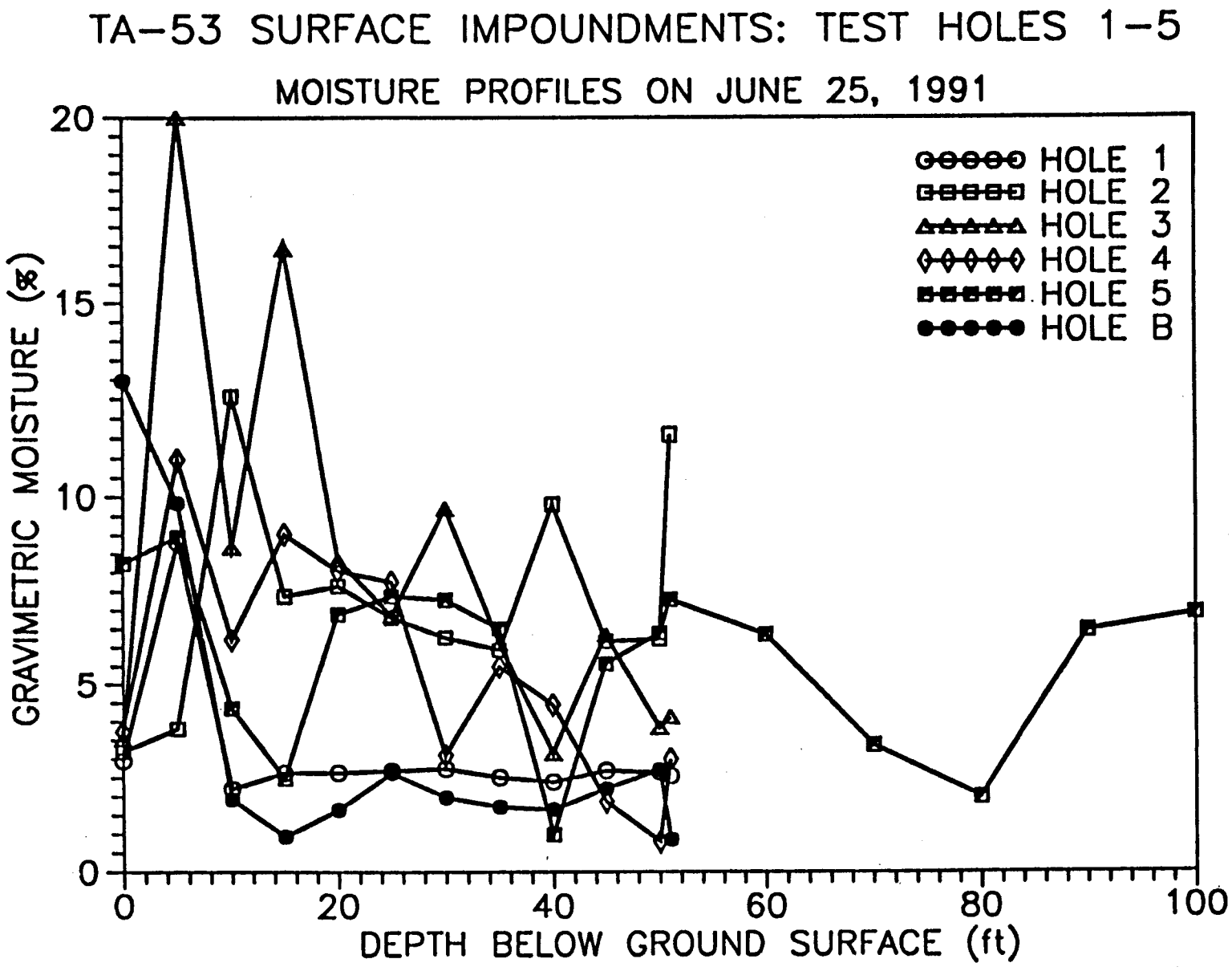

TA-53 SURFACE IMPOUNDMENTS: AUGER HOLE NO. 3
GRAVIMETRIC AND VOLUMETRIC MOISTURE PROFILES
GRAVIMETRIC ON 6-25-91
VOLUMETRIC ON 8-29-91
GRAVIMETRIC MOISTURE (%)
VOLUMETRIC MOISTURE (%)
DEPTH BELOW GROUND SURFACE (ft)
0
5
10
15
20
0
10
20
30
40
50
60

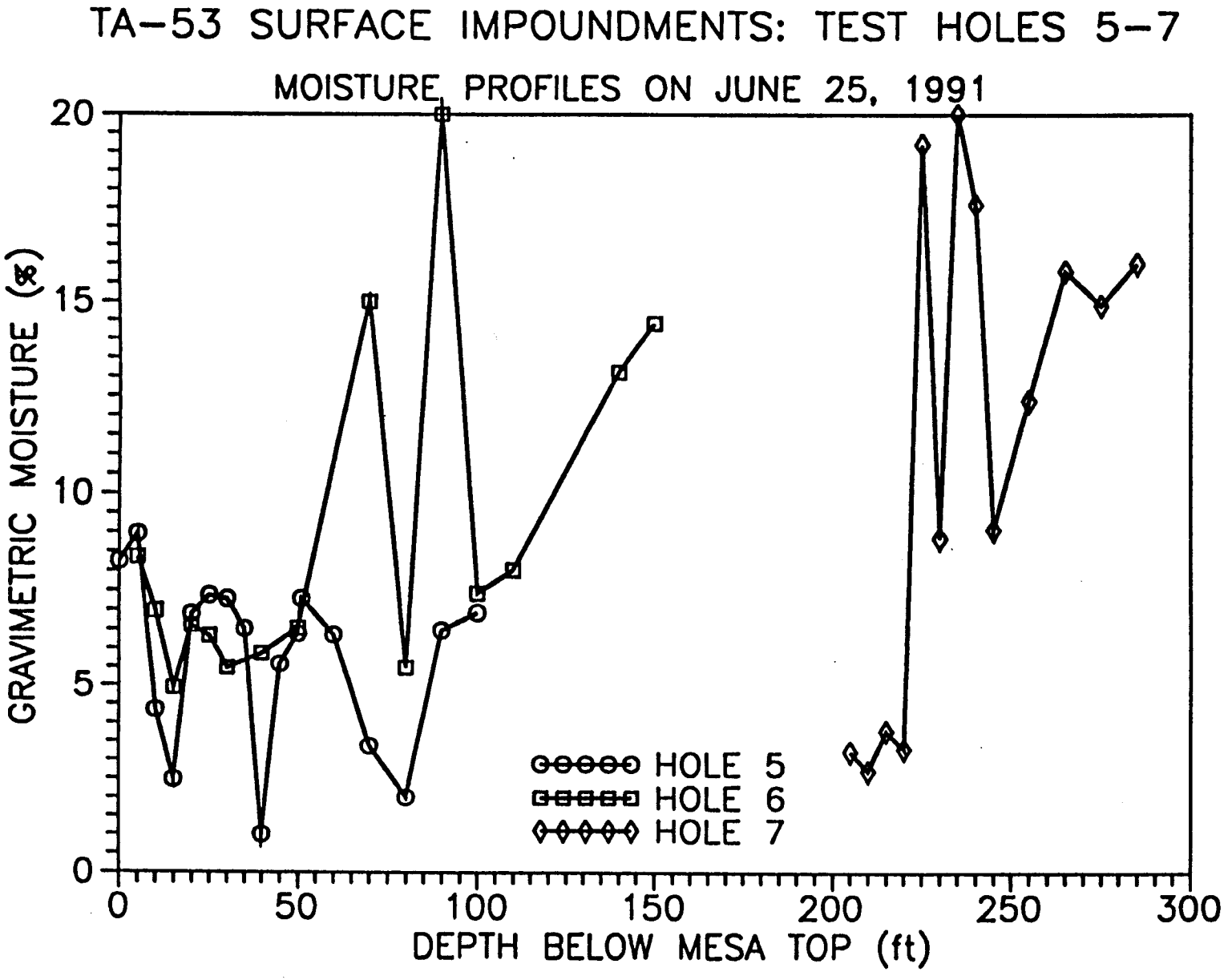

TA-53 SURFACE IMPOUNDMENTS: AUGER HOLE NO. 4
GRAVIMETRIC AND VOLUMETRIC MOISTURE PROFILES
GRAVIMETRIC ON 6-25-91
VOLUMETRIC ON 8-29-91
GRAVIMETRIC MOISTURE (%)
VOLUMETRIC MOISTURE (%)
DEPTH BELOW GROUND SURFACE (ft)
0
5
10
15
20
0
10
20
30
40
50
60

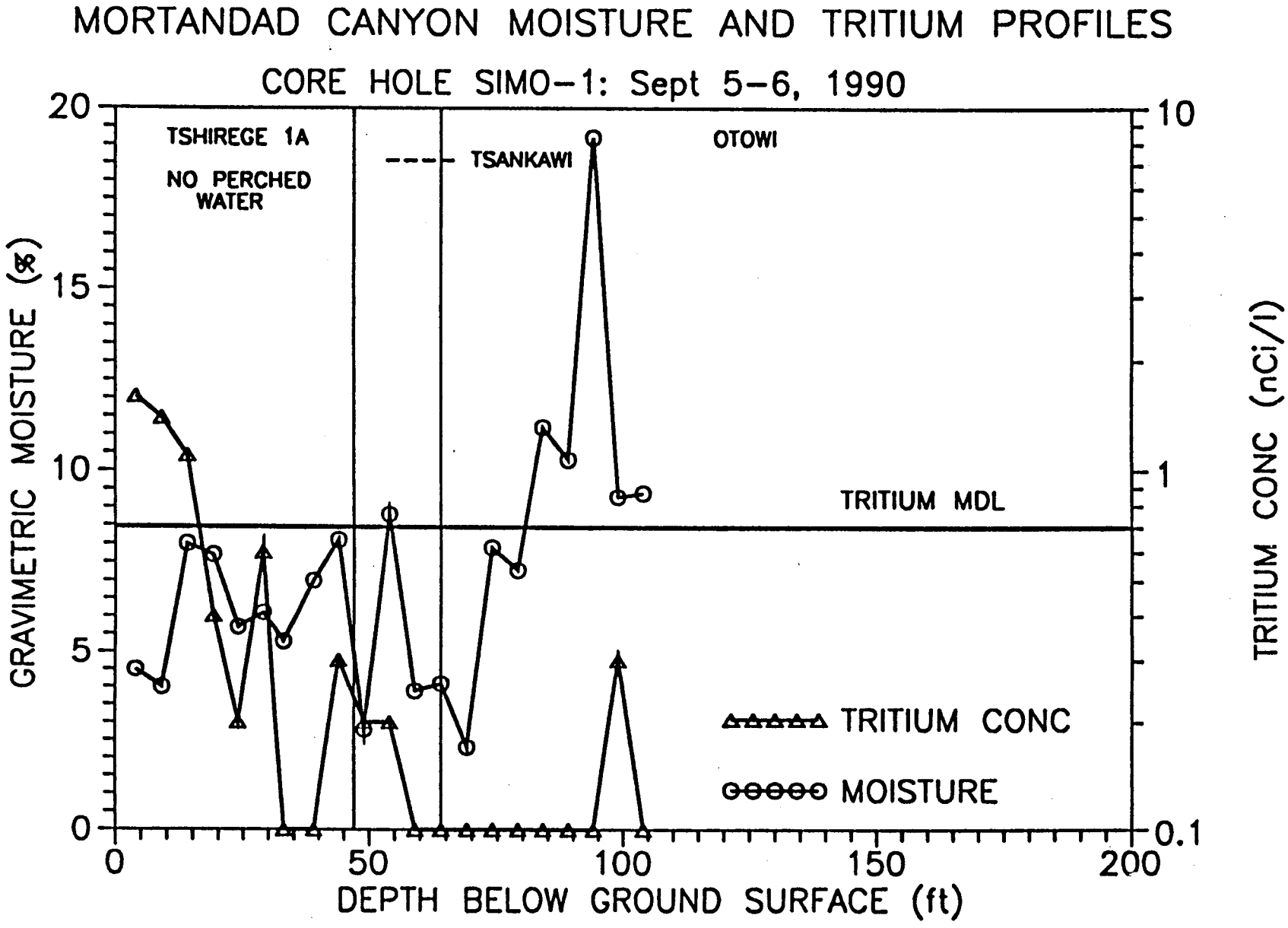

TA-53 SURFACE IMPOUNDMENTS: CORE HOLE NO. 7
GRAVIMETRIC AND VOLUMETRIC MOISTURE PROFILES
GRAVIMETRIC ON 6-25-91
VOLUMETRIC ON 8-29-91
GRAVIMETRIC MOISTURE (%)
VOLUMETRIC MOISTURE (%)
DEPTH BELOW GROUND SURFACE (ft)
0
10
20
30
40
0
20
40
60
80


TA-53 SURFACE IMPOUNDMENTS: AUGER HOLE NO. 5
MOISTURE AND TRITIUM PROFILES ON JUNE 25, 1991
TRITIUM CONC
MOISTURE
TRITIUM BGC
TRITIUM MDL
SOIL GRAB SAMPLES
TSHIREGE 2B
TSHIREGE 2A
GRAVIMETRIC MOISTURE (%)
TRITIUM CONC (nCi/l)
DEPTH BELOW GROUND SURFACE (ft)
0
5
10
15
20
0.1
1
10
100
0
20
40
60
80
100


TA-53 SURFACE IMPOUNDMENTS: CORE HOLE NO. 6
MOISTURE AND TRITIUM PROFILES ON JUNE 25, 1991
CORE SAMPLES
TRITIUM CONC
MOISTURE
TRITIUM BGC
TRITIUM MDL
TSHIREGE 2B
UNIT 2A
GRAVIMETRIC MOISTURE (%)
TRITIUM CONC (nCi/l)
DEPTH BELOW GROUND SURFACE (ft)
0
5
10
15
20
0.1
1
10
100
0
50
100
150
200


TA-53 SURFACE IMPOUNDMENTS: TEST HOLES 1-5
MOISTURE PROFILES ON JUNE 25, 1991
HOLE 1
HOLE 2
HOLE 3
HOLE 4
HOLE 5
HOLE B
GRAVIMETRIC MOISTURE (%)
DEPTH BELOW GROUND SURFACE (ft)
0
5
10
15
20
0
20
40
60
80
100


TA-53 SURFACE IMPOUNDMENTS: TEST HOLES 5-7
MOISTURE PROFILES ON JUNE 25, 1991
GRAVIMETRIC MOISTURE (%)
DEPTH BELOW MESA TOP (ft)
0
5
10
15
20
0
50
100
150
200
250
300
HOLE 5
HOLE 6
HOLE 7


MORTANDAD CANYON MOISTURE AND TRITIUM PROFILES
CORE HOLE SIMO-1: Sept 5-6, 1990
TSHIREGE 1A
NO PERCHED WATER
TSANKAWI
OTOWI
TRITIUM MDL
TRITIUM CONC
MOISTURE
GRAVIMETRIC MOISTURE (%)
TRITIUM CONC (nCi/l)
DEPTH BELOW GROUND SURFACE (ft)
0
5
10
15
20
0.1
1
10
0
50
100
150
200