LA-9445-PNTX-H

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

Supplementary Documentation for an Environmental Impact Statement Regarding the Pantex Plant

Geohydrologic Investigations

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

This report was prepared by Kathy Derouin, Lois Schneider, and Mary Lou Keigher, Group H-8.

LA-9445-PNTX-H

Issued: December 1982

Supplementary Documentation for an Environmental Impact Statement Regarding the Pantex Plant

Geohydrologic Investigations

William D. Purtymun
Naomi M. Becker
Max Maes

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

SUPPLEMENTARY DOCUMENTATION FOR AN ENVIRONMENTAL IMPACT STATEMENT REGARDING THE PANTEX PLANT:

GEOHYDROLOGIC INVESTIGATIONS

by

William D. Purtymun, Naomi M. Becker, and Max Maes

ABSTRACT

This report documents work performed in support of preparation of an Environmental Impact Statement (EIS) regarding the Department of Energy's Pantex Plant near Amarillo, Texas. Subsurface investigations were made to examine soil characteristics. Samples from test holes were analyzed for inorganic and organic chemicals, explosives, and radioactivity. Radiochemical analyses were also performed on surface and ground water, soil, and sediments in and adjacent to the Pantex Plant. Waste water and sediments from drainage ditches from the plant, ponded water and sediments from a playa basin, and sanitary effluent were examined for explosives and organic compounds.

I. INTRODUCTION

This report documents work performed in support of preparation of an Environmental Impact Statement (EIS) regarding the Department of Energy's Pantex Plant near Amarillo, Texas. This EIS addresses continuing nuclear weapons operations at Pantex and the construction of additional facilities to house those operations. The EIS was prepared in accordance with current regulations under the National Environmental Policy Act. Regulations of the Council on Environmental Quality (40 CFR 1500) require agencies to prepare a concise EIS with less than 300 pages for complex projects. This report was prepared by Los Alamos National Laboratory to document details of work performed and supplementary information considered during preparation of the Draft EIS.

This report presents results of a subsurface investigation that was made to examine the soil characteristics on the upland plains and ponds in playa basins and possible transport of surface inorganic or organic chemicals, explosives, or radionuclides with the water. The report also documents the distribution of radionuclides in surface and ground water, soil and sediments, as well as the distribution of explosive residues and some of the organic compounds that are

released in effluents from Zones 11 and 12 at the Pantex Plant. Analyses were made for organic compounds in sanitary effluents. Some of the organic compound analyses are classified as priority pollutants (USEPA 1981). References for the methods employed in the analysis of various types of samples and the personnel responsible are shown in the Appendix.

The Pantex Plant is located on the southern High Plains in West Texas. The topography at the plant is composed of relatively flat uplands or plains containing playa basins. The uplands or plains at the plant are quite level with slopes varying from a 10-ft drop in 4000 ft to a 10-ft drop in 500 ft near each of the playa basins. All surface water drainage at the plant is into the playa basins (Becker 1982). The playas are large depressions (as much as 1 mile in diameter and up to 50 or 60 ft below the general level of the plain) formed in the upper surface of the upland plain.

The main ground water body (aquifer) is in the Tertiary gravels of the Ogallala Formation. Water occurs in the lower part of the formation perched on the relatively impermeable Triassic "red beds" of silts, clays, shales, and silty sandstones. Water from the aquifer furnishes water for industrial, municipal, and agricultural use in the area. At the Pantex Plant the top of the aquifer is at a depth of over 400 ft.

Two of three test holes drilled in 1976 at Pantex encountered perched ground water above the main zone of saturation in the Ogallala Formation. These perched water bodies are of local extent and are not considered dependable sources of water supply.

II. SUBSURFACE INVESTIGATION

A subsurface investigation was carried out by drilling 29 test holes that ranged in depth from 18 to 48 ft (Fig. 1). The holes were drilled with a 4-in.-diam auger. Lithology of the cuttings was described and samples were analyzed for inorganic and organic chemicals, explosives, or radionuclides.

Three test holes (TH-10, -11, -26) were located in areas remote from plant operations. These test holes were drilled to collect samples to establish base line or background concentrations of inorganic and organic chemicals, explosives, or radionuclide concentrations: Discussion of results is based on mean concentrations and standard deviation of the number of samples collected and analyzed from each test hole. Samples from the test holes were collected from land surface to a depth of 3 ft and then at 5-ft intervals to the bottom of the hole. The number of samples and analyses from each hole varies according to depth. For example, 4 samples from an 18-ft hole, 5 samples from a 23-ft hole, 6 samples from a 28-ft hole, and 10 samples from a 48-ft hole were obtained. If significant trends in concentrations occurred within a set of samples, those trends are discussed.

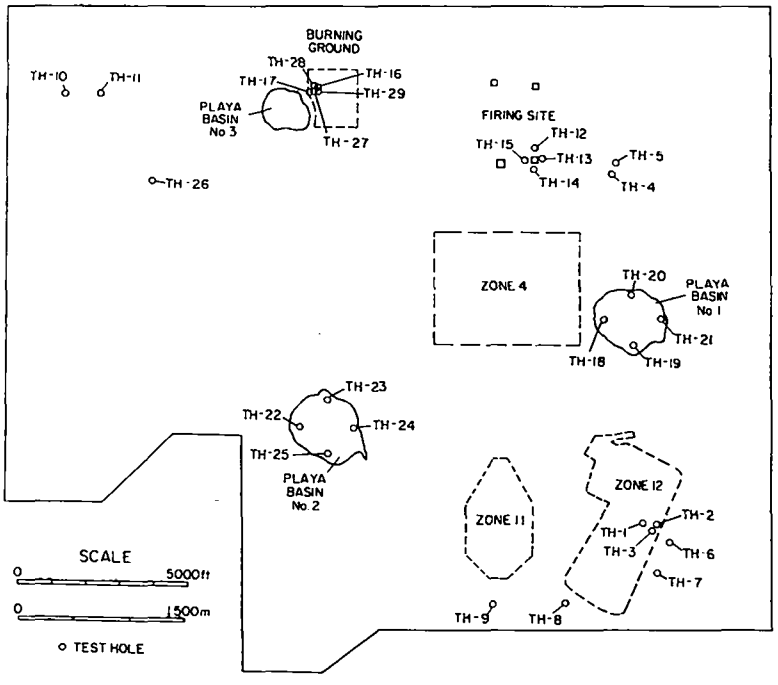


Fig. 1. Location of test holes (TH) at the Pantex Plant.

A. Subsurface Investigation of Upland Soils and Playa Basin Deposits

The test holes were drilled in or through upland soils and playa basin deposits at the Pantex Plant. The upland soils and playa basin deposits are developed in the upper surface of the Ogallala Formation. The soils (windblown sand) on the uplands at the Pantex Plant are of the Pullman clay loam series. The Pullman soil series consists of grayish-brown clay loam of very low permeability with a dark-brown clay subsoil. These soils are formed from fine textured calcareous sediments that have originated from loess or other windblown materials (Jacquot 1962).

A typical soil profile of the Pullman series consists of the A zone of dark-grayish-brown silty clay loam about 0.5 to 1 ft thick. The underlying B zone consists of dark-brown to dark-reddish-brown clay and silty clay that becomes plastic when wet and extremely hard when dry. The B zone is from 3 to 5 ft thick. The underlying C zone is a pinkish-white silty clay that contains soft concretions of calcium carbonate (caliche); the thickness ranges from 3 to 6 ft. The A, B, and C zones are, in turn, underlain by over 50 ft of silt and clay that overlie the gravels of the Ogallala Formation.

The intake rate (permeability) of water into the soil is low, ranging from 0.2 to 0.6 in./h for the A zone, <0.06 in./h for the B zone, and from <0.06 to

0.2 in./h for the C zone (Pringle 1980). Thus, prolonged flooding by irrigation or rainfall is required for large quantities of water to percolate into the soil. The Pullman clay loam requires about a 5-in. application of water for irrigation of wheat or sorghum. One to three applications of water may be needed during the early growing season. If there is sufficient precipitation during this period, irrigation is not needed.

The low permeability and depth of infiltration of water from precipitation and irrigation into the Pullman soil are reflected in a study of soil moisture in deep borings by the US Department of Agriculture (USDA) at the Bushland Research Station. The study concluded that, under present land management and irrigation practices, the possibility of infiltration of water through the Pullman soil and underlying unsaturated sediment of the Ogallala Formation into the Ogallala Aquifer is remote (Aronovice 1972).

The playas are large depressions formed in the upper surface of the Ogallala Formation. The basins are numerous in the upland surface in and adjacent to the Pantex Plant. The playa deposits formed in the depression are of the Randall clay soil series.

The Randall clay soils are dark-gray, very low permeability clayey soils in deposited depressions or playa basins. The soils are deep and generally consist of noncalcareous massive clay. They have formed from sediments washed in from the surface of the surrounding plain. A typical soil profile consists of an A and C zone; no B zone is described. The A zone consists of dark-gray to brownish-gray silty clay loam in the upper section underlain by a dark clay with a thickness of 6 ft. The C zone is a light brownish-gray clay that exceeds a thickness of 20 ft. The intake rate (permeability) of water into the clay is <0.06 in./h, thus allowing little, if any, water in the playa to infiltrate into the underlying sediments of the Ogallala Formation (Pringle 1980).

The playa basins were formed by breaching of the caprock (caliche layers within the Ogallala Formation) by water and subsequent removal of material by wind erosion. There is no indication of breaching of the playa basins by faulting. Studies of wind deposits on the leeward side of the basin show no displacement that would indicate faulting or collapse by solution.

Logs of test holes are shown in Table I. Test holes TH-1 through TH-17 and test holes TH-26 through TH-29 are located on the upland plain within the Pantex Plant (Fig. 1). The Pullman soil series (upland soil) zones A and B penetrated by the test holes were logged as "soil" (Table I). The test holes penetrated 1 to 4 ft of soil (zones A and B) of a sandy loam. The loam ranged in color from gray to dark brown depending on the amount of organic material it contained and amount of weathering.

Underlying the soil on the upland surface is the caliche zone (zone C of the Pullman soil series), ranging in thickness from 5 to 19 ft. It was about

TABLE I

LOGS OF TEST HOLES

Test Hole No.	Depth in Feet			Results
	Soil	Caliche	Silty Clay	
1	0 - 3	3 - 15	15 - 28	Zone 12
2	0 - 2	2 - 16	16 - 28	Zone 12
3*	0 - 1	--	1 - 28	Zone 12
4	0 - 3	3 - 20	20 - 28	Near well 6
5	0 - 3	3 - 22	22 - 28	Near well 6
6	0 - 4	4 - 18	18 - 28	East of Zone 12
7	0 - 3	3 - 18	18 - 28	East of Zone 12
8**	--	0 - 13	13 - 28	South of Zone 12
9*	0 - 3	--	3 - 28	South of Zone 11
10	0 - 4	4 - 18	18 - 28	Sample control
11	0 - 4	4 - 18	18 - 28	Sample control
12	0 - 3	3 - 14	14 - 28	Firing site 2
13	0 - 3	3 - 14	14 - 18	Firing site 2
14	0 - 3	3 - 14	14 - 18	Firing site 2
15	0 - 3	3 - 14	14 - 18	Firing site 2
16	0 - 4	4 - 13	13 - 28	Burning ground
17	0 - 4	4 - 9	9 - 28	Burning ground
18	0 - 6	--	6 - 28	Playa Basin No. 1
19	0 - 7	7 - 10	10 - 28	Playa Basin No. 1
20	0 - 2	2 - 6	6 - 28	Playa Basin No. 1
21	0 - 7	7 - 13	13 - 28	Playa Basin No. 1
22	0 - 7	--	7 - 28	Playa Basin No. 2
23	0 - 4	--	4 - 28	Playa Basin No. 2
24	0 - 3	--	3 - 28	Playa Basin No. 2
25	0 - 6	--	6 - 28	Playa Basin No. 2
26	0 - 4	4 - 18	18 - 23	Sample control
27	0 - 3	3 - 9	9 - 23	Burning ground
28	0 - 4	4 - 11	11 - 28	Burning ground
29	0 - 5	5 - 15	15 - 48	Burning ground

*In or adjacent to drainage ditch, caliche weathered to silt clay.
**Soil removed by construction in area.

three times the thickness reported in the soil survey of the County (Pringle 1980; Jacquot 1962). The caliche zone ranged from light reddish white to light reddish brown and was composed of limestone stringers and limestone fragments, gravels to clays. The caliche zone was underlain by dense silty clay and occational fragments of limestone. The silty clays ranged in color from dark gray to light reddish brown and dark brown. All holes terminated in the silty clay, which exceeds 33 ft in thickness (test hole TH-29, Table I).

Test holes TH-18 through TH-25 were drilled in the floor of two playa basins (Fig. 1). Test holes TH-18 through TH-21 were located in Playa Basin No. 1, which receives some release of sanitary and industrial effluents from the Pantex operations. The playa contains some ponded water. Though the holes were drilled within 10 ft of the pond, no free water was encountered in the holes. The samples collected were not exceedingly wet. Test holes TH-22 through TH-25 were located in Playa Basin No. 2 (Fig. 1). Playa Basin No. 2 receives natural runoff from precipitation. Only during periods after heavy precipitation does the playa contain ponded water and then only for short periods of time because of the high evaporation rate of the area (Purtymun 1982).

The soils in the playas at Pantex ranged from 2 to 7 ft in thickness, which is equivalent to the soil zones A, B, and probably a part of C of the Randall soil series (Table I). The playa soil was a clay loam containing a lot of organic material. The color ranged from dark gray to black. The soil in test holes TH-19 through TH-21 in Playa Basin No. 1 was underlain by a thin caliche zone that ranged in thickness from 3 to 6 ft. The zone contained limestone stringers and fragments and some gravels in a dark-brown clay. Although the caliche zone was more permeable than overlying soil or underlying clay, it contained no free water. The test holes in the playas beneath the soil or caliche terminated in a silty clay, which contained some gravel and a few limestone fragments. The clays were dense, ranging in color from dark gray to light reddish brown to light brown to dark brown.

In 1980, an engineering study was made for proposed waste retention ponds (Playa Basin Nos. 1 and 2). The study included a permeability test on 16 test holes up to 10 ft deep in Playa Basin No. 1 and 12 test holes up to 10 ft deep in Playa Basin No. 2. The tests indicated the playa deposits (Randall soil series) were impermeable with intake rates of <0.06 in./h (Tillery 1980).

B. Inorganic Chemicals

Playa Basin No. 1 contains water all year around, whereas Playa Basin No. 2 contains water for only short periods after a large amount of precipitation. Chemical analyses for chloride, sulfate, fluoride, and nitrate were performed on cuttings from two test holes on the upland plain (TH-8, -9) and eight test holes in two playa basins (TH-18 through TH-25). Because of variations in these chemical concentrations in cuttings, sampling results were inconclusive in

determining if chemical properties of the soil in the plain or playa basin could be related to infiltration of water from precipitation (uplands) or playa basins (ponds).

1. Chlorides. Chloride concentrations varied slightly at similar depths. On the average, chloride concentrations were higher in cuttings from holes on the upland plain than from test holes in the playa basins (Table II). In turn, the average concentrations were higher in the playa that contained a perennial pond (TH-18 through TH-21) than the playa that contained an intermittent pond (TH-21 through TH-25).

2. Sulfate. Concentrations of sulfates in cuttings from upland and playa holes varied considerably at depths showing no trends. Sulfate concentrations appeared to be slightly higher in cuttings from the playa basin holes (Table II).

3. Fluoride. Concentrations of fluoride were higher in cuttings from the upland than test holes in the playas. Fluoride concentrations were slightly greater (from 3 to 28 ft) than from the upper soil (0 to 3 ft) in cuttings from upland holes (TH-8, TH-9). Fluoride concentrations from cuttings taken at different depths in the playas showed no significant trends (Table II).

4. Nitrates. No significant change in nitrate concentrations occurred at different depths or between holes, on uplands or in playas (Table II).

TABLE II

CHLORIDE, SULFATE, FLUORIDE, AND NITRATE CONCENTRATIONS
IN CUTTINGS FROM TEST HOLES
($\bar{x}$ + SD of a number of analyses; in ppm)

Test Hole	Chloride	Sulfate	Fluoride	Nitrate	Remarks
8	100 ± 20	100 ± 70	22 ± 7	3 ± 1	Upland
9	60 ± 25	480 ± 330	20 ± 5	2 ± 0	Upland
18	40 ± 20	305 ± 280	8 ± 4	2 ± 0	Playa
19	45 ± 20	350 ± 80	7 ± 2	2 ± 0	Playa
20	40 ± 0	720 ± 50	7 ± 0	3 ± 2	Playa
21	25 ± 10	370 ± 260	7 ± 0	4 ± 2	Playa
22	<20 ± 0	390 ± 250	4 ± 1	4 ± 1	Playa
23	<20 ± 0	470 ± 340	3 ± 0	6 ± 3	Playa
24	<20 ± 0	300 ± 35	3 ± 1	3 ± 2	Playa
25	<20 ± 0	280 ± 180	14 ± 13	3 ± 1	Playa

Test holes were located in the upland soil and playa basins where plant operations could have resulted in excessive amounts of total chromium, chromates (Cr^{+6}), or cyanide in the soil. The analyses of cuttings indicated that the plant operations did not add any significant amount of these chemicals to the soils in the upland plain or playa basins.

5. Total Chromium. Concentrations of total chromium in cuttings from test holes showed no significant trends at depths or significant differences between test holes located on the uplands or in the playas (Table III).

6. Chromates (Cr^{+6}). Concentrations of chromates (Cr^{+6}) were below limits of detection in cuttings from test holes located in the upland and playa basin (Table IV).

7. Cyanide. Concentrations of cyanide were below limits of detection in cuttings from test holes located in the uplands and playa basins (Table V).

TABLE III

TOTAL CHROMIUM IN CUTTINGS FROM TEST HOLES
($\bar{x}$ ± SD of a number of analyses; in ppm)

Test Hole	Total Chromium	Remarks
1	60 ± 20	Upland
2	50 ± 6	Upland
3	55 ± 10	Upland
4	50 ± 15	Upland
5	50 ± 5	Upland
6	50 ± 10	Upland
7	45 ± 7	Upland
8	50 ± 10	Upland
9	45 ± 10	Upland
10*	60 ± 20	Upland
11*	60 ± 20	Upland
18	45 ± 10	Playa
19	45 ± 10	Playa
20	50 ± 10	Playa
21	50 ± 8	Playa
22	45 ± 10	Playa
23	45 ± 15	Playa
24	45 ± 10	Playa
25	50 ± 7	Playa

*Control hole.

TABLE IV

CHROMATES IN CUTTINGS FROM TEST HOLES
(maximum concentration; in ppm)

Test Holes	Chromates (Cr^{+6})	Remarks
8	<0.5	Upland
9	<0.5	Upland
18	<0.5	Playa
19	<0.5	Playa
20	<0.5	Playa
21	<0.5	Playa
22	<0.5	Playa
23	<0.5	Playa
24	<0.5	Playa
25	<0.5	Playa

TABLE V

CYANIDE IN CUTTINGS FROM TEST HOLES
(maximum concentration; in ppm)

Test Hole	Cyanide	Remarks
1	<0.5	Upland
2	<0.5	Upland
3	<0.5	Upland
6	<0.5	Upland
7	<0.5	Upland
10*	<0.5	Upland
11*	<0.5	Upland

*Control hole.

C. Organic Chemicals

Chemical analyses for phenol on cuttings from six test holes (TH-4, -5, -10, -11, -16, -17) on the upland plain and analyses for solvent wastes such as

toluene, dimethylformamide methanol (DMF-MeOH), tetrahydrofuran (THF), and acetone from four holes (TH-26 through TH-29) on the upland plain were made. The solvent wastes contain high explosive (HE) particles from the plant operation. The solvent-HE wastes were released into an unlined pit before 1980; the liquids infiltrated or evaporated and the residual HE was burned. Since 1980, the solvent-HE wastes have been contained in shallow tanks to allow the solvents to evaporate and then the residual HE in the tanks is burned. As the solvent wastes are highly volatile (vaporize to a gas at low temperature), the cuttings from the test holes were frozen immediately on recovery to keep the solvent in a liquid (solid) form. Test hole TH-26 was the control hole located 5600 ft southwest of the burning ground. Test hole TH-27 was located 150 ft southwest, TH-28 was located 110 ft west, and TH-29 was located 10 ft southwest of the burn pit for the solvents.

1. Phenol. Phenol can be the result of pollution by industrial wastes. Cuttings from four test holes (TH-4 and TH-5 located by a closed sanitary landfill and TH-16 and TH-17 located near pads used for burning of explosives) were analyzed for phenol. Also, for control and to obtain background results, cuttings were analyzed from two holes, TH-10 and TH-11, remote from any of the Pantex Plant operations. Concentrations of phenol from the four test holes near plant operations and from the two control holes were below limits of detection (Table VI).

2. Toluene. Concentrations of toluene in cuttings from test holes TH-26 (control hole) and TH-27 through TH-29 (near burn pit) were below limits of detection (Table VII).

TABLE VI

PHENOL IN CUTTINGS FROM TEST HOLES
(maximum concentration; in ppm)

Test Holes	Phenols	Remarks
4	<1	Uplands
5	<1	Uplands
10*	<1	Uplands
11*	<1	Uplands
16	<1	Uplands
17	<1	Uplands

*Control hole.

TABLE VII

TOLUENE, DMF-MeOH, THF, AND ACETONE IN CUTTINGS FROM TEST HOLES
(maximum concentration; in ppm)

Test Hole	Toluene	DMF	THF	Acetone
26*	<2	<1	<1	<1
27	<2	<1	<1	<1
28	<2	<1	<1	<1
29	<2	<1	<1	**

*Control hole.
**See Table VIII.

NOTE: DMF-MeOH = Dimethylformamide methanol.
THF = Tetrahydrofuran.

3. Dimethylformamide Methanol (DMF-MeOH). Concentrations of DMF-MeOH in cuttings from test hole TH-26 (control hole) and TH-27 through TH-29 (near burn pit) were below limits of detection (Table VII).

4. Tetrahydrofuran (THF). Concentrations of THF in cuttings from test holes TH-26 (control hole) and TH-27 through TH-29 (near burn pit) were below limits of detection (Table VII).

5. Acetone. Concentrations of acetone in cuttings from test holes (TH-26 (control area) and TH-26 and -28 (near burn pit) were below limits of detection (Table VII). Cuttings from test hole TH-29, located 10 ft from the southwest corner of the burn pit, contained trace amounts of the solvent acetone. The acetone occurred at depths of 13 to 43 ft with the greatest concentration occurring from 23 to 33 ft (Table VIII). Acetone is highly volatile and is readily soluble in water. The acetone was probably absorbed in soil moisture in the silty clay from 13 to 43 ft (Table I).

The acetone was allowed to evaporate or infiltrate with the other solvent waste in unlined pits before 1980; now all solvents are contained to allow evaporation. The concentrations of acetone in the silty clay will continue to decline as the acetone comes in contact with additional entrapped soil moisture, much of which is in the vapor phase.

It has been shown that little, if any, precipitation infiltrates through the upland plain or playa basin to the main aquifer in the Ogallala Formation (Aronovice 1972). The top of the aquifer lies at a depth of about 450 ft at the

TABLE VIII

ACETONE IN CUTTINGS FROM TEST HOLE TH-29
(analyses in ppm)

Depth (ft)	Acetone
0 - 3	<1
3 - 8	<1
8 - 13	<1
13 - 18	5
18 - 23	1
23 - 28	7
28 - 33	10
33 - 38	2
38 - 43	2
43 - 48	<1

burning ground. Based on lack of recharge to the aquifer, depth to the aquifer, and low concentration of acetone found in the cuttings, the acetone in the silty clay poses no problem to the aquifer or use of the aquifer for domestic, municipal, agricultural, or industrial water supply.

D. High Explosives

Pantex Plant was established in 1942 as a US Army ordnance depot that manufactured munitions. As a result, explosive waste residues were created that were, in part, flushed with water into the Playa Basin No. 1. The plant has been used since 1951 or 1952 by the Department of Energy and predecessors. There are liquid effluents created by machining of explosives with water, which are released into the Playa Basin No. 1. A concerted effort has been made to treat the effluents by filtering and use of settling basins to remove the explosive particles before release. Most explosives are insoluble in water (Dobratz 1981).

Test holes TH-1 through TH-3 and TH-6 through TH-9 are located around Zones 11 and 12 on the upland plain. Test holes TH-10 and TH-11 are control holes, whereas TH-16 and TH-17 are located near the area where the explosives are burned. Test holes TH-18 through TH-21 are located in Playa Basin No. 1, which receives the effluent released after treatment from the explosive machining activities. Test holes TH-22 through TH-25 are located in Playa Basin No. 2, which receives some runoff from Zone 11, an explosive processing area. All these test holes were drilled to a depth of 28 ft resulting in six samples from each hole or a total of 114 samples.

The samples were analyzed for the explosives HMX, RDX, TNT, PETN, and TCTNB (Rickenbaugh 1981). The results indicate that the explosives were below the limits of detection (Table IX). Where some type of explosive should have been present, such as in Playa Basin No. 1 or the burning ground, no explosives were detected.

E. Radionuclides

Total uranium was determined from cuttings from 25 test holes, ^{235}U on cuttings from 20 test holes, and tritium on cuttings from 10 test holes. In addition, gross alpha and beta activity, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{90}Sr, ^{235}U, total uranium, and tritium were determined from cuttings from two test holes in Playa Basin No. 1 (TH-21) and Playa Basin No. 2 (TH-24).

There was no significant difference in total uranium concentrations at depth in cuttings from individual test holes or between individual test holes

TABLE IX

HIGH EXPLOSIVES IN SAMPLES FROM TEST HOLES
(maximum concentration; in ppm)

Test Hole	HMX	RDX	TNT	PETN	TCTNB
1	<1	<1	<1	<1	<1
2	<1	<1	<1	<1	<1
3	<1	<1	<1	<1	<1
6	<1	<1	<1	<1	<1
7	<1	<1	<1	<1	<1
8	<1	<1	<1	<1	<1
9	<1	<1	<1	<1	<1
10*	<1	<1	<1	<1	<1
11*	<1	<1	<1	<1	<1
16	<1	<1	<1	<1	<1
17	<1	<1	<1	<1	<1
18	<1	<1	<1	<1	<1
19	<1	<1	<1	<1	<1
20	<1	<1	<1	<1	<1
21	<1	<1	<1	<1	<1
22	<1	<1	<1	<1	<1
23	<1	<1	<1	<1	<1
24	<1	<1	<1	<1	<1
25	<1	<1	<1	<1	<1

*Control hole.

except from cuttings from test holes TH-2 and TH-3, both located near Zone 12, and TH-4, located near the old sanitary landfill (Fig. 1, Table X). The total uranium mean concentrations in cuttings from the three test holes show no significant change with depth in individual test holes, and concentrations are lower than those found in the remaining 22 test holes. There is no apparent reason for the lower concentrations.

TABLE X

TOTAL URANIUM, URANIUM-235, AND TRITIUM IN CUTTINGS FROM TEST HOLES
($\bar{x}$ ± SD of a number of analyses)

Test Hole	Total Uranium (µg/g)	^{235}U (at.%)	^{3}H (10^{-6} µCi/mℓ)
1	2.1 ± 0.1	0.81 ± 0.11	--
2	1.7 ± 0.2	0.70 ± 0.18	--
3	0.8 ± 0.2	0.74 ± 0.02	--
4	0.4 ± 0.1	--	--
5	2.2 ± 0.6	--	--
6	2.4 ± 0.1	0.80 ± 0.02	--
7	2.4 ± 0.2	--	--
8	2.6 ± 0.4	0.75 ± 0.04	0.3 ± 0.4
9	2.5 ± 0.2	0.72 ± 0.03	0.4 ± 0.3
10*	2.7 ± 0.3	0.74 ± 0.02	--
11*	2.8 ± 0.1	0.79 ± 0.05	--
12	2.7 ± 0.3	0.75 ± 0.07	--
13	2.7 ± 0.6	0.70 ± 0.16	--
14	2.4 ± 0.2	0.75 ± 0.02	--
15	2.2 ± 0.3	0.80 ± 0.02	--
16	2.4 ± 0.2	--	--
17	2.4 ± 0.2	--	--
18	2.5 ± 0.5	0.73 ± 0.03	0.5 ± 0.4
19	2.3 ± 0.4	0.72 ± 0.03	-0.3 ± 0.2
20	2.2 ± 0.5	0.74 ± 0.05	-0.3 ± 0.2
21	2.2 ± 0.4	0.72 ± 0.04	0.1 ± 0.1
22	2.4 ± 0.5	0.76 ± 0.03	-0.2 ± 0.2
23	2.2 ± 0.8	0.78 ± 0.03	-0.2 ± 0.3
24	2.2 ± 0.4	0.73 ± 0.02	0.1 ± 0.3
25	2.9 ± 0.3	0.74 ± 0.02	-0.2 ± 0.3

*Control hole.

Note: ^{3}H determined from soil moisture in cuttings.

The ^{235}U in cuttings from the 20 test holes shows that the distribution of uranium in the cuttings reflects normal uranium (0.72 ± 0.08 at.%) that is not depleted or enriched. It is naturally occurring uranium found in the soil or playa deposits derived from the Ogallala Formation.

Test holes TH-12 through TH-15 are located around the firing site where there is some depleted uranium as a result of tests. Depleted or enriched uranium is determined from the ^{235}U concentration expressed in atomic per cent. Normal distribution of ^{235}U is 0.72 ± 0.08 at.%. Depleted uranium would be less than 0.72 ± 0.08 at.%, whereas enriched uranium would be greater than 0.72 ± 0.08 at.%. Cuttings from these four holes showed no depleted uranium (Table X).

Tritium concentrations were determined from soil moisture in the cuttings from two test holes on the upland plains (TH-8, TH-9) and eight test holes (TH-18 through TH-25) located in playa basin. The concentrations of tritium were at or below limits of detection.

Complete radiochemical analyses were run on two test holes, TH-21 and TH-24 in Playa Basin Nos. 1 and 2 (Fig. 1, Table XI). Playa Basin No. 1 receives most, if not all, of the effluents released from the Plant operations. Future plans include diversion of some of the effluents into Playa Basin No. 2. Thus, the analyses are made to compare radionuclide concentrations in each basin with the other and provide background data for Playa Basin No. 2 before diversion of effluents into the basin.

There is no significant difference in concentrations of gross alpha and beta activity or total uranium in cuttings from test hole TH-21 or TH-24 (Table XII). These concentrations of gross alpha and beta activity and total uranium reflect natural activity that occurs in the earth materials. The percentage of ^{235}U indicates that the uranium is natural, neither depleted nor enriched.

The concentrations of ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{90}Sr, and ^{3}H (artificially produced) in cuttings from the two test holes (TH-21, -24) are below limits of detection and are thus also below fallout levels for the area (see Section IV).

III. RADIOCHEMICAL QUALITY OF SURFACE AND GROUND WATER

Surface water samples were collected from four onsite stations and five offsite stations (Figs. 2 and 3). Ground water samples (wells) were collected from five onsite stations. The samples were analyzed for gross alpha, gross beta, ^{137}Cs, ^{238}Pu, ^{239}Pu, total uranium, and tritium (Table XIII). The ^{235}U was determined on three water samples to determine if uranium was natural, enriched, or depleted.

Onsite surface and ground water gross alpha activity (average 0.7 pCi/ℓ) and gross beta activity (average 10 pCi/ℓ) reflect natural activity in the

TABLE XI

RADIOCHEMICAL ANALYSES OF CUTTINGS FROM TEST HOLES IN PLAYA BASIN NO. 1 AND NO. 2

	Depth (ft)	pCi/g						Total U (μg/g)	^{235}U (atom%)	^{3}H (10^{-6} μCi/mℓ)
		Gross Alpha	Gross Beta	^{137}Cs	^{238}Pu	^{239}Pu	^{90}Sr			
Playa Basin No. 1 Test Hole TH-21	0 - 3	5.9 ± 1.3	7.1 ± 0.8	0.16 ± 0.04	0.000 ± 0.001	0.001 ± 0.002	0.23 ± 0.10	2.6 ± 0.3	0.73 ± 0.04	0.0 ± 0.3
	3 - 8	4.9 ± 1.2	6.9 ± 0.8	0.10 ± 0.04	-0.001 ± 0.001	0.002 ± 0.001	0.07 ± 0.04	2.4 ± 0.2	0.80 ± 0.04	0.0 ± 0.3
	8 - 13	4.5 ± 1.0	6.2 ± 0.8	0.09 ± 0.04	-0.002 ± 0.002	-0.002 ± 0.002	0.48 ± 0.06	2.6 ± 0.2	0.70 ± 0.04	0.1 ± 0.3
	13 - 18	4.0 ± 1.0	5.3 ± 0.7	0.07 ± 0.07	-0.001 ± 0.001	-0.002 ± 0.001	0.00 ± 0.06	2.2 ± 0.2	0.71 ± 0.04	-0.1 ± 0.3
	18 - 23	5.2 ± 1.6	8.7 ± 1.0	-0.04 ± 0.04	0.000 ± 0.001	0.001 ± 0.001	0.34 ± 0.07	1.8 ± 0.2	0.67 ± 0.03	0.1 ± 0.3
	23 - 28	3.3 ± 1.5	6.2 ± 0.8	0.10 ± 0.04	0.000 ± 0.001	0.000 ± 0.001	0.51 ± 0.11	1.7 ± 0.2	0.71 ± 0.04	0.3 ± 0.3
	$\bar{x}$ ± SD	4.6 ± 0.9	6.7 ± 1.1	0.08 ± 0.07	-0.001 ± 0.001	0.000 ± 0.002	0.27 ± 0.21	2.2 ± 0.4	0.72 ± 0.04	0.1 ± 0.1
Playa Basin No. 2 Test Hole TH-24	0 - 3	5.2 ± 1.2	7.4 ± 0.9	0.02 ± 0.02	-0.001 ± 0.001	0.000 ± 0.001	0.34 ± 0.08	2.4 ± 0.2	0.71 ± 0.04	-0.2 ± 0.03
	3 - 8	5.2 ± 1.2	9.7 ± 1.1	0.01 ± 0.04	-0.001 ± 0.001	0.000 ± 0.001	0.12 ± 0.07	2.5 ± 0.3	0.77 ± 0.04	0.4 ± 0.03
	8 - 13	6.1 ± 1.4	8.8 ± 1.0	0.09 ± 0.04	0.000 ± 0.001	0.001 ± 0.001	0.05 ± 0.05	2.5 ± 0.3	0.73 ± 0.04	0.1 ± 0.03
	13 - 18	4.2 ± 1.0	6.8 ± 0.8	-0.04 ± 0.05	--	--	0.15 ± 0.07	2.6 ± 0.3	0.71 ± 0.04	0.6 ± 0.03
	18 - 23	5.9 ± 1.7	6.7 ± 0.9	0.13 ± 0.09	--	--	0.33 ± 0.08	2.0 ± 0.2	0.72 ± 0.04	0.1 ± 0.03
	23 - 28	5.3 ± 1.8	7.4 ± 1.0	0.21 ± 0.08	--	--	0.12 ± 0.08	1.5 ± 0.2	--	0.0 ± 0.03
	$\bar{x}$ ± SD	5.3 ± 0.7	7.8 ± 1.2	0.07 ± 0.09	-0.001 ± 0.001	0.000 ± 0.001	0.17 ± 0.15	2.2 ± 0.4	0.73 ± 0.02	0.0 ± 0.3

TABLE XII

RADIOCHEMICAL ANALYSES OF CUTTINGS IN TEST HOLES IN PLAYA BASIN
($\bar{x}$ ± SD of a number of analyses; in pCi/g except as noted)

Radionuclide	Playa Basin No. 1 (TH-21)	Playa Basin No. 2 (TH-24)
Gross alpha	4.6 ± 0.9	5.3 ± 0.7
Gross beta	6.7 ± 1.1	7.8 ± 1.2
^{137}Cs	0.08 ± 0.07	0.07 ± 0.09
^{238}Pu	-0.001 ± 0.001	-0.001 ± 0.001
^{239}Pu	0.000 ± 0.002	0.000 ± 0.001
^{90}Sr	0.27 ± 0.21	0.17 ± 0.15
Total U*	2.2 ± 0.2	2.2 ± 0.4
^{235}U**	0.72 ± 0.04	0.73 ± 0.02
^{3}H***	0.1 ± 0.1	0.0 ± 0.3

*µg/g.
**At.%
***10^{-6} µCi/mℓ.

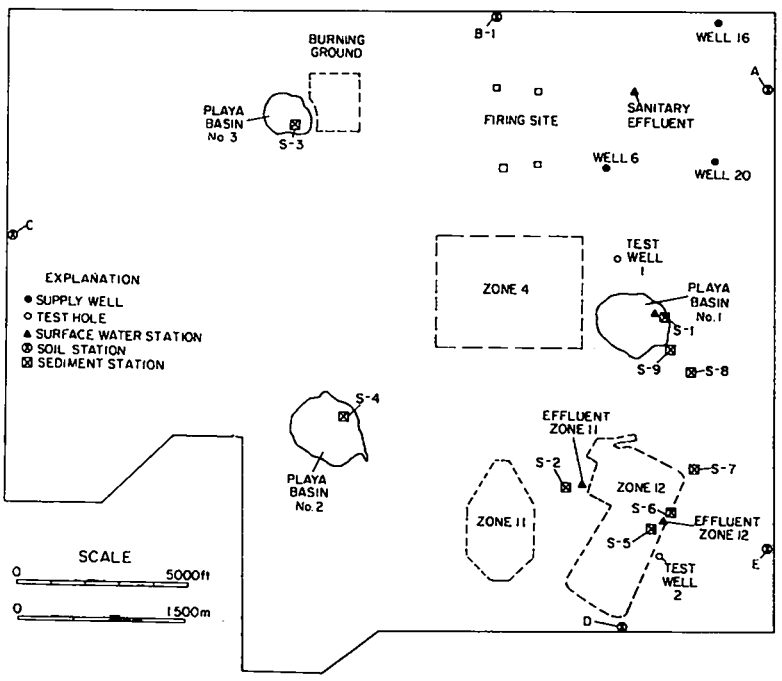


Fig. 2. Onsite water, soil, and sediment sampling stations on the Pantex Plant.

TABLE XIII

RADIOCHEMICAL ANALYSES OF SURFACE AND GROUND WATER

Stations	Date 1981	pCi/ℓ Gross Alpha	Gross Beta	^{137}Cs	^{238}Pu	^{239}Pu	Total U (μg/ℓ)	^{3}H (10^{-6} μCi/mℓ)
Onsite								
Water Supply								
Well 6	8-7	6.5 ± 1.0	7.6 ± 1.2	70 ± 30	-0.009 ± 0.015	-0.007 ± 0.015	6.5 ± 0.7	1.3 ± 0.3
Well 16	8-5	1.2 ± 1.1	8.1 ± 1.2	0 ± 50	-0.030 ± 0.020	-0.024 ± 0.016	4.5 ± 0.5	-1.1 ± 0.4
Well 20	8-6	1.5 ± 1.1	6.6 ± 1.1	130 ± 50	-0.010 ± 0.030	-0.020 ± 0.030	6.0 ± 0.6	-0.8 ± 0.4
Test Wells								
TW-1	8-5	-0.8 ± 1.1	6.7 ± 1.2	30 ± 40	-0.007 ± 0.010	0.007 ± 0.018	0.0 ± 0.4	-1.0 ± 0.4
TW-2	8-5	3.5 ± 1.5	9.8 ± 1.4	50 ± 30	0.005 ± 0.007	0.010 ± 0.009	0.0 ± 0.4	-1.6 ± 0.3
Sanitary Effluent	8-5	1.1 ± 1.5	11 ± 1.5	0 ± 13	0.012 ± 0.015	0.006 ± 0.013	5.8 ± 0.6	-1.4 ± 0.3
Playa Basin No. 1	8-5	0.1 ± 2.0	15 ± 1.9	5 ± 16	0.020 ± 0.030	-0.020 ± 0.003	6.0 ± 0.6	-1.3 ± 0.3
Effluent Zone 11	8-5	-2.5 ± 1.7	22 ± 2.0	60 ± 30	0.009 ± 0.001	0.009 ± 0.008	0.0 ± 0.4	-1.5 ± 0.3
Effluent Zone 12	8-6	1.6 ± 1.3	8.8 ± 1.3	80 ± 60	0.005 ± 0.008	0.005 ± 0.009	5.0 ± 0.5	-1.2 ± 0.3
	$\bar{x}$ ± SD	0.7 ± 1.7	10 ± 5.0	47 ± 44	-0.003 ± 0.015	0.001 ± 0.015	3.8 ± 2.8	-1.2 ± 0.5
Offsite								
Pantex Lake	8-5	2.6 ± 1.4	15 ± 1.8	50 ± 20	0.005 ± 0.009	-0.005 ± 0.005	--	-1.6 ± 0.3
7-Mile Playa	8-5	0.4 ± 1.7	27 ± 3.0	30 ± 20	-0.005 ± 0.005	-0.005 ± 0.005	4.0 ± 0.4	-1.6 ± 0.3
Playa near Panhandle	8-6	-1.2 ± 0.7	17 ± 2.0	0 ± 15	0.020 ± 0.020	0.010 ± 0.020	0.0 ± 0.4	-1.4 ± 0.3
Lake Meredith	8-6	80 ± 20	26 ± 3.0	20 ± 40	0.008 ± 0.007	-0.004 ± 0.007	8.5 ± 0.9	-1.3 ± 0.3
Canadian River	8-6	-1.0 ± 2.0	7.3 ± 1.7	9 ± 22	0.017 ± 0.010	0.004 ± 0.008	5.5 ± 0.6	-1.5 ± 0.3
	$\bar{x}$ ± SD	16 ± 36	18 ± 8.0	22 ± 20	0.009 ± 0.010	0.000 ± 0.007	4.5 ± 3.5	-1.5 ± 0.2

NOTE: All surface water except water supply and test wells.

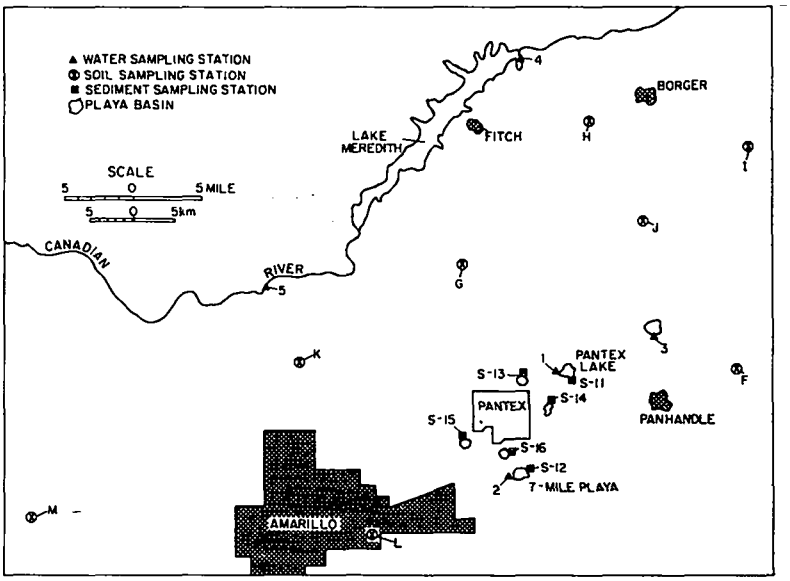


Fig. 3. Offsite water, soil, and sediment stations adjacent to the Pantex Plant.

water. Cesium-137, ^{238}Pu, ^{239}Pu, and ^{3}H are at or below the limits of detection, indicating no detectable Cs, Pu, or ^{3}H in surface or ground water at the plant. Total uranium averaged about 3.8 µg/ℓ. Ground water from supply wells, sanitary effluent, ponded water in Playa Basin No. 1 (mainly sanitary effluent), and effluent from zone 12 contained total uranium ranging from 4.5 to 6.5 µg/ℓ, which reflects those concentrations in the main aquifer (Ogallala Formation) pumped from the supply wells. Total uranium was below limits of detection from the test wells completed into the perched aquifer above the main aquifer in the Ogallala Formation. Total uranium in the effluents from Zone 11 was also below limits of detection probably because of treatment of the effluents to remove explosives, which also removes the uranium.

Offsite gross alpha and beta activity in the water samples reflects naturally occurring activity. Gross alpha (80 pCi/ℓ) occurring in water from Lake Meredith is an anomaly related to sample preparation or counting, as the results of the analyses have a very high error term. Cesium-137, ^{238}Pu, ^{239}Pu, and ^{3}H are at or below limits of detection. Total uranium concentrations reflect naturally occurring uranium. Total uranium below limits of detection from 7-Mile Playa reflects mainly runoff from precipitation from the surrounding area that would add no appreciable uranium to the runoff.

Samples of water were collected from onsite locations at supply well 6 and Playa Basin No. 1 and the offsite location at Lake Meredith and analyzed for ^{235}U. The ^{235}U found in water from supply well 6 (0.70 ± 0.08 at.%), Playa Basin No. 1 (0.70 ± 0.08 at.%), and Lake Meredith (0.72 ± 0.08 at.%) was naturally occurring, neither enriched nor depleted.

IV. RADIOACTIVITY IN SOIL AND SEDIMENTS

Five soil and nine sediment samples were collected onsite, and eight soil and eight sediment samples were collected offsite (Figs. 2 and 3). The analyses were made to determine if the worldwide fallout levels of radionuclides at and near the Pantex Plant are similar to those concentrations in other parts of the United States. The soil and sediment samples were analyzed for gross alpha, gross beta, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{90}Sr, total uranium, and ^{235}U (Table XIV).

Gross alpha and beta activity and total uranium concentrations in soils and sediments are dominated by naturally occurring radioactivity that occurs in the earth's crust. These concentrations vary throughout the United States.

The average gross alpha activity in onsite soils and sediments is about 18 pCi/g, whereas the gross alpha activity of offsite soils and sediments averaged 19 pCi/g (Table II). The average gross beta activity in onsite soils and sediments was about 18 pCi/g, whereas offsite activity was similar at 17 pCi/g. The average total uranium concentration in onsite soils and sediments was 3.1 µg/g; the average concentration in offsite soils and sediments was similar at 2.7 µg/g.

The ^{235}U was used to determine if the uranium in the soil and sediments was naturally occurring. Naturally occurring uranium would have a ratio of 0.72 ± 0.08 at.%. The ^{235}U of onsite and offsite soils and sediments falls within the naturally occurring ratio. The average onsite soil and sediment ratio is 0.77 ± 0.03 at.%, whereas the average offsite ratio is 0.74 ± 0.05 at.% (Table XIV).

Soils and sediments are derived from weathering, and transporting them from the Ogallala Formation results in some variation in concentrations of gross alpha, gross beta, and total uranium when individual samples are compared (Table XIV). However, the variation is small, usually at or within analytical error term, and therefore, the variations are not considered significant.

There is no significant difference in onsite and offsite concentrations of ^{137}Cs, ^{238}Pu, ^{239}Pu, and ^{90}Sr in soil and sediments (Table XV). These concentrations of radionuclides are low; they show no effect of the operations of the Pantex plant. The low concentrations reflect worldwide fallout of radionuclides (^{137}Cs, ^{238}Pu, ^{239}Pu, and ^{90}Sr) from atmospheric nuclear tests. The fallout concentrations vary on the earth's surface in relation to location of nuclear test and prevailing upper winds in the area. However, in similar and adjacent geographic areas, the fallout levels may be nearly the same.

The average onsite and offsite concentrations (fallout levels) of ^{137}Cs, ^{238}Pu, ^{239}Pu, and ^{90}Sr at Pantex are comparable to levels in northern New Mexico for the period 1974-1977. Additional fallout levels were determined in New Mexico in 1981 (Table XV). There were no significant differences in the fallout levels in northern New Mexico in 1974-1977 and 1981 when compared to the fallout

TABLE XIV

RADIOCHEMICAL ANALYSES OF SOIL AND SEDIMENTS

Station Designation	pCi/g						Total U (µg/ℓ)	^{235}U (atom%)
	Gross Alpha	Gross Beta	^{137}Cs	^{238}Pu	^{239}Pu	^{90}Sr		
Soils								
Onsite								
A	34 ± 8.0	26 ± 3.0	0.53 ± 0.05	0.001 ± 0.000	0.013 ± 0.004	0.42 ± 0.06	3.3 ± 0.3	0.76 ± 0.04
B	16 ± 4.0	16 ± 1.7	0.78 ± 0.06	0.001 ± 0.001	0.012 ± 0.003	0.42 ± 0.06	3.3 ± 0.3	0.72 ± 0.04
C	12 ± 3.0	13 ± 1.4	0.39 ± 0.04	0.001 ± 0.000	0.009 ± 0.003	0.02 ± 0.08	3.1 ± 0.3	0.80 ± 0.04
D	13 ± 3.0	14 ± 3.2	0.43 ± 0.10	0.001 ± 0.001	0.015 ± 0.003	0.30 ± 0.07	3.1 ± 0.3	0.80 ± 0.08
E	21 ± 5.0	25 ± 3.0	1.01 ± 0.10	0.004 ± 0.000	0.020 ± 0.004	0.22 ± 0.07	3.3 ± 0.3	0.70 ± 0.04
$\bar{x}$ ± SD	19 ± 9.0	19 ± 6.2	0.63 ± 0.26	0.002 ± 0.001	0.014 ± 0.004	0.28 ± 0.17	3.2 ± 0.1	0.76 ± 0.05
Offsite								
F	7.3 ± 1.7	9.0 ± 1.0	0.05 ± 0.06	0.001 ± 0.001	0.002 ± 0.001	0.08 ± 0.08	3.4 ± 0.3	0.72 ± 0.04
G	2.9 ± 0.7	4.4 ± 0.6	0.24 ± 0.04	0.001 ± 0.000	0.003 ± 0.001	0.17 ± 0.10	1.2 ± 0.3	0.72 ± 0.04
H	6.9 ± 1.6	11 ± 1.2	0.63 ± 0.06	0.001 ± 0.001	0.007 ± 0.002	0.16 ± 0.09	2.4 ± 0.3	0.72 ± 0.04
I	1.3 ± 0.4	2.2 ± 0.4	0.39 ± 0.04	0.001 ± 0.000	0.014 ± 0.003	0.25 ± 0.07	2.0 ± 0.3	0.80 ± 0.04
J	2.4 ± 0.8	5.2 ± 0.7	0.08 ± 0.05	0.001 ± 0.000	0.000 ± 0.000	0.10 ± 0.06	1.5 ± 0.3	0.80 ± 0.04
K	4.0 ± 1.0	6.9 ± 0.8	0.47 ± 0.04	0.005 ± 0.001	0.013 ± 0.003	0.26 ± 0.09	2.3 ± 0.3	0.72 ± 0.04
L	44 ± 10	31 ± 3.0	0.10 ± 0.04	0.002 ± 0.001	0.001 ± 0.000	0.57 ± 0.04	2.9 ± 0.3	0.68 ± 0.03
M	37 ± 8.0	26 ± 3.0	0.96 ± 0.06	0.002 ± 0.002	0.026 ± 0.005	0.33 ± 0.09	2.9 ± 0.3	0.68 ± 0.03
$\bar{x}$ ± SD	13 ± 17	12 ± 11	0.37 ± 0.32	0.002 ± 0.001	0.008 ± 0.009	0.24 ± 0.16	2.3 ± 0.7	0.73 ± 0.05
Onsite and Offsite								
$\bar{x}$ ± SD	16 ± 14	15 ± 9.5	0.47 ± 0.32	0.002 ± 0.001	0.010 ± 0.008	0.25 ± 0.16	2.7 ± 0.7	0.74 ± 0.05
Sediments								
Onsite								
S-1	28 ± 6.0	19 ± 2.0	0.02 ± 0.05	0.002 ± 0.000	0.001 ± 0.001	--	2.6 ± 0.3	0.80 ± 0.04
S-1 (wet)	8.8 ± 1.0	8.1 ± 0.9	0.58 ± 0.04	0.002 ± 0.001	0.010 ± 0.002	--	2.9 ± 0.3	0.72 ± 0.04
S-2	45 ± 10	28 ± 3.0	0.00 ± 0.03	0.001 ± 0.000	0.002 ± 0.001	0.51 ± 0.08	2.7 ± 0.3	0.76 ± 0.04
S-3	15 ± 3.0	32 ± 3.0	0.48 ± 0.05	0.004 ± 0.001	0.012 ± 0.002	0.19 ± 0.07	3.0 ± 0.3	0.76 ± 0.04
S-4	11 ± 2.0	12 ± 1.3	0.73 ± 0.05	0.001 ± 0.000	0.016 ± 0.003	0.17 ± 0.07	3.3 ± 0.3	0.76 ± 0.04
S-5	6 ± 1.4	7.9 ± 0.9	0.32 ± 0.08	0.000 ± 0.001	0.000 ± 0.002	0.08 ± 0.06	3.7 ± 0.3	0.79 ± 0.04
S-6	--	--	--	--	--	--	2.7 ± 0.3	0.82 ± 0.04
S-7	--	--	--	--	--	--	3.0 ± 0.3	0.72 ± 0.04
S-8	--	--	--	--	--	--	3.1 ± 0.3	0.77 ± 0.04
S-9	7.8 ± 1.7	9.7 ± 1.1	0.04 ± 0.08	-0.002 ± 0.001	0.006 ± 0.002	0.03 ± 0.06	3.0 ± 0.3	0.77 ± 0.04
$\bar{x}$ ± SD	17 ± 14	17 ± 9.9	0.31 ± 0.30	0.001 ± 0.002	0.007 ± 0.006	0.20 ± 0.19	3.0 ± 0.3	0.76 ± 0.03

TABLE XV

AVERAGE MAXIMUM CONCENTRATIONS OF RADIONUCLIDES IN SOILS AND SEDIMENTS IN NORTHERN NEW MEXICO AND ONSITE AND OFFSITE AT PANTEX
(analyses in pCi/g)

	^{137}Cs	^{238}Pu	^{239}Pu	^{90}Sr
Northern New Mexico				
Soils 1974-77*	1.12	0.008	0.036	0.87
Soils 1981**	1.24	0.0090	0.0250	1.10
Sediments 1974-77*	0.54	0.006	0.018	0.70
Sediments 1981**	0.61	0.0017	0.0105	0.68
Pantex near Amarillo Texas				
Soils (onsite)	1.15	0.004	0.022	0.62
Soils (offsite)	0.69	0.004	0.026	0.54
Sediments (onsite)	0.91	0.004	0.023	0.58
Sediments (offsite)	1.47	0.004	0.027	0.68

*Purtymun 1980.
**ESG 1982.

Note: Define average maximum concentrations as $\bar{x}$ + 2 SD.

levels or concentrations in soil and sediments at and adjacent to Pantex in 1981 (Purtymun 1980, ESG 1982).

A comparison of the fallout levels of plutonium in the entire United States with those fallout levels at and adjacent to Pantex indicated that the plutonium concentrations at Pantex are about 0.3 to 0.5 of the average fallout levels for the United States (USEPA 1977).

V. MONITORING OF WASTE WATER

Waste water from plant operations is released into ditches that drain into Playa Basin No. 1. Waste water is mainly from machining and formulation of high explosives but also includes some water from the laundry, boiler plant blowdown, and release associated with operations of refrigeration units for cooling.

The ditches in uplands around Zones 11 and 12 carry industrial effluent or waste water into Playa Basin No. 1 (Fig. 4). The high-explosive wastes in the

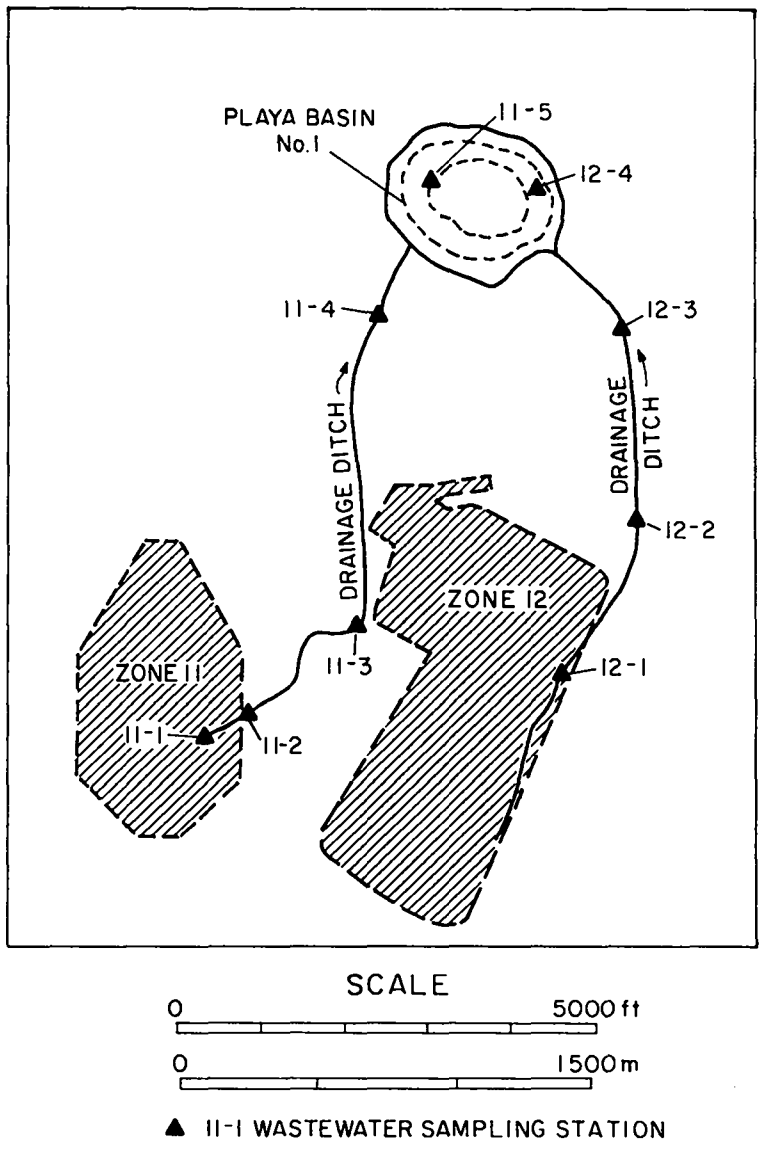


Fig. 4. Waste water sampling stations in drainage ditches from Zones 11 and 12.

water are conveyed from machining buildings to settling and filtering treatment stations where most of the high-explosive particles are extracted. The treated effluents containing some fine-grained suspended particles and traces of dissolved high explosives are then released into ditches. Other effluents released into the ditches require no special treatment. The chemical constituents of water in the ditches are within criteria for irrigation (Purtymun 1982).

The ditches from Zones 11 and 12 are cut into the upland soil (Pullman soil series), which is relatively impermeable; however, evaporation and transpiration rates along the ditches are high. Thus, in the ditch from Zone 11, the flow

into Playa Basin No. 1 is intermittent and occurs only when there is heavy or prolonged precipitation that results in storm runoff. The flow of waste water from zone 12 is also intermittent; however, the flow volume is larger and the discharge into the playa basin is more frequent and over a longer period of time than the discharge from Zone 11.

The ditches are flushed several times a year by storm runoff that disperses any high-explosive particles that may have settled out in the ditches after treatment. The transport of sediments and explosive particles by storm runoff downgradient to Playa Basin No. 1 disperses the explosives in ditches so that a high buildup does not occur near the point of effluent release.

Waste water and sediments in both ditches from Zones 11, 12, and Playa Basin No. 1 were collected for analyses for various types of explosives and organic compounds. Also, a sample of sanitary effluent from the sanitary treatment plant was analyzed for organic compounds. The sanitary effluent is released in the Playa Basin No. 1.

A. High Explosives in Waste Water and Sediments

Seven waste waters and nine sediment samples in two drainage ditches from Zones 11 and 12 were analyzed for explosives (Table XVI and Fig. 4). The analyses were made for explosive compounds of TNT, PETN, RDX, HMX, HNAB, HNS, and TATB (Quinlin 1982). When the samples were taken, waste water was found at stations 11-1, -2, -3, and stations 12-1, -2, -3, and -4. Stations 11-5 and 12-4 are in Playa Basin No. 1. No water was found at station 11-5 (west side of Playa Basin No. 1); however, a sample was collected at the east side of the playa at station 12-4 (Fig. 4). Sediment samples were taken at the same location as waste water samples. Only sediment samples were collected at locations 11-4 and 11-5 because the ditch was dry as was the west side of the playa.

Concentrations of TNT were below limits of detection in waste water (<0.01 ppm) and sediments (<0.01 ppm) in the ditches from Zones 11 and 12. Concentrations in waste water of PETN (<0.2 ppm), HNAB (<0.1 ppm), and HNS (<0.08 ppm) and concentrations found in sediments of PETN (<0.3 ppm), HNAB (<0.2 ppm), and HNS (<0.14 ppm) were below limits of detection (Table XVI).

Trace amounts of RDX (5.5 ppm) were found in waste water at station 11-1 near the point of effluent release. Other waste water samples (<0.05 ppm) and all sediment samples (<0.1 ppm) were below limits of detection.

Trace amounts of HMX (≈4 ppm) were found in waste water from Zone 11 at stations 11-1 and -2. At station 11-3 the HMX was <0.05 ppm. Sediment concentrations of HMX at station 11-1, near the point effluent release, were 1940 ppm. Concentrations in the sediments remained about the same at stations 11-2 (40 ppm), 11-3 (38 ppm), and in the western part of the playa at station

TABLE XVI

CONCENTRATIONS OF EXPLOSIVES IN DRAINAGE DITCHES FROM ZONES 11 AND 12 INTO PLAYA BASIN NO. 1
(analysis in ppm)

Sample Location	TNT	PETN	RDX	HMX	HNAB	HNS	TATB
Zone 11							
Water							
11-1	<0.01	<0.20	5.5	4.2	<0.10	<0.08	<0.02
11-2	<0.01	<0.20	<0.05	4.4	<0.10	<0.08	<0.02
11-3	<0.01	<0.20	<0.05	<0.05	<0.10	<0.08	<0.02
Sediment							
11-1	<0.01	<0.30	<0.10	1940	<0.20	<0.14	4.29
11-2	<0.01	<0.30	<0.10	40	<0.20	<0.14	<0.04
11-3	<0.01	<0.30	<0.10	38	<0.20	<0.14	0.96
11-4	<0.01	<0.30	<0.10	0.3	<0.20	<0.14	0.38
11-5	<0.01	<0.30	<0.10	43	<0.20	<0.14	0.91
Zone 12							
Water							
12-1	<0.01	<0.20	<0.05	1.50	<0.10	<0.08	<0.02
12-2	<0.01	<0.20	<0.05	1.10	<0.10	<0.08	<0.02
12-3	<0.01	<0.20	<0.05	0.50	<0.10	<0.08	<0.02
12-4	<0.01	<0.20	<0.05	<0.05	<0.10	<0.08	<0.02
Sediment							
12-1	<0.01	<0.30	<0.10	1964	<0.20	<0.14	1.02
12-2	<0.01	<0.30	<0.10	<0.1	<0.20	<0.14	1.02
12-3	<0.01	<0.30	<0.10	<0.1	<0.20	<0.14	0.07
12-4	<0.01	<0.30	<0.10	8.0	<0.20	<0.14	<0.04

Note: Sample locations shown in Fig. 4.

11-5 (43 ppm). At station 11-4 the concentration was 0.3 ppm. The channel in this area is scoured into the soil and most sediments are transported to the playa.

Waste water from Zone 12 contained traces of HMX at point of effluent outfall station 12-1 (1.5 ppm) decreasing to less than limits of detection (<0.05 ppm) in water in the playa. Concentrations of HMX in sediments varied from 1964 ppm at the effluent outfall (station 12-1) to <0.1 ppm at the two intermediate stations (12-2 and -3) and about 8 ppm in sediments in the playa.

Concentrations of TATB were below limits of detection (<0.02 ppm) in waste water from Zones 11 and 12 and in the playa basin (Table XVI). Trace amounts of TATB were found in the sediments of both drainage ditches ranging from <0.04 ppm to about 4.3 ppm in the drainage from Zone 11 and from <0.04 ppm to 1.02 ppm in the drainage from Zone 12. Concentrations vary somewhat but are highest near point of waste water release, decreasing downgradient in the drainage.

In general, the concentrations of explosives are greater in the sediments than in solution in the waste water. Concentrations in both the waste water and sediments decrease downgradient in the ditches from the point of effluent outfall to the playa. The concentrations of explosives (HMX and TATB) found in sediments at the playa were low. No explosives were detected in water of the playa.

B. Organic Compounds in Waste Water and Sediments

Four water and four sludge, soil, or sediment samples were analyzed for organic compounds. The samples were collected from waste water ditches from Zones 11 and 12, water from Playa Basin No. 1, sanitary effluent, and soil from near the burning ground.

Only those compounds listed as priority pollutants were qualified from standards (USEPA 1979, USEPA 1981). Some compounds are identified only by their type because obtaining an exact identification from the mass spectrum would be difficult. An estimate of the amount of these compounds is reported as <500 ppb (Sutcliffe 1982).

Zone 11 waste water and sediment samples were collected at station 11-2 in the ditch draining Zone 11 to Playa Basin No. 1. Waste water at this sampling station contained branched hydrocarbon <500 ppb, trichloroethylene 66 ppb, toluene 37 ppb, cyclic hydrocarbon <500 ppb, di-n-butyl phthalate 57 ppb, and four branch hydrocarbons <500 ppb. Sediments at the same station contain hydrocarbon <500 ppb, trichloroethylene 736 ppb, toluene 265 ppb, dimethyl-benzene 36 ppb, ethenylbenzene 100 ppb, alcohol <500 ppb, and four hydrocarbons <500 ppb.

Zone 12 waste water and sediments were collected in the drainage ditch to Playa Basin No. 1 at station 12-2 (Fig. 4). The waste water contained two branch hydrocarbons <500 ppb, one unknown phthalate ≈10 ppb, and branched hydrocarbon <500 ppb. The sediments at the same station contained hydrocarbon <500 ppb, trichloroethylene 194 ppb, toluene 21 ppb, dimethylbenzene 10 ppb, cyclohexene <500 ppb, and three branched hydrocarbons <500 ppb.

The waste water and sediments from Playa Basin No. 1 were collected at station 12-4 (Fig. 4). The water in the playa contains a combination of waste water from Zones 11 and 12, sanitary effluents, and storm runoff. The water in the playa contained butanol <500 ppb, unknown alcohol <500 ppb, branched

hydrocarbon <500 ppb, alcohol <500 ppb, unknown phthalate ≈10 ppb, hydrocarbon <500 ppb, and di-n-butyl phthalate 10 ppb. The sediments from the playa contained hydrocarbon <500 ppb, trichloroethylene 133 ppb, and toluene 106 ppb.

Sanitary effluent was collected after being treated, but before being released into Playa Basin No. 1. The effluent contained hydrocarbon <500 ppb, trichloroethylene 100 ppb, toluene 99 ppb, cyclic hydrocarbon <500 ppb, and three branch hydrocarbons <500 ppb.

A soil sample was collected north of the pad area where high explosives are burned (Burning Ground, Fig. 2). The soil sample contained hydrocarbon <500 ppb, trichloroethylene 510 ppb, and toluene 68 ppb.

The levels of the organic compounds (priority pollutants) in waste water (<500 ppb), sanitary effluents (<500 ppb), and sediment and soils (<750 ppb) are low or near background concentrations. Based on the low level of the organics, there is no environmental impact. There is no possibility of any organics reaching the aquifer in the Ogallala Formation because of low concentration of organics in waste water, hydrologic characteristics of soil and playa basin deposits (clays relatively impermeable), and depth to the top of the aquifer (about 450 ft).

VI. SUMMARY

Subsurface investigation indicates soil and playa deposits are similar to those described by the soil survey in the county. Soil thickness in the upland plains (up to 19 ft thick) was underlain by more than 33 ft of a silty clay. The playa basin deposits, a clay loam, were in excess of 28 ft thick. The permeability of both the upland soil and playa basin deposits is very low, less than 0.06 to 0.2 in./h.

Analyses of inorganic chemicals found in test hole cuttings [chloride, sulfate, fluoride, nitrate, total chromium, chromate (Cr^{+6}), and cyanide] indicated no significant trends between holes located on upland plain and playa basins. The analyses indicated that, when compared to cuttings from control holes, there was no effect from the plant's operation and release of liquid effluents.

Organic chemicals (phenols, toluene, dimethylformamide methanol, tetrahydrofuran, and acetone) were analyzed in cuttings from test holes. Only acetone was detected at a depth of 13 to 43 ft adjacent to a pit used to burn solvents. The concentrations are low, less than 10 ppb, and pose no threat of contamination to the main aquifer at the site. The solvents are now contained when burned; thus, the source for continued contamination has been removed.

High explosives (HMX, RDX, TNT, PETN, and TCTNB) were analyzed in cuttings from test holes. The results indicate that the explosives were less than the

limits of detection (1 ppm). No explosives were detected in test holes in Playa Basin No. 1 or at the burning ground, where explosive waste may have been present at the land surface.

Total uranium in test holes on the upland plain and playa basins was naturally occurring in the soils and playa deposits. There was no significant difference in concentrations in total uranium at depth or between cuttings from test holes except for two holes on the upland plain, where uranium concentrations were lower than concentrations in the other 23 holes.

The ^{235}U in cuttings from the test holes indicated that the uranium was naturally occurring. Tritium concentrations from 10 test holes were below limits of detection (1×10^{-6} µCi/mℓ). Cuttings from one test hole in Playa Basin No. 1 and one test hole in Playa Basin No. 2 were analyzed for gross alpha, gross beta, and total uranium concentrations and ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{90}Sr, and ^{3}H. The concentrations were at or below limits of detection or worldwide fallout levels. These analyses indicated no effect on or from plant operations.

Radiochemical quality of water from four onsite, five offsite surface water stations, and five onsite ground water stations indicates only naturally occurring gross alpha, gross beta, and total uranium concentrations. The ^{137}Cs, ^{238}Pu, ^{239}Pu, and ^{3}H concentrations were at or below limits of detection. The ^{235}U analyses from one offsite surface water station and two onsite (surface water and ground water) indicate only naturally occurring uranium.

Radiochemical analyses of soil and sediments, onsite and offsite, indicated only naturally occurring concentrations of gross alpha, gross beta, and total uranium. The atomic per cent of ^{235}U indicates natural uranium. Concentrations of ^{137}Cs, ^{238}Pu, ^{239}Pu, and ^{90}Sr were in the worldwide fallout range of concentrations because of nuclear atmospheric tests. These concentrations at Pantex were similar to those concentrations found in soil and sediments in Northern New Mexico.

Trace amounts of explosive RDX were found in waste water at point of effluent release from Zone 11. Trace amounts of explosive HMX were found in waste water near point of release at Zones 11 and 12 with concentrations decreasing downgradient toward the playa. TATB was found in sediments in trace amounts in drainage areas from both Zones 11 and 12. The concentrations of TNT, PETN, HNAB, and HNS in waste water and sediments were low, below limits of detection. The concentration of explosives in the sediments of the playa basin is low or below limits of detection. No explosives were detected in the water of the playa. Water in playa basins is not a source of recharge to the perched or main aquifer in the Ogallala Formation. The treatment of explosive effluents before release and dispersion and dilution of explosives in the ditches by storm runoff have eliminated any potential contamination of the water resources of the area.

Trace amounts of organic compounds reported in waste water and sediments (in drainage ditches from Zones 11 and 12, Playa Basin No. 1, sanitary effluent, and soil near the burning ground) are at levels of concentration too low to be considered significant, as the water in ditches or playa basins is not a source of recharge to aquifers in the Ogallala Formation.

ACKNOWLEDGMENTS

The authors would like to acknowledge Bill Laseter, Ron Alexander, Tim Quinlin, Quentin Gill, and Jan Snyder of Mason and Hanger for all the support they provided us for the data collection at Pantex. We also appreciate the analytic support provided by the personnel of WX-3, H-5, H-7, and H-8 of the Los Alamos National Laboratory.

REFERENCES

Aronovice 1972: U. S. Aronovice and A. D. Schneider, "Deep Percolation through Pullman Soil in the Southern High Plains," J. of Soil Water Conserv. 27, No. 2 (March-April 1972).

Becker 1982: N. M. Becker and W. D. Purtymun, "Supplementary Documentation for an Environmental Impact Statement Regarding the Pantex Plant: Hydrologic Study for Pantex," Los Alamos National Laboratory report LA-9445-PNTX-A (1982).

Dobratz 1981: B. M. Dobratz, "LLNL Explosive Handbook, Properties of Chemical Explosives and Explosive Stimulants," Lawrence Livermore National Laboratory report UCRL-52997 (March 1981).

ESG 1982: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1981," Los Alamos National Laboratory report LA-9349-ENV (April 1982).

Jacquot 1962: L. L. Jacquot, "Soil Survey of Carson County, Texas," US Department of Agriculture series 1959, No. 10 (July 1962).

Pringle 1980: Fred Pringle, "Supplement to Soil Survey of Carson County, Texas," US Department of Agriculture (June 1980).

Purtymun 1980: W. D. Purtymun, R. J. Peters, and A. K. Stoker, "Radioactivity in Soils and Sediments in and Adjacent to the Los Alamos Area, 1974-1977," Los Alamos Scientific Laboratory report LA-8234-MS (February 1980).

Purtymun 1982: William D. Purtymun and Naomi M. Becker, "Supplementary Documentation for an Environmental Impact Statement Regarding the Pantex Plant: Geohydrology," Los Alamos National Laboratory report LA-9445-PNTX-I (1982).

Quinlin 1982: W. T. Quinlin and C. L. Schaffer, "Explosive Contents in Pantex Internal Drainage System," Mason and Hanger--Silas Mason Co., Inc., Technical Report MHSMP-82-22 (August 1982).

Rickenbaugh 1981: D. Rickenbaugh, "Analytical Results of Explosive Analysis of Soil," Los Alamos National Laboratory, WX-3, memorandum to W. D. Purtymun (May 29, 1981).

Sutcliffe 1982: C. R. Sutcliffe, "Amarillo Pantex Sludge and Water Samples," Los Alamos National Laboratory memorandum H-5-82-0969S to W. D. Purtymun and N. M. Becker (August 9, 1982).

Tillery 1980: B. R. Tillery, "Sub-Soil Investigations, Water Retention Lakes near Pantex Plant, Amarillo, Texas," Amarillo Testing and Engineering, Inc., (March 24, 1980).

USEPA 1977: US Environmental Protection Agency, "Proposed Guidance on Dose Limits for Persons Exposed to Transuranium Elements in the General Environment," USEPA Office of Radiation Programs report EPA 540/4-77-106 (September 1977).

USEPA 1979: US Environmental Protection Agency, "Water Quality Criteria; Availability," Federal Register, Vol. 44, No. 191, October 1, 1979, Notices, Washington, DC (1979).

USEPA 1981: US Environmental Protection Agency, "Code of Federal Regulations, Title 40 CFR 136--Guidelines Establishing Test Procedures of the Analysis of Pollutants," Office of Federal Register, GSA, Washington, DC (1981).

APPENDIX

METHODS OF ANALYSES FOR VARIOUS TYPES OF SAMPLES

Test Hole Cuttings (Section II)	Extraction	Method	References
Inorganic chemicals			
Chloride, sulfate, fluoride nitrates, chromates (Cr^{+6})	Distilled water	Standard	USEPA 1979; Adams 1981
Cyanide	Distilled water, adjust pH	Standard	USEPA 1979; Adams 1981
Total Chromium	--	Neutron activation	ESG 1982
Organic chemicals			
Phenol	Distilled water	Gas chromatography	Martinez 1981
Dimethylformamide methanol (DMF), tetrahydrofuran (THF), acetone, toluene	2% chloroform in dimethyl sulfoxide	Gas chromatography	Nies 1982; Mueller 1981
High explosives			
HMX, RDX, TNT, PETN, TCTNB	Distilled water	Liquid chromatography	Rickenbaugh 1981
Radionuclides (Sections II, III, and IV)			
Water, soil, sediments, and test hole cuttings, gross alpha, gross beta, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{90}Sr, ^{3}H, total U	--	--	ESG 1982
Water, soil, sediments, ^{235}U	--	Neutron activation	Gladney 1982A; 1982B
Waste Water (Section V)			
High explosives			
PETN, TATB, HMX, RDX, HNAB, TNT, HNS	--	Gas, liquid, and thin layer chromatography	Quinlin 1982
Organic chemicals	--	Gas chromatography and mass spectrometer	Sutcliffe 1982

REFERENCES FOR APPENDIX

Adams 1981: W. H. Adams, "Soil Analyses Pantex," Los Alamos National Laboratory, H-7, memorandum H-7-81-248 to W. D. Purtymun (May 14, 1981).

ESG 1982: Environmental Surveillance Group, "Environmental Surveillance at Los Alamos During 1981," Los Alamos National Laboratory report LA-9349-ENV (April 1982).

Gladney 1982A: E. S. Gladney, R. J. Peters, and D. R. Perrin, "The Determination of U^{235}/U^{238} Ratio in Natural Waters by Chelex 100 Ion-Exchange and Neutron Activation Analyses" (in preparation).

Gladney 1982B: E. S. Gladney, R. J. Peters, and D. R. Perrin, "The Determination of U^{235}/U^{238} Ratio in Soils by Neutron Activation Analyses" (in preparation).

Martinez 1981: A. M. Martinez, "Determination of Selected Volatile Organics in Soils," Los Alamos National Laboratory, memorandum H-5-81-606 to W. D. Purtymun (June 16, 1981).

Mueller 1981: J. J. Mueller, "Report of Analyses," Controls for Environmental Pollution, Inc., Santa Fe, New Mexico, memorandum to Bill Laseter, Mason and Hanger--Silas Mason Co., Amarillo, Texas (August 31, 1981).

Nies 1982: J. D. Nies, "Analytical Results Inorganic Solvents," Ana Chem, Inc., Albuquerque, New Mexico, memorandum to N. Becker (January 6, 1982).

Quinlin 1982: W. T. Quinlin and C. L. Shaffer, "Explosive Content in Pantex Internal Drainage System," Mason and Hanger--Silas Mason Co., Inc., Technical Report MHSMP-82-22 (August 1982).

Rickenbaugh 1981: D. Rickenbaugh, "Analytical Results Explosive Analysis of Soil," Los Alamos National Laboratory, WX-3, memorandum to W. D. Purtymun (May 29, 1981).

Sutcliffe 1982: C. R. Sutcliffe, "Amarillo Pantex Sludge and Water Samples," Los Alamos National Laboratory memorandum H-5-82-09695 to W. D. Purtymun and N. M. Becker (August 9, 1982).

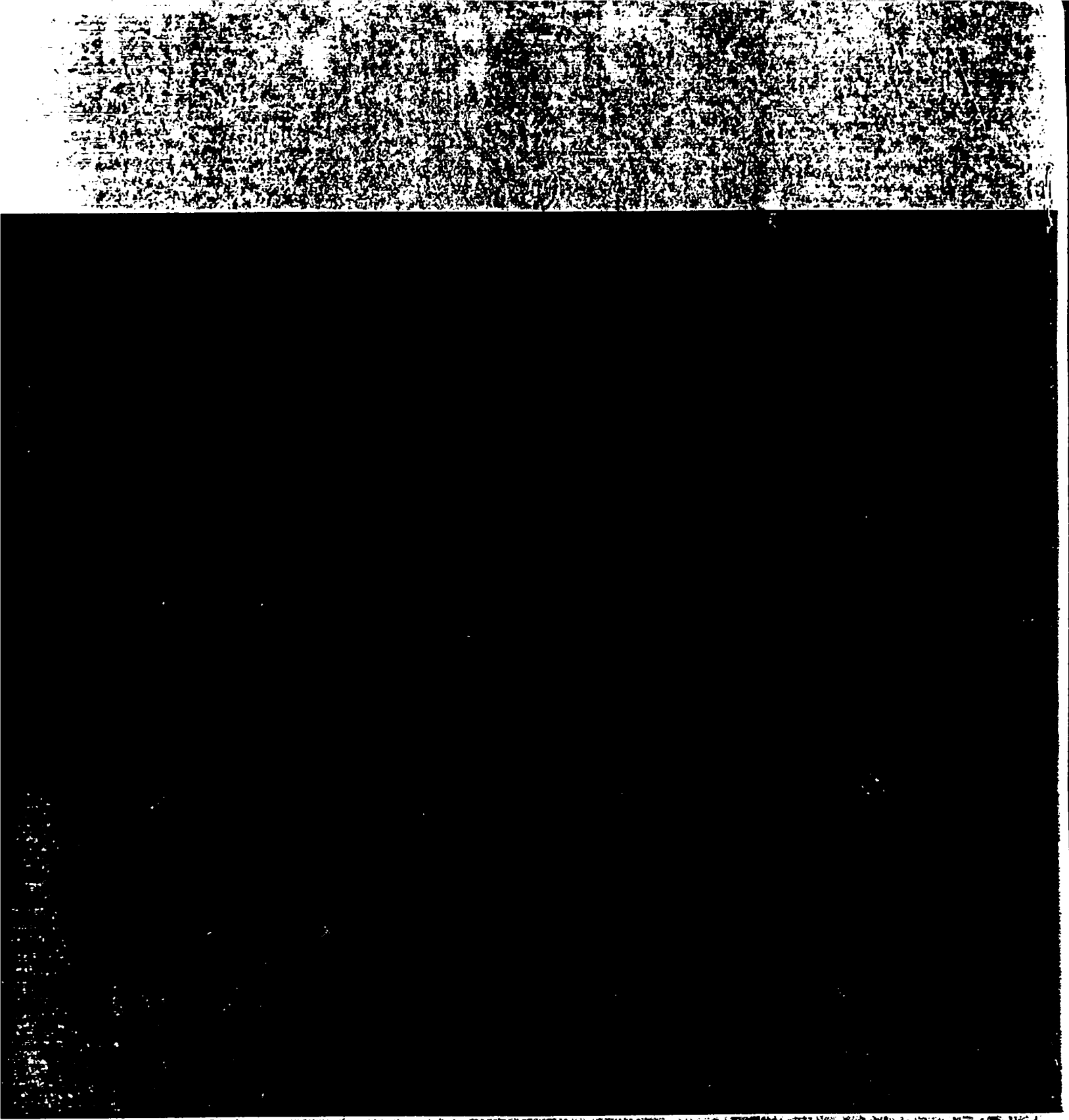
USEPA 1979: US Environmental Protection Agency, "Methods for Chemical Analysis of Water and Waste," USEPA, Office of Technology Transfer, EPA-600-4-79-020, Washington, DC (1979).

Printed in the United States of America
Available from
National Technical Information Service
US Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

Microfiche (A01)

Page Range	NTIS Price Code	Page Range	NTIS Price Code	Page Range	NTIS Price Code	Page Range	NTIS Price Code
001-025	A02	151-175	A08	301-325	A14	451-475	A20
026-050	A03	176-200	A09	326-350	A15	476-500	A21
051-075	A04	201-225	A10	351-375	A16	501-525	A22
076-100	A05	226-250	A11	376-400	A17	526-550	A23
101-125	A06	251-275	A12	401-425	A18	551-575	A24
126-150	A07	276-300	A13	426-450	A19	576-600	A25
						601-up*	A99

*Contact NTIS for a price quote.



Los Alamos