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Reconnaissance Survey of the Intermediate-Level Liquid Waste Transfer Line Between X-10 and the Hydrofracture Site

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RECONNAISSANCE SURVEY OF THE INTERMEDIATE-LEVEL LIQUID WASTE TRANSFER LINE BETWEEN X-10 AND THE HYDROFRACTURE SITE

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ABSTRACT

Two leakage points on an intermediate-level liquid waste line were located. The waste line is used periodically to transfer waste between X-10 and the hydrofracture site. The first leak had occurred prior to this survey and had been repaired. However, no contaminated soil had been removed. The second leak had not been discovered previously and soil contamination in this area was more intense than at the first leak. Analyses of soil samples taken from both locations are given in this report. Groundwater data that indicate the effectiveness of the removal of the contaminated material from leak two are presented.

INTRODUCTION

The purpose of this report is to record data collected from two areas on the intermediate-level liquid waste transfer line between X-10 and the hydrofracture site. These areas were contaminated accidentally by seepage of radioactive waste from the line at points of minor line-coupling failure. While both areas were small the levels of soil contamination and the effects of cleanup and repair operations may be important in future studies of radionuclide movement in the White Oak drainage.

The transfer line is used periodically to transport waste from storage tanks at X-10 to the hydrofracture site (Fig. 1). The first 1-1/2-mile section of the line is 2-in.-diam cast iron pipe was

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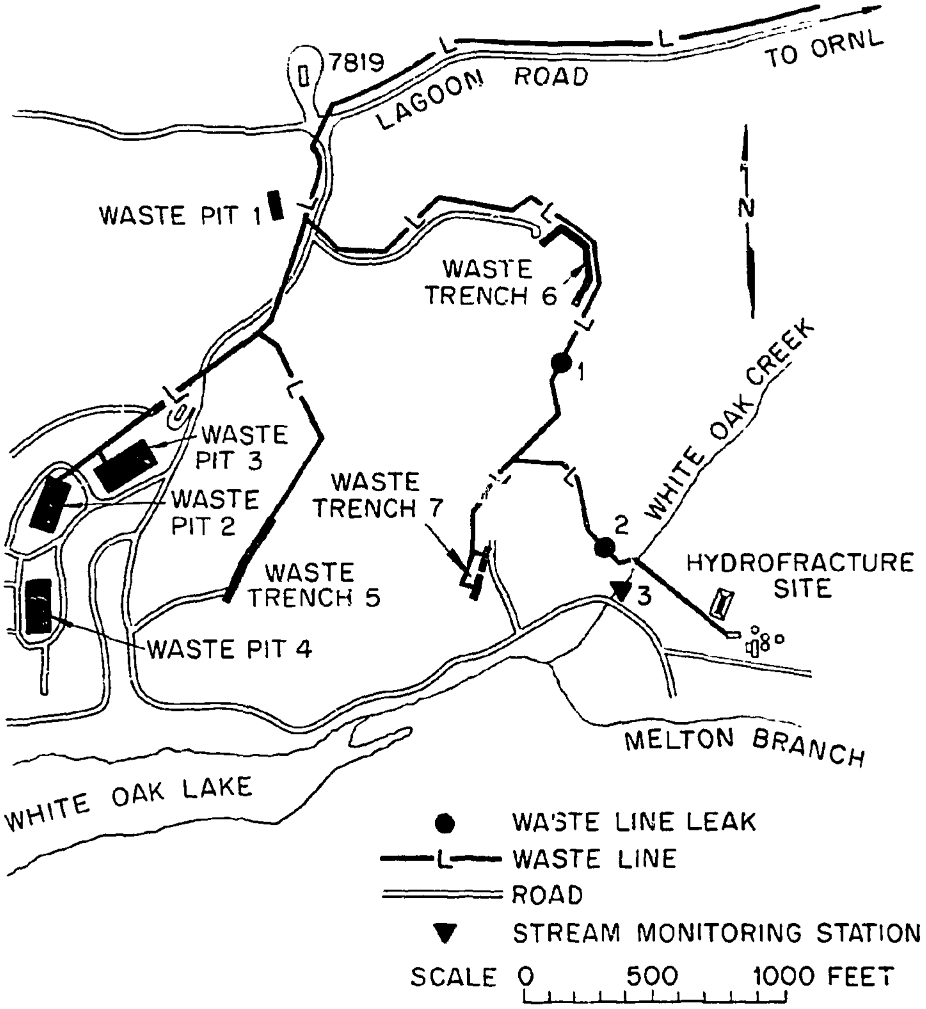

Fig. 1. Location of Waste Line Leaks on Transfer Line between ORNL and the Hydrofracture Site.

put into operation in June 1954 to transfer waste from X-10 to seepage pit 2 (not fully shown in Fig. 1). By 1960 a 2-in.-diam black steel extension had been added to transfer waste to trench 5. In 1961 a further extension of the 2-in.-diam cast iron line was used for trench 6. By 1962 the cast iron line had been extended from trench 6 to trench 7, which was used between 1962 and 1965. In 1965 the method of disposal of liquid waste into pits and trenches was discontinued, and the 2-in.-diam cast iron line was subsequently extended to the hydrofracture site. The first use of hydrofracture as a method of disposal of intermediate-level liquid waste was begun in December 1966.

LEAK ONE

Leak one is located on the waste transfer line near waste trench 6 (Fig. 1). Evidence of the leak was first surveyed by the authors on July 16, 1973. This leak occurred at an earlier date and had been repaired. Waste had seeped from the buried line at a connector between adjacent sections of pipe, and the repair work consisted of making a small excavation and tightening the coupling. After the repair work was completed, the excavation was filled and uncontaminated fill was placed over the contaminated area. The amount of liquid waste that seeped from the line was small, probably only a few gallons.

The transfer line is buried in weathered Conasauga shale. This formation has relatively high adsorptive properties for radionuclides. Thus the contamination was concentrated in the shale in a small region near the leak. At this location the waste had reached the ground surface and had spread laterally for several feet. The level of contamination observed during this survey was either exposed by erosion of the uncontaminated fill that was placed over the area or was contaminated by leaching of the underlying soil after the repair was completed. At the time of leakage the area near the leak would probably have appeared damp and no visible flow would have been observed.

Surface erosion of the weathered shale and leaching of radioactive contamination from the shale during heavy rains had caused downslope movement of the radionuclides in a southwesterly direction (Fig. 2). The primary mechanism of transport was erosion and subsequent downslope movement of sediment on which the radionuclides were adsorbed. The area near the leak and sediment accumulations in the small drainage below the leak were sampled on July 23, 1973. A total of nine soil samples were collected, with sample number 1 representing soil at the leak itself and sample number 9 representing soil from the point farthest from the leak (Fig. 3). Samples 7 through 9 were collected from sediment accumulations in the drainage below the leak; thus these three samples have high radionuclide concentrations because of the concentration of contaminated sediment in small depressions within the drainage.

The depth to the groundwater table at this location is approximately 12 ft. It would be expected that some contamination had reached the water table; however, no wells were drilled at this location, and the only seep within the drainage had been contaminated previously from leakage from waste trench 6.

The analyses of soil samples from leak one are shown in Table 1. The division of the total alpha contamination into separate components was not made; however, the primary alpha contributor to intermediate-level

Table 1. Analysis of Soil Samples Taken Near Leak One on July 23, 1973

Sample	Total α (cpm/g)	^{90}Sr (dpm/g)	^{60}Co (dpm/g)	^{95}ZrNb (dpm/g)	^{106}Ru (dpm/g)	^{125}Sb (dpm/g)	^{134}Cs (dpm/g)	^{137}Cs (dpm/g)
1	3.01×10^{3}	4.83×10^{6}	$\leq 2.0 \times 10^{5}$	1.52×10^{6}	$\leq 1.0 \times 10^{6}$	$\leq 2.0 \times 10^{6}$	$\leq 4.0 \times 10^{5}$	9.70×10^{7}
2	73.8	6.20×10^{4}	$\leq 4.0 \times 10^{3}$	3.08×10^{4}	$\leq 2.0 \times 10^{4}$	$\leq 3.0 \times 10^{4}$	$\leq 8.0 \times 10^{3}$	1.95×10^{6}
3	49.0	1.15×10^{3}	$\leq 3.0 \times 10^{2}$	4.87×10^{2}	$\leq 1.0 \times 10^{3}$	$\leq 3.0 \times 10^{2}$	$\leq 4.0 \times 10^{2}$	2.39×10^{4}
4	6.58×10^{2}	7.64×10^{4}	$\leq 3.0 \times 10^{2}$	1.34×10^{4}	$\leq 3.0 \times 10^{4}$	$\leq 1.0 \times 10^{4}$	$\leq 7.0 \times 10^{3}$	7.59×10^{5}
5	1.50×10^{3}	3.15×10^{6}	$\leq 6.0 \times 10^{5}$	1.81×10^{6}	$\leq 4.0 \times 10^{6}$	$\leq 3.0 \times 10^{6}$	$\leq 1.0 \times 10^{6}$	1.06×10^{8}
6	56.7	3.00×10^{2}	$\leq 2.0 \times 10^{2}$	3.29×10^{2}	$\leq 2.0 \times 10^{3}$	$\leq 7.0 \times 10^{2}$	$\leq 3.0 \times 10^{2}$	1.74×10^{4}
7	2.10×10^{2}	1.19×10^{6}	$\leq 7.0 \times 10^{4}$	7.83×10^{5}	$\leq 5.0 \times 10^{5}$	5.79×10^{5}	$\leq 2.0 \times 10^{5}$	4.79×10^{7}
8	3.75×10^{2}	3.45×10^{5}	$\leq 4.0 \times 10^{3}$	3.62×10^{4}	$\leq 3.0 \times 10^{4}$	$\leq 5.0 \times 10^{4}$	$\leq 1.0 \times 10^{4}$	2.0×10^{6}
9	1.38×10^{2}	1.88×10^{5}	$\leq 9.0 \times 10^{3}$	2.16×10^{4}	$\leq 4.0 \times 10^{4}$	$\leq 3.0 \times 10^{4}$	$\leq 9.0 \times 10^{3}$	1.28×10^{6}

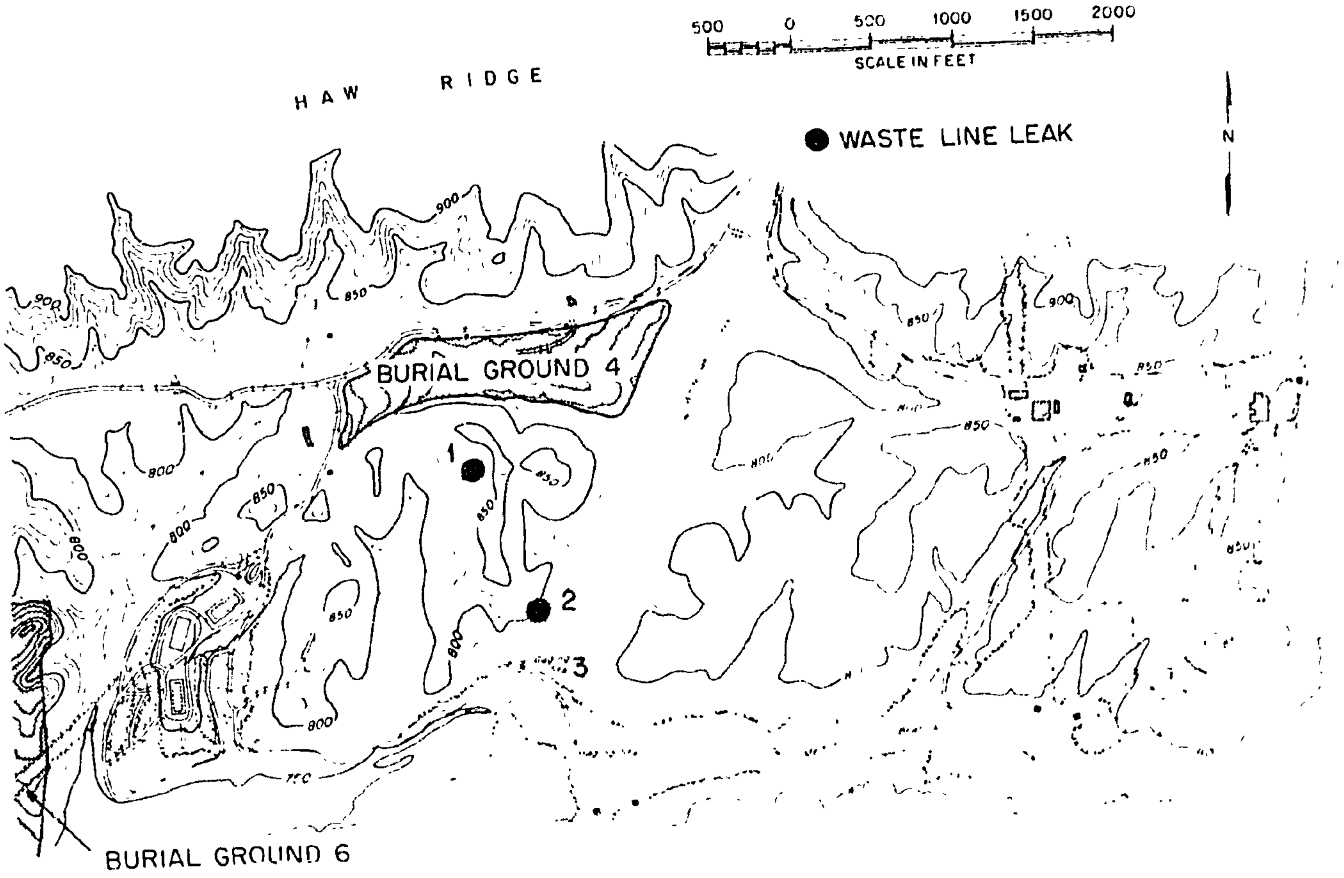

Fig. 2. Contour Map Showing Location of Waste Line Leaks.

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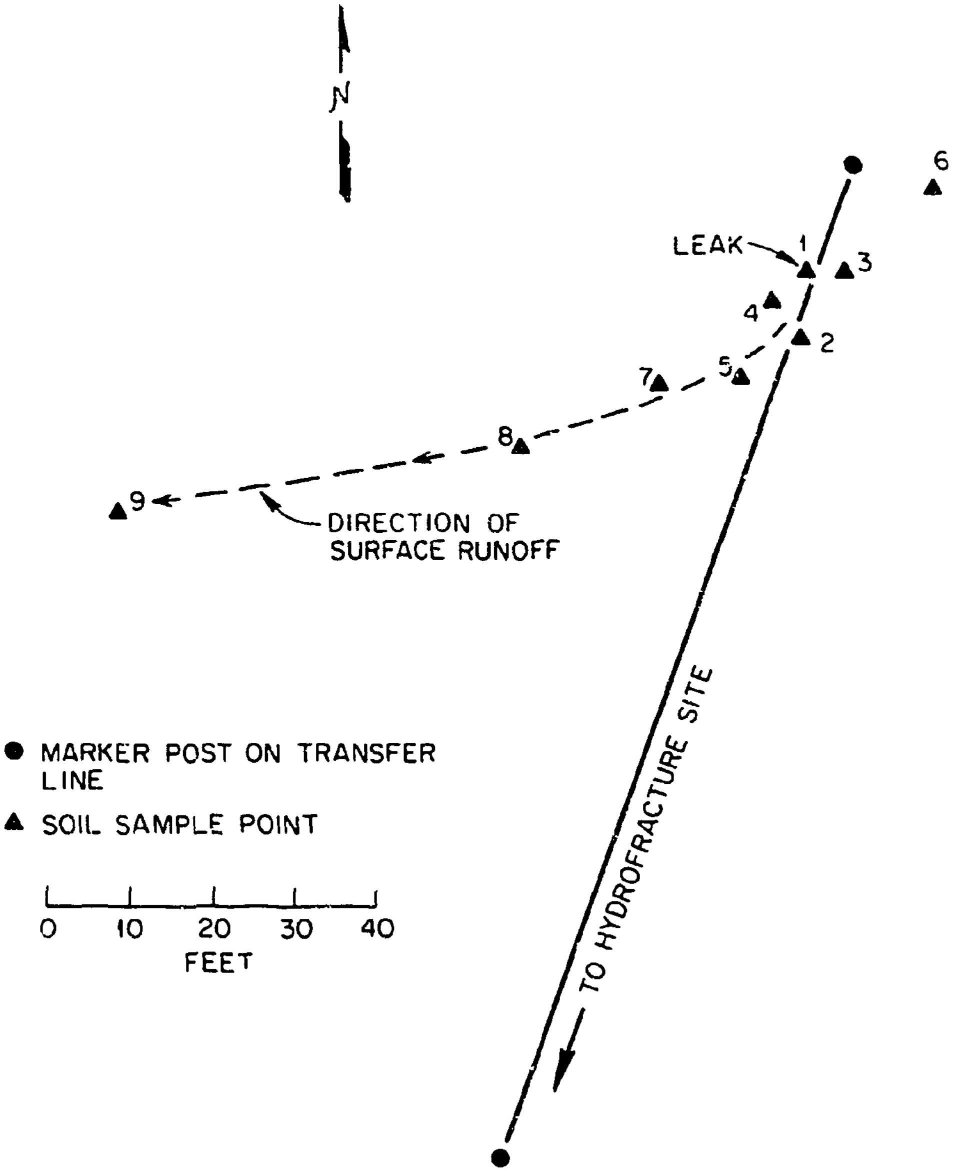

Fig. 3. Approximate Locations of Soil Samples Taken Near Leak One on July 23, 1973.

waste is ^{244}Cm. The waste also contains minor amounts of ^{241}Am, ^{238}Pu, and ^{239}Pu. In all of the samples ^{137}Cs was observed at higher activity levels than other radionuclides. This is caused by the adsorption of ^{137}Cs by the shale and by its high concentration in the waste itself.

LEAK TWO

Leak two is located on the transfer line approximately 200 ft west of the point where the line crosses White Oak Creek (Fig. 1). At this location the surface and groundwater drainage is in an easterly direction toward White Oak Creek (Fig. 2). The contaminated area was discovered on July 16, 1973. In this area, as in the case of leak one, the waste had seeped from a pipe coupling and had reached the ground surface where it spread laterally over a small area. The leak had occurred during a previous transfer. However, it would have been detected before the next waste transfer by pressure testing of the line (a procedure that is carried out before each transfer).

During reconnaissance of the area, lush vegetation was observed near the point of leakage. The lush growth was caused by the high nitrate concentration in the waste. The point of leakage was characterized by a small depression approximately 1 ft in diameter and several inches deep. The depression was formed by consolidation of the soil above the line as water flowed from the saturated soil after completion of the waste transfer.

The primary mechanism of transport of the radioactive material appeared to be erosion of contaminated shale and subsequent deposition of sediment on the slope between the leak and the stream. Contaminated sediment had reached the creek channel, as was evident from deposition of contamination near the water's edge.

On July 17, 17 soil samples were collected from the area (Fig. 4). The location of sample points was made using a survey meter, and the sample was collected from the point of highest reading. Sample 1 was collected on the creek bank, and sample 17 was taken from the depression near the leak itself. The locations of these soil samples are shown in Fig. 4, and their analyses are given in Table 2.

The total alpha count in sample 17 was 4.06×10^6 cpm/g, which for a counting efficiency of 50% is 8.12×10^6 dpm/g, or 3.65 μCi/g. The components of the total alpha found in this sample were approximately 3.43 μCi/g of ^{244}Cm, 0.19 μCi/g of ^{241}Am and ^{238}Pu, and 0.03 μCi/g of ^{239}Pu. The total amount of ^{90}Sr contained in this sample was 4.22×10^2 μCi/g, and the total gamma activity was 6.21×10^2 μCi/g. The amount of radioactive contamination dropped rapidly after sample point 6. This is explained by the downslope movement of contaminated sediment (i.e., it had not progressed much beyond point 6). However, small amounts of contaminated sediment could be identified with a survey meter between point 6 and White Oak Creek.

During July and August 1973 a total of 3,415 ft^3 of contaminated soil (weathered Conasauga shale) was removed from the vicinity of the leak. The soil removal was carried out by the ORNL Operations Division, and the soil was transported to burial ground 6 for disposal. During this cleanup operation, 875 ft^3 of contaminated soil was buried in trench 3 and 2,540 ft^3 of contaminated soil was disposed of in trench

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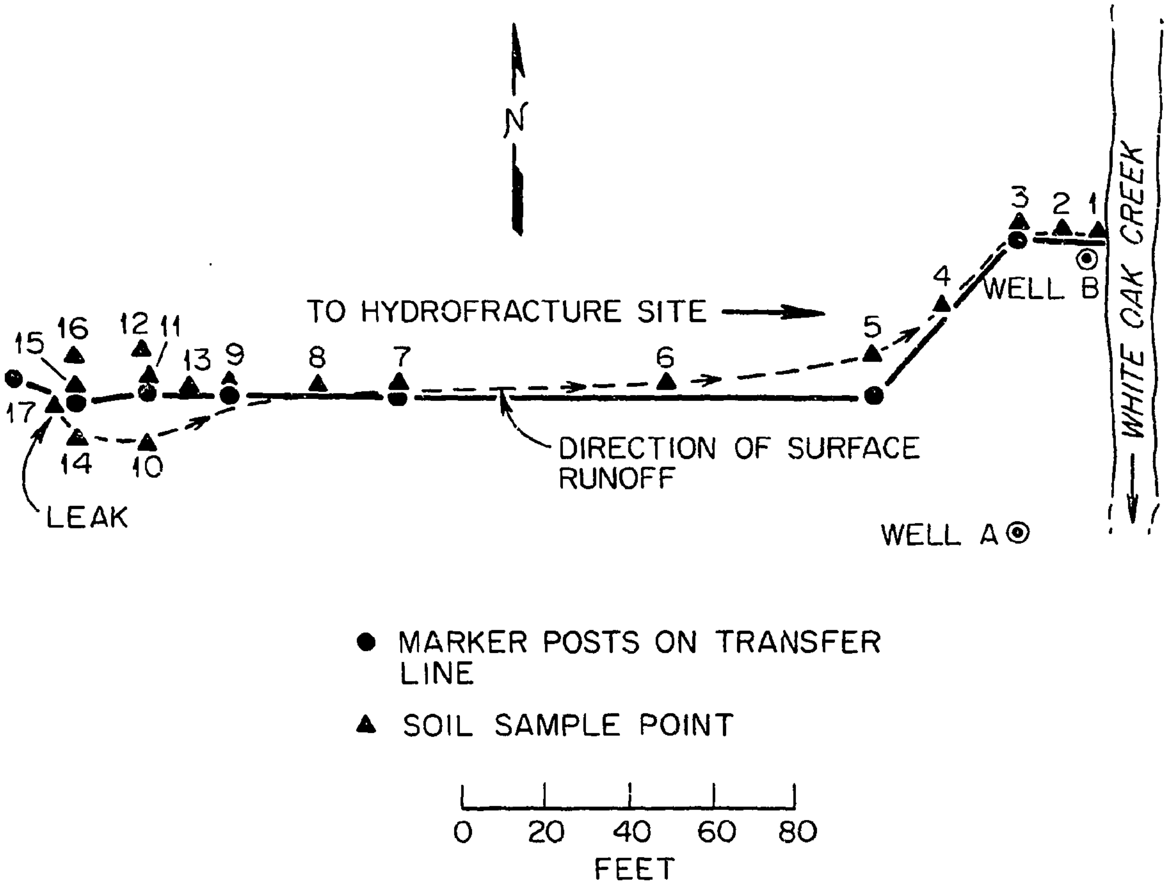

Fig. 4. Approximate Locations of Soil Samples Taken Near Leak Two on July 17, 1973.

Table 2. Analysis of Soil Samples Taken Near Leak Two on July 17, 1973

Sample	Total α (cpm/g)	^{90}Sr (dpm/g)	^{60}Co (dpm/g)	^{95}ZrNb (dpm/g)	^{106}Ru (dpm/g)	^{125}Sb (dpm/g)	^{134}Cs (dpm/g)	^{137}Cs (dpm/g)
1	17.0	9.28×10^{2}	$\leq 4.0 \times 10^{2}$	1.76×10^{2}	$\leq 1.0 \times 10^{3}$	$\leq 3.0 \times 10^{2}$	$\leq 4.0 \times 10^{2}$	6.83×10^{3}
2	25.0	3.13×10^{3}	$\leq 4.0 \times 10^{2}$	1.37×10^{2}	$\leq 3.0 \times 10^{3}$	$\leq 2.0 \times 10^{2}$	$\leq 3.0 \times 10^{2}$	6.57×10^{3}
3	52.0	4.35×10^{3}	2.59×10^{2}	1.55×10^{2}	1.34×10^{3}	$\leq 1.0 \times 10^{2}$	$\leq 4.0 \times 10^{2}$	8.02×10^{3}
4	858.0	4.25×10^{3}	3.22×10^{3}	4.14×10^{3}	1.06×10^{4}	$\leq 3.0 \times 10^{3}$	3.97×10^{3}	2.14×10^{5}
5	300.0	6.34×10^{4}	8.78×10^{2}	4.91×10^{2}	2.57×10^{3}	$\leq 5.0 \times 10^{2}$	7.98×10^{2}	2.39×10^{4}
6	6.21×10^{3}	2.14×10^{6}	2.08×10^{4}	2.14×10^{4}	6.23×10^{4}	$\leq 2.0 \times 10^{4}$	2.30×10^{4}	1.10×10^{6}
7	4.42×10^{3}	1.47×10^{6}	1.37×10^{4}	1.10×10^{4}	3.51×10^{4}	$\leq 1.0 \times 10^{4}$	1.30×10^{4}	5.37×10^{5}
8	4.17×10^{3}	3.53×10^{6}	2.74×10^{4}	4.65×10^{4}	9.31×10^{4}	$\leq 4.0 \times 10^{4}$	3.88×10^{4}	2.25×10^{6}
9	284.0	2.26×10^{5}	$\leq 8.0 \times 10^{3}$	8.04×10^{4}	$\leq 6.0 \times 10^{4}$	$\leq 8.0 \times 10^{4}$	$\leq 2.0 \times 10^{4}$	4.82×10^{6}
10	1.03×10^{4}	6.63×10^{6}	4.12×10^{4}	5.12×10^{4}	1.61×10^{5}	$\leq 5.0 \times 10^{4}$	4.92×10^{4}	2.53×10^{6}
11	22.0	3.86×10^{3}	$\leq 2.0 \times 10^{2}$	$\leq 2.0 \times 10^{2}$	$\leq 9.0 \times 10^{2}$	$\leq 2.0 \times 10^{2}$	$\leq 4.0 \times 10^{2}$	3.05×10^{3}
12	10.0	8.72×10^{2}	$\leq 1.0 \times 10^{2}$	$\leq 1.0 \times 10^{2}$	$\leq 6.0 \times 10^{2}$	$\leq 2.0 \times 10^{2}$	$\leq 2.0 \times 10^{2}$	2.23×10^{3}
13	380.0	1.16×10^{5}	$\leq 4.0 \times 10^{3}$	2.63×10^{4}	$\leq 4.0 \times 10^{4}$	$\leq 3.0 \times 10^{4}$	$\leq 1.0 \times 10^{4}$	1.58×10^{6}
14	6.67×10^{4}	2.55×10^{7}	1.81×10^{5}	2.21×10^{5}	6.72×10^{5}	$\leq 2.0 \times 10^{5}$	2.46×10^{5}	1.07×10^{7}
15	105.0	1.55×10^{4}	3.19×10^{2}	1.23×10^{2}	$\leq 2.0 \times 10^{3}$	$\leq 4.0 \times 10^{2}$	$\leq 4.0 \times 10^{2}$	6.83×10^{3}
16	35.0	1.67×10^{4}	$\leq 3.0 \times 10^{2}$	1.66×10^{3}	$\leq 7.0 \times 10^{2}$	$\leq 4.0 \times 10^{2}$	$\leq 4.0 \times 10^{2}$	6.90×10^{3}
17	4.06×10^{6}	9.37×10^{8}	2.43×10^{7}	7.37×10^{6}	4.86×10^{7}	$\leq 7.0 \times 10^{6}$	1.78×10^{7}	3.48×10^{8}

4. Trenches 3 and 4 are located in the northeast corner of burial ground 6 (Fig. 5).

Three shallow wells (4 to 10 ft deep) were installed on the floodplain of White Oak Creek to determine the effect of leak two on the level of radioactivity in the groundwater. Two of these wells, A and B, are shown in Fig. 4. The third well, C, was located approximately 350 ft upstream from well B near the bank of White Oak Creek. Well C was used as a background well to determine the level of contamination in the groundwater moving down the floodplain of the creek. The analyses of sediment and water from these wells are shown in Table 3. The initial water sample from well B contained 1.35 dpm/ml of ^{90}Sr and 0.19 dpm/ml of ^{137}Cs. This sample was collected approximately 1 month after the source of contamination (the contaminated soil) had been removed. The level of contamination found in wells A and B during August and September suggests that the groundwater was still under the influence of the leak and that the contamination had not yet been flushed from the system. Samples collected in October show that the level of radioactive contamination in the groundwater was reduced by removal of the contaminated soil near the leak. The samples from wells A and B that were collected over the 3-month period (August-October) indicate that the level of contamination in the groundwater rapidly returned to near background (see Well C, Table 3). The data presented in Table 3 show the importance of the removal of the highly contaminated source material and the effects of the removal on the reduction of groundwater transport of radionuclides from the area.

Table 3. Analysis of Soil and Water Samples from Wells Located Near Leak Two

Sample	Date (1973)	Type	Total α (cpm/g)	^{90}Sr (dpm/g)	^{60}Co (dpm/g)	^{95}ZrNb (dpm/g)	^{125}Sb (dpm/g)	^{125}Sb (dpm/g)	^{137}Cs (dpm/g)
Well B	Aug. 27	Water	≤ 0.09	1.35	4.06×10^{-1}	$\leq 1.1 \times 10^{-2}$	2.22	$\leq 6.5 \times 10^{-2}$	1.85×10^{-1}
Well A	Sept. 25	Soil	≤ 2.95	7.95×10^{2}	$\leq 1.05 \times 10^{1}$	≤ 5.0	≤ 3.0	≤ 10.0	141.0
Well B	Sept. 25	Soil	≤ 9.9	6.06×10^{2}	1.13×10^{3}	5.81×10^{2}	$\leq 8.0 \times 10^{2}$	$\leq 5.1 \times 10^{2}$	4.14×10^{2}
Well A	Oct. 5	Water	≤ 0.17	7.49×10^{-1}	9.64×10^{-2}	$\leq 5.0 \times 10^{-3}$	2.84	$\leq 2.8 \times 10^{-2}$	$\leq 2.44 \times 10^{-2}$
Well B	Oct. 5	Water	$\leq 8.7 \times 10^{-2}$	2.79×10^{-1}	5.06×10^{-2}	$\leq 5.7 \times 10^{-3}$	6.3×10^{-1}	$\leq 4.1 \times 10^{-2}$	$\leq 2.1 \times 10^{-2}$
Well C	Oct. 5	Water	$\leq 6.5 \times 10^{-2}$	≤ 0.15	$\leq 3.6 \times 10^{-2}$	$\leq 4.0 \times 10^{-3}$	$\leq 1.5 \times 10^{-1}$	$\leq 2.3 \times 10^{-2}$	3.0×10^{-2}

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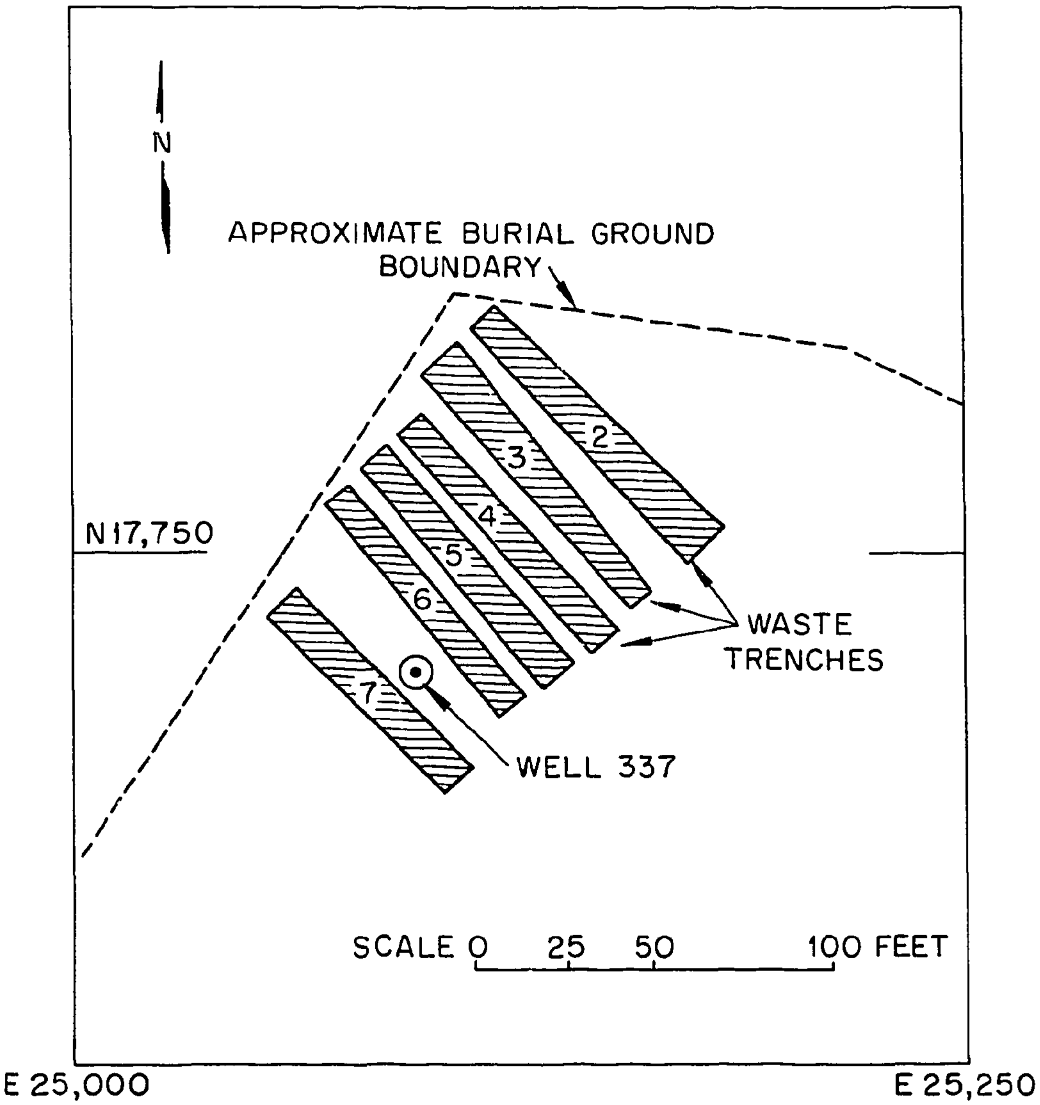

Fig. 5. Trench Location in the Northeast Corner of Burial Ground 6.

Calculations of the annual discharge of ^{90}Sr from burial ground 4 for the years 1971 through 1973 were used to approximate the amount of ^{90}Sr which entered White Oak Creek from leak two (1). This amount is estimated to be 0.4 Ci and is based on the difference between calculated annual discharge from burial ground 4 and the annual discharge that is attributed to the burial ground from stream monitoring data.

DISCUSSION

The data collected from both leaks in the transfer line indicate that the Conasauga shale played an important role in limiting the spread of radioactive contamination. The strong adsorptive properties of the shale caused high concentrations of radionuclides in the immediate vicinity of the leak and delayed the transport of contamination into the surface waters of the drainage. Subsequent erosion of the contaminated material and downslope movement of sediment by surface runoff appear to be the major factors in radionuclide movement at both leaks. In the case of leak one, erosion and transport of contaminated soil do not pose an immediate problem in the contamination of surface waters of the drainage because of the location of the leak and the large distance between the contaminated area and White Oak Creek. At leak two, the distance of sediment transport to the creek is shorter than in the case of leak one, and contaminated sediment had reached the creek channel; thus, at this location the removal of the contaminated sediment was necessary.

Leaching of the contaminated soil during infiltration of precipitation will increase the radionuclide concentration in the groundwater at both locations. However, no wells were installed near leak one to determine its effect on the groundwater. Here, as in the case of surface transport of contamination, the location of the leak is an important factor in reducing the amount of contamination that is likely to reach White Oak Creek. The wells that were installed below leak two show the influence of the leak on the radionuclide concentation in the groundwater near White Oak Creek. The monitoring data from these wells also show the reduction of radioactive contamination in the groundwater to near background levels within a 3-month period after the source of contamination had been removed. The source of contamination (3,415 ft^3 of contaminated soil) was removed and disposed of in burial ground 6.

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