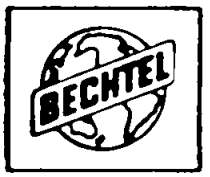
35639
DOE/OR/20722-83
M-022

Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-81OR20722

POST-REMEDIAL ACTION REPORT FOR THE RESIDENTIAL PROPERTIES ON GROVE AVENUE AND PARKWAY

Rochelle Park, New Jersey

March 1986



Bechtel National, Inc.
Advanced Technology Division

35439

DOE/OR/20722-83

POST-REMEDIAL ACTION REPORT FOR THE RESIDENTIAL PROPERTIES ON GROVE AVENUE AND PARKWAY ROCHELLE PARK, NEW JERSEY

MARCH 1986

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

Under Contract No. DE-AC05-81OR20722

By

Bechtel National, Inc.

Advanced Technology Division

Oak Ridge, Tennessee

Bechtel Job No. 14501

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

dpm	**disintegrations per minute***
g	**gram**
h	**hour**
l	**liter**
uR	**microroentgens**
mrem	**millirem**
pCi	**picocurie**
WL	**working level**
yr	year

*Words appearing in bold face print are explained in the glossary.

1.0 INTRODUCTION

Bechtel National Inc. (BNI) removed radioactive contamination from residential properties on Grove Avenue and Parkway in Rochelle Park, New Jersey, as part of the Department of Energy's (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP). The purpose of this report is to document BNI post-remedial action sampling of properties in the vicinity of the Stepan Company plant which is in Maywood, New Jersey. This report briefly describes the origin of the radioactive contamination on the properties, the methods used to determine the extent of it, and the types of remedial action performed. It also provides the guidelines used in performing the remedial action and data on the current radiological status of the properties.

Background

From about 1916 until 1956, Maywood Chemical Works extracted thorium compounds and rare earths from a natural, sand-like ore called monazite. The thorium was used to manufacture a number of products including mantles for gas lanterns. Stepan Company acquired the site in 1959. In 1984, Congress directed the DOE to initiate a research and development effort for the decontamination project involving the site and vicinity properties in Maywood. The Maywood site and vicinity properties, which include the residential properties on Grove Avenue and Parkway, were assigned by the DOE to FUSRAP. FUSRAP is a DOE effort to identify, decontaminate, or otherwise control sites where low-level radioactive contamination (exceeding current guidelines) remains from the early days of the nation's atomic energy program. Although the contamination at the Rochelle Park residences did not result from the atomic energy program, it was included as part of FUSRAP by Congress. FUSRAP is currently being managed by DOE's Oak Ridge Operations Office. BNI is the Project Management Contractor and acts as DOE's representative in the planning, management, and implementation of FUSRAP.

During the period when Maywood Chemical Works was processing thorium, waste sludges were pumped into settling lagoons. Two of these areas are located on the Ballod property (Figure 1). Radioactive contamination has migrated from these areas in surface runoff of rainwater and in dirt taken from the site and used as fill material on the Grove and Parkway properties located in Rochelle Park, New Jersey. From previous radiological surveys of the Ballod Property (Refs. 1 and 2), radioactive contamination was known to exist up to the property lines of the homes along Grove Avenue and Parkway. Since it was suspected that this contamination extended onto the residential properties, a radiological survey of these properties was performed in 1983 by BNI. The survey results were reported in September 1984 (Refs. 3 through 11).

2.0 REMEDIAL ACTION GUIDELINES

The radioactive contamination on the Grove Avenue and Parkway residences consisted primarily of thorium-232, with lesser amounts of radium-226 and uranium-238. Table 1 (Ref. 12) lists the DOE guidelines for residual contamination. DOE used the thorium-232 and radium-226 limits listed in Table 1 for the remedial actions at these properties. DOE implemented these guidelines on the basis of their compatibility with the criteria used by the Environmental Protection Agency (Ref. 13). If these guidelines are exceeded, contaminated soil is removed from the property until radionuclide concentrations are within guideline values. Once the guidelines have been met, the property can be released for unrestricted use.

3.0 REMEDIAL ACTION

Based on the results of the 1983 radiological surveys of these properties, DOE "designated" them for remedial action. This means that each designated property was contaminated above DOE guidelines and that the contamination would be cleaned up. The residents were notified at this time, and BNI began engineering design work and related activities to hire local subcontractors to perform the cleanup work (Ref. 14).

Cleanup/Decontamination Activities

When the design work had been completed and permission (a construction access agreement) received from the property owner to perform the remedial action, the local subcontractor began work. The subcontractor excavated the property based on drawings that showed the extent of the contamination for each property. The shaded areas in Figures 3, 5, 7, 9, 11, 13, 15, 17, and 19 show these limits of contamination. The subcontractor then removed the soil as indicated in the drawings, placed it in watertight dump trucks, and transported it to the storage pile on the Maywood Interim Storage Site (MISS) which is adjacent to Stepan Company plant. The soil will be stored at the MISS until a permanent disposal site is selected for this material.

After the radioactively contaminated soil was removed, the property was restored to its original condition. This included backfilling the excavation followed by sodding and/or seeding. If shrubbery or trees were removed during the cleanup, they were replaced or alternative arrangements were made with the individual property owners. In some cases, removing the contamination necessitated alterations to buildings, fences, or pavement. If this occurred, the affected structures were also restored to their original status. Figures 3, 5, 7, 9, 11, 13, 15, 17, and 19 show what types of remedial actions were required on each property.

Contamination Control During the Cleanup

During the cleanup, several procedures were implemented to control the radioactive materials being removed from the Grove Avenue and Parkway residences. These procedures were designed to keep the workers and residents from being exposed to radiation.

The primary pathway by which residents could be exposed to radiation would be from dust released during the excavation. To avoid this, the subcontractor was required to keep all excavations and work

Air sampling was performed at the perimeter of the excavation areas to demonstrate compliance with DOE standards for airborne radioactivity. These samples are collected by pulling large quantities of air through a filter. Airborne dust which could potentially contain radioactive materials is captured by the filter. The filters are then removed and analyzed for radioactivity. Because the amount of air drawn through the filter is known, the amount of radioactivity in the air can be calculated. None of the measured radioactivity concentrations in air exceeded the applicable DOE standards. areas free from dust by keeping the soil moistened. Results for air sampling taken during remedial action are given in Tables 2 and 10.

To keep uncontaminated areas clean during excavation work, trucks were draped with tarpaulins prior to filling. This kept the contaminated dirt from getting on the truck exterior and later falling off on clean property. If trucks were to be loaded on a clean area, the ground was covered with a tarpaulin before the truck pulled onto it for loading. If contaminated soil was spilled during the loading of the truck, this tarpaulin prevented the contamination of clean ground. Finally, all trucks hauling radioactively contaminated soil were loaded only to about 80 percent of their capacity and were covered before moving. This too prevented soil from falling out of the truck onto clean ground or roadways.

Using this combination of procedures, the subcontractor could control the contamination and prevent its spread onto areas accessible to the general public.

4.0 POST-REMEDIAL ACTION SAMPLING

After the soil containing the radioactive contaminants was removed, another radiological survey was conducted to ensure that the property was indeed clean (no radionuclide concentrations in excess of DOE criteria). This survey used several techniques.

Surface Gamma Radiation Scans - Two types of gamma radiation scans were conducted to determine whether all radioactively contaminated soil was removed. The first was a "walkover" scan. In this type of survey, the technician holds the radiation detector a few inches above the surface and moves it slowly from side to side while walking over the excavated area. The purpose of a walkover survey is to quickly detect areas of residual contamination. The advantage of this type of survey is that the area is quickly scanned with the detector as excavation proceeds.

The second gamma radiation scan was performed after all contamination detected by the walkover scan was removed. This survey used a lead-shielded detector to ensure that the only radiation detected was coming from the ground under the detector. Measurements were made on each property at 10-ft intervals to ensure that the property had been cleaned of radioactively contaminated soil.

Soil Sampling - The primary method of ensuring that the DOE cleanup guidelines were met was to take soil samples. These samples were analyzed in a laboratory to determine the concentrations of radium-226, thorium-232, and uranium-238. Because they were taken at the bottom of the excavations, the 15-pCi/g guideline applies these samples. Soil sampling locations are shown in Figures 3, 5, 7, 9, 11, 13, 15, 17, and 19.

Exposure Rate Measurements - Pressurized ionization chamber (PIC) readings were taken to measure the gamma radiation exposure rate after removal of the contamination. The PIC was set up at the locations shown in Figures 2, 6, 8, 10, 12, 14, 16, and 18.

Exposure to gamma radiation was also measured by placing thermoluminescent dosimeters (TLD) at the homes. A TLD is a radiation measuring device that was left in place for an extended period, typically a month, and then removed and sent to a laboratory for analysis. This analysis determined how much gamma radiation was

absorbed by the TLD, and this dose is an indication of the radiation exposure of the resident.

Measured gamma radiation exposure rates were used to calculate annual doses assuming continuous exposure at the point of measurement. A background radiation contribution of 100 mrem/yr was subtracted from the calculated dose. Doses are reported in Tables 2, 4, 6, 8, 10, 12, 14, 16, and 18. For comparison, the DOE radiation protection standard is 100 mrem/yr. None of the PIC or TLD readings exceed this level.

Radon Monitoring - Because radium is one of the radioactive materials found in the Maywood Chemical wastes, radon and radon daughter monitoring was performed within some of the homes on Davison and Latham. Radon is produced from the radioactive decay of radium and can be used as an indicator of the presence of radium. The DOE standard for radon and radon daughters is 3 pCi/l and 0.02 WL, respectively. Radon concentrations are reported in Tables 2, 4, 6, 8, 12, and 14.

5.0 POST-REMEDIAL ACTION STATUS

As shown in Tables 3, 5, 7, 9, 11, 13, 15, 17, and 19, the soil samples taken after removing the radioactive materials show that there is no area where radioactive contamination still exists in excess of the remedial action guidelines established by DOE. An independent review of the remedial action performed on the parcels discussed in this report has been conducted by the Oak Ridge National Laboratory, Radiological Survey Activities Group. The purpose of the assessment was to verify the data supporting the adequacy of the remedial action and to confirm the site's compliance with remedial action guidelines (Ref. 12).

Based on all data collected, these parcels conform to all applicable DOE radiological guidelines established for release of these properties for unrestricted use (Refs. 15, 16, and 17).

In addition to the surveys that have been performed on behalf of DOE, measures have been taken by the New Jersey Department of Environmental Protection to monitor remedial action activities. These measures include observing on-site operations and procedures, and analyzing archived soil samples.

TABLE I

SUMMARY OF RESIDUAL CONTAMINATION GUIDELINES

FOR THE MAYWOOD SITE

BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 500 mrem/yr for a period of exposure not to exceed 5 years and an average of 100 mrem/yr over a lifetime.

SOIL (LAND) GUIDELINES (MAXIMUM LIMITS FOR UNRESTRICTED USE)

Radionuclide	Soil Concentration (pCi/g) above background[a,b,c]
Radium-226 Radium-228 Thorium-230 Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer.
Other radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use.

STRUCTURE GUIDELINES (MAXIMUM LIMITS FOR UNRESTRICTED USE)

Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.[d] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

Indoor/Outdoor Structure Surface Contamination

	Allowable Surface Residual Contamination[e] (dpm/100 cm^2)		
Radionuclide[f]	Average[g,h]	Maximum[g]	Removable[g]
Transuranics, Ra-226 Ra-228, Th-230, Th-228 Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224 U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000 α	15,000 α	1,000 α

TABLE I

(Continued)

Indoor/Outdoor Structure Surface Contamination (continued)

Radionuclide[f]	Allowable Surface Residual Contamination[e] (dpm/100 cm^2) Average[g,h]	Maximum[g,i]	Removable[g,j]
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 β-γ	15,000 β-γ	1,000 β-γ

[a] In the event of occurrence of mixtures of radionuclides, the fraction contributed by each radionuclide to its limit shall be determined, and the sum of these fractions shall not exceed 1.

[b] These guidelines represent unrestricted-use residual concentrations above background averaged across any 15-cm thick layer to any depth and over any contiguous 100-m^2 surface area.

[c] Localized concentrations in excess of these limits are allowable provided that the average over 100 m^2 is not exceeded.

[d] A working level (WL) is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

[e] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[f] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides shall apply independently.

[g] Measurements of average contamination should not be averaged over more than 1 m^2. For objects of less surface area, the average shall be derived for each such object.

[h] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm respectively, measured through not more than 7 mg/cm^2 of total absorber.

[i] The maximum contamination level applies to an area of not more than 100 cm^2.

[j] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

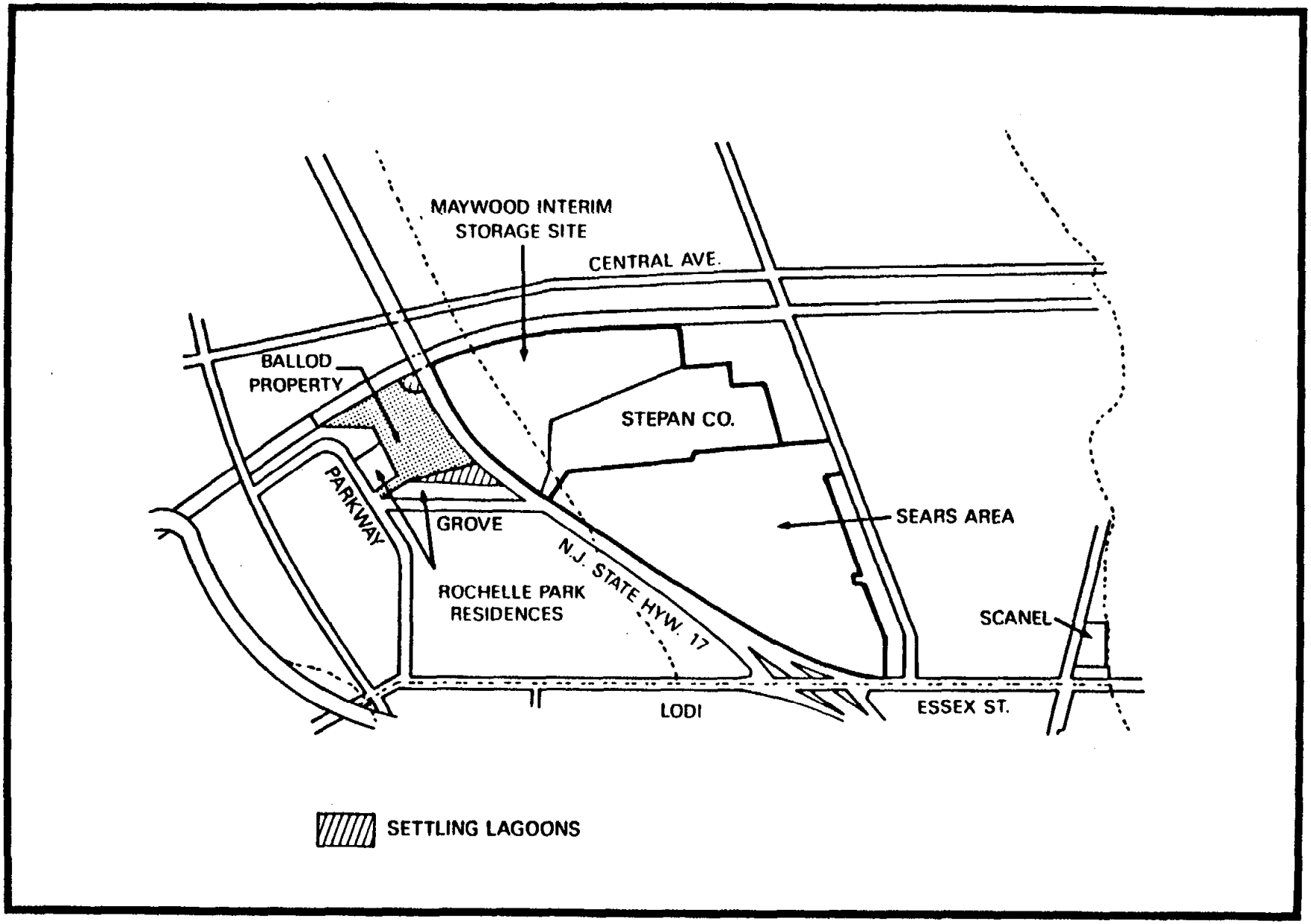


FIGURE 1 LOCATION OF BALLOD PROPERTY AND GROVE AVENUE AND PARKWAY RESIDENCES

35439

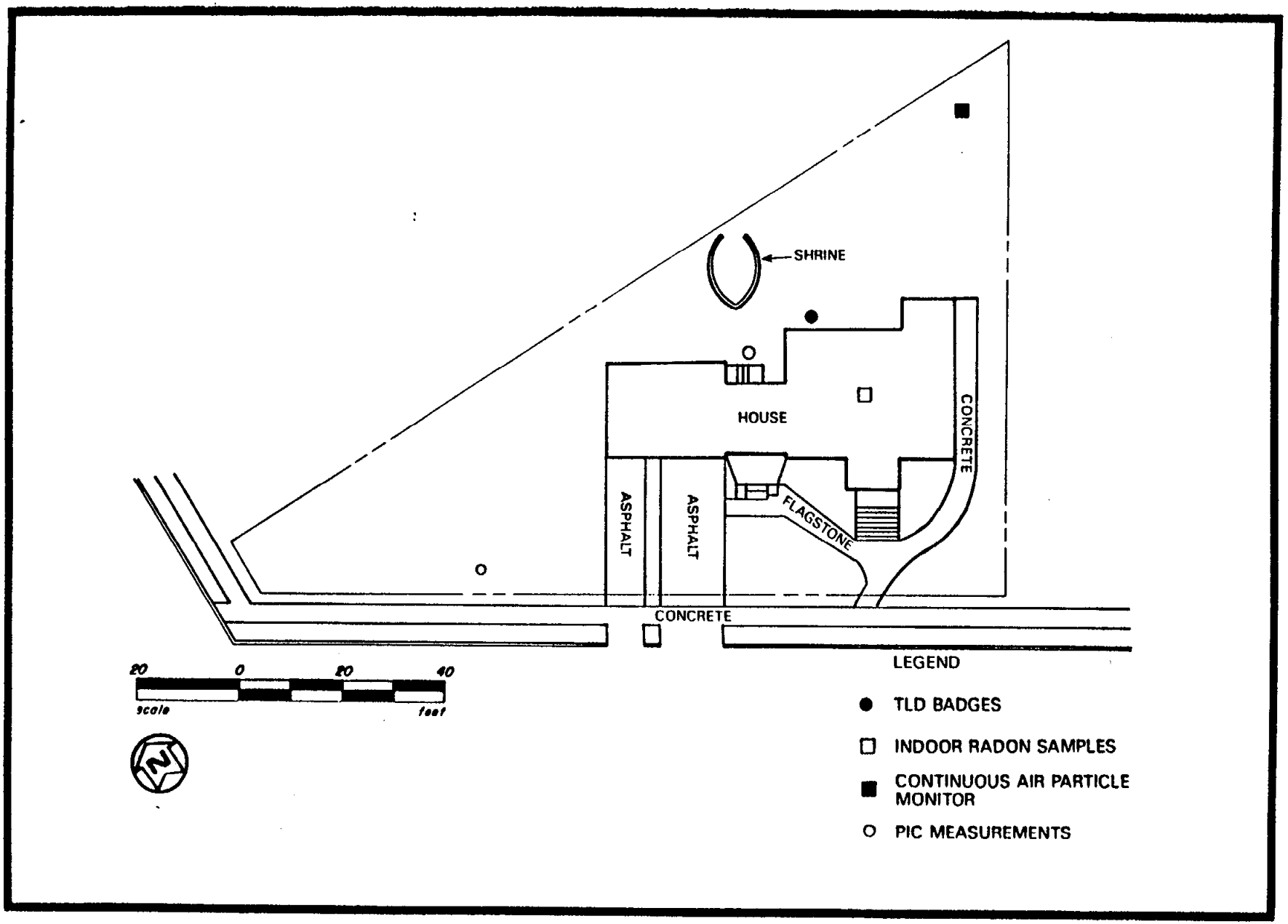


FIGURE 2 MONITORING LOCATIONS AT 10 GROVE AVENUE

35739

TABLE 2

REMEDIAL ACTION MONITORING RESULTS

FOR 10 GROVE AVENUE

Type Measurement	Units	Number of Measurements	Average	Range	DOE Guideline[a]
Gamma exposure rate (TLD)[b]	mrem/yr	3	4	0-30	100
Air sampling for radon[c]	pCi/l	1	0.4	0.4	3.0
Gamma exposure rate (PIC)[b]	mrem/yr	1	0	0-0	100
Air sampling for particulates[d]	10^{-14} uCi/ml (gross alpha)	40	0.7	0.1-2.3	100

[a]DOE guidelines are specified to be above background values.

[b]Calculated from exposure rate measurements assuming continuous occupancy. The natural background radiation of 100 mrem/yr has been subtracted.

[c]Average background contribution of 0.5 pCi/l has been subtracted.

[d]Most restrictive limit for radionuclide present.

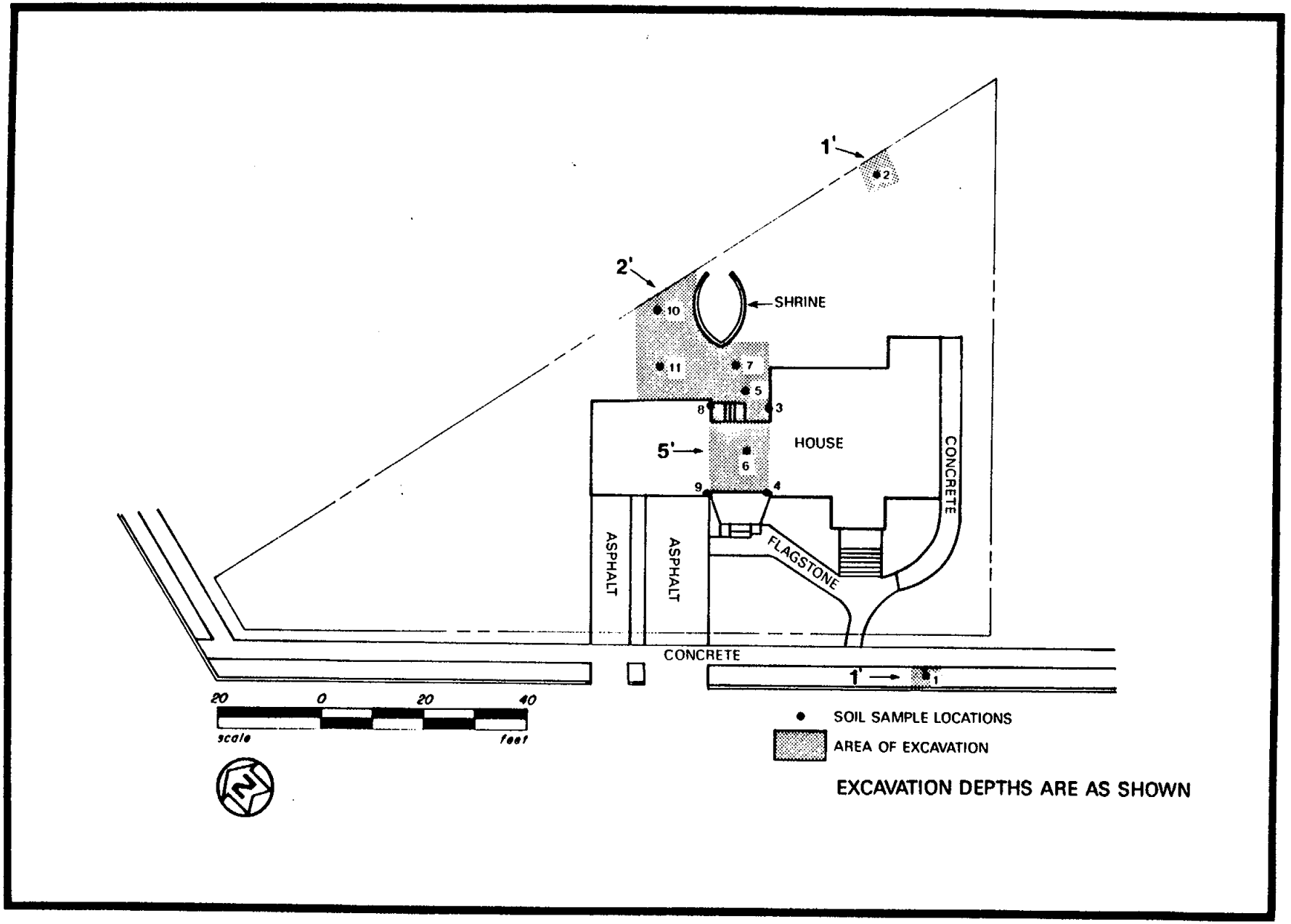


FIGURE 3 REMEDIAL ACTION AT 10 GROVE AVENUE

35439

TABLE 3

POST-REMEDIAL ACTION SOIL SAMPLE RESULTS FOR
10 GROVE AVENUE

Soil Sample Number	Uranium-238	Radium-226	Thorium-232
	(picocuries per gram ± 2 sigma)		
1	<5.0	0.5 ± 0.4	3.8 ± 0.4
2	<5.0	1.4 ± 0.1	5.5 ± 0.3
3	<5.0	0.5 ± 0.1	0.8 ± 0.2
4	<5.0	0.3 ± 0.1	1.1 ± 0.2
5	<2.1	0.6 ± 0.1	1.4 ± 0.3
6	<1.7	0.6 ± 0.1	0.6 ± 0.1
7	<2.0	0.7 ± 0.1	0.9 ± 0.3
8	<1.5	0.4 ± 0.1	0.4 ± 0.1
9	<2.0	0.7 ± 0.1	1.7 ± 0.2
10	<5.0	0.7 ± 0.1	0.5 ± 0.2
11	<1.6	0.7 ± 0.1	0.3 ± 0.1

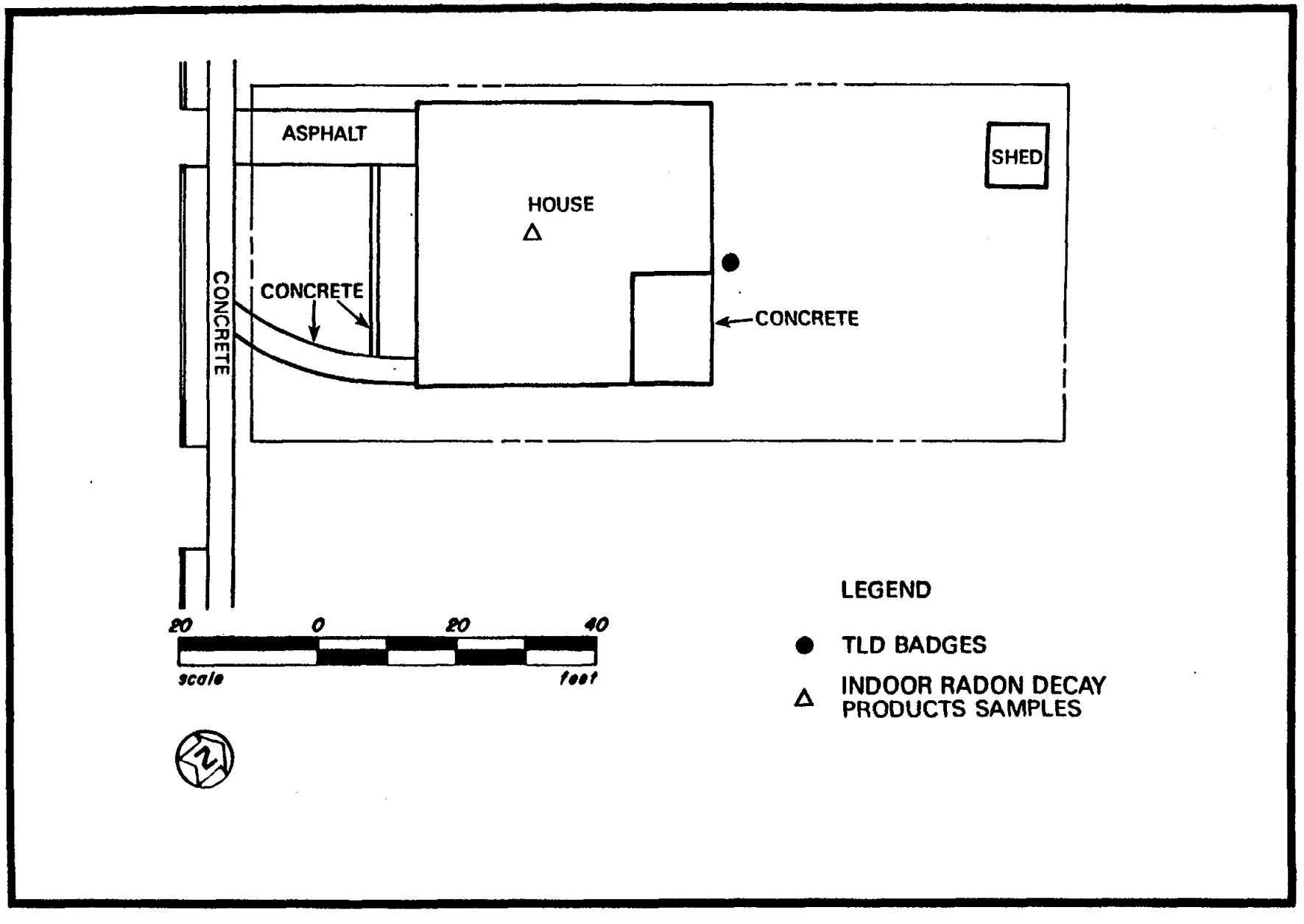


FIGURE 4 MONITORING LOCATIONS AT 22 GROVE AVENUE

TABLE 4

REMEDIAL ACTION MONITORING RESULTS

FOR 22 GROVE AVENUE

Type of Measurement	Units	Number of Measurements	Average	Range	DOE Guideline[a]
Gamma exposure rate (TLD)[b]	mrem/yr	3	0	0-9	100
Air sampling for radon decay products[c]	WL	2	0	0-0	0.02

[a]DOE standards are specified to be above background values.

[b]Calculated from exposure rate measurements assuming continuous occupancy. A natural background contribution of 100 mrem/yr has been subtracted.

[d]A background contribution of 0.005 WL has been subtracted.

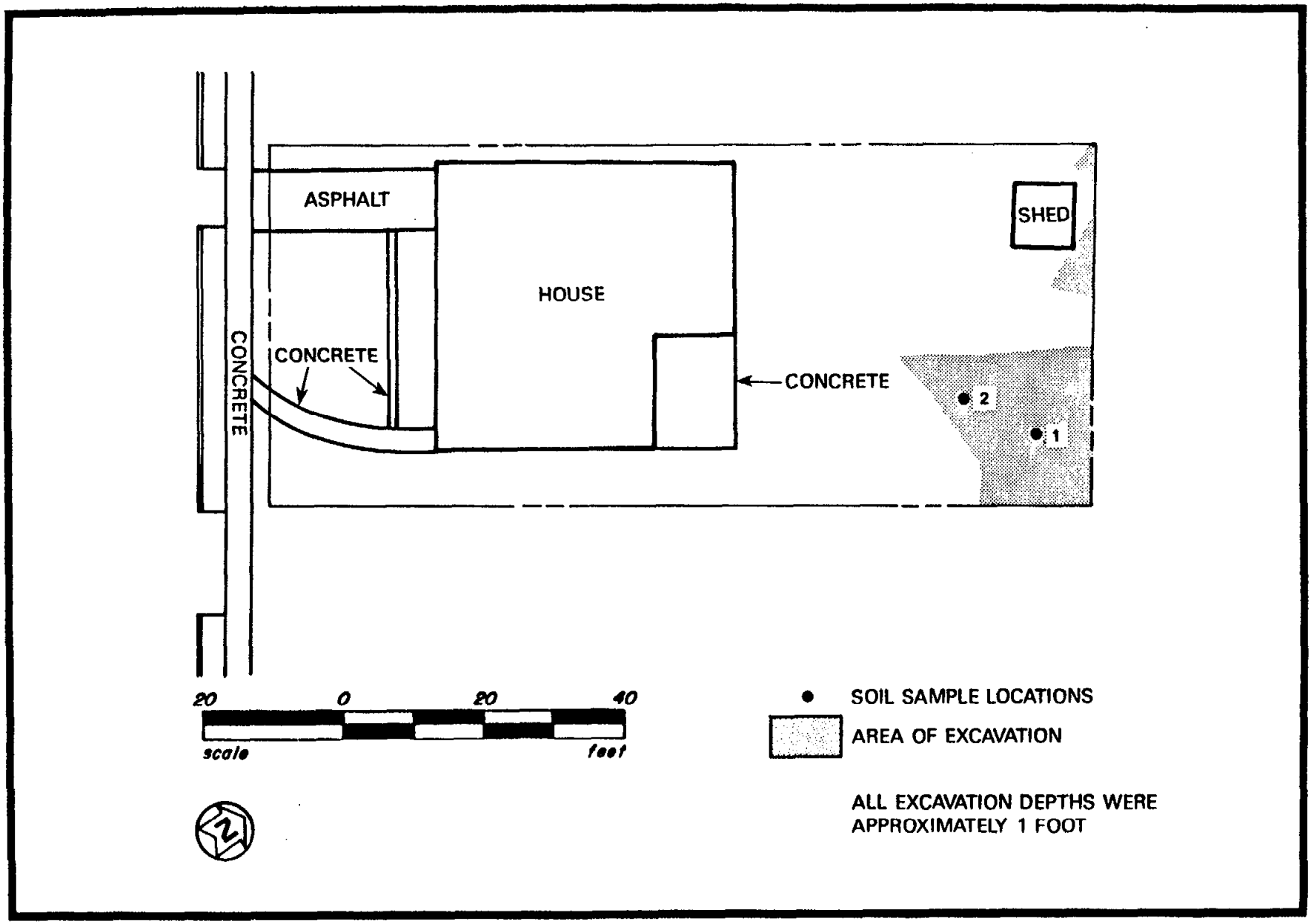


FIGURE 5 REMEDIAL ACTION AT 22 GROVE AVENUE

35739

TABLE 5

POST-REMEDIAL ACTION SOIL SAMPLE RESULTS FOR
22 GROVE AVENUE

Soil Sample Number	Uranium-238	Radium-226	Thorium-232
	picocuries per gram ± 2 sigma		
1	1.4 ± 0.6	1.4 ± 0.9	5.3 ± 0.2
2	1.4 ± 0.4	1.3 ± 0.6	4.2 ± 0.1

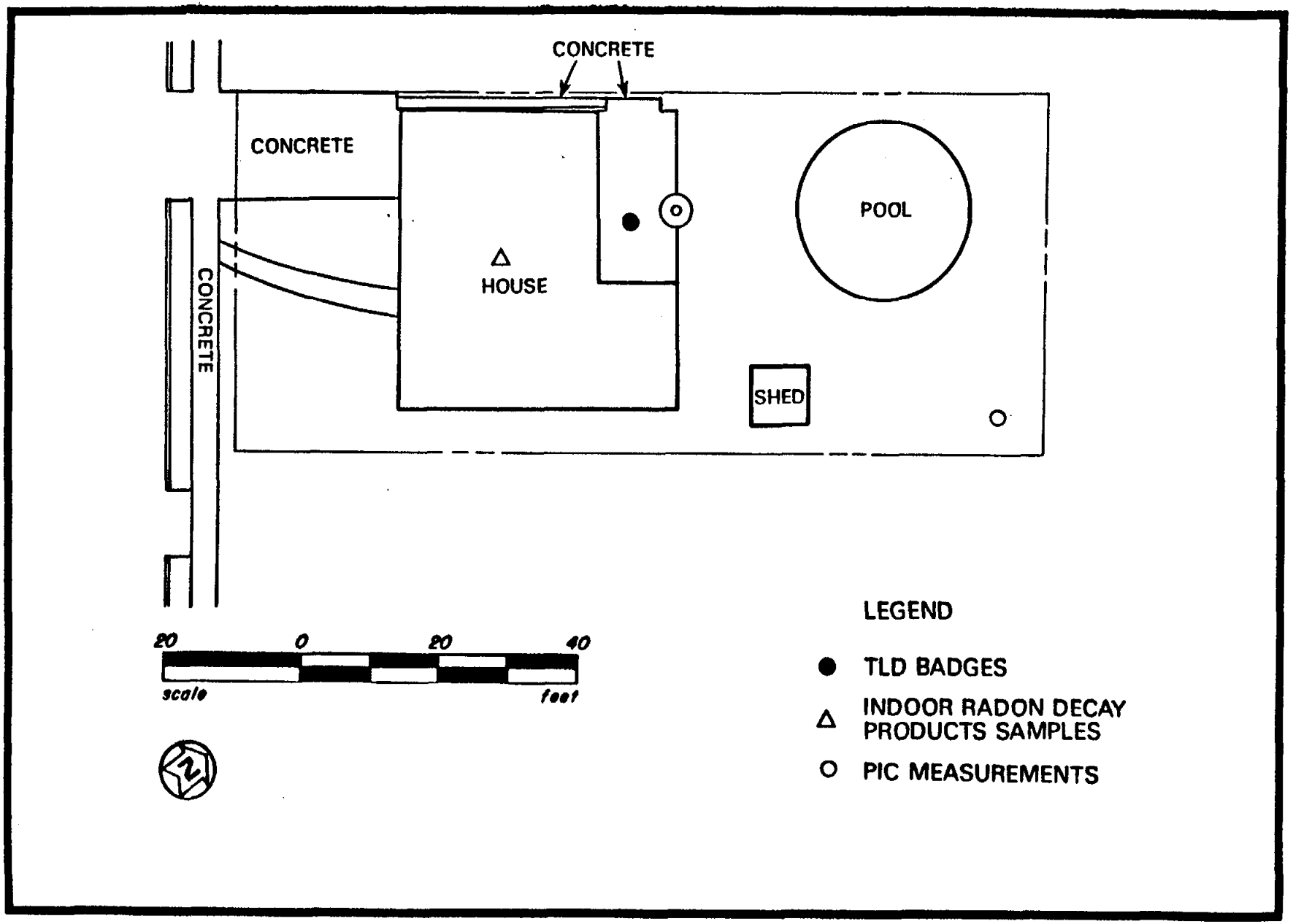


FIGURE 6 MONITORING LOCATIONS AT 26 GROVE AVENUE

35439

TABLE 6

REMEDIAL ACTION MONITORING RESULTS

FOR 26 GROVE AVENUE

Type of Measurement	Units	Number of Measurements	Average	Range	DOE Guideline[a]
Gamma exposure rate (TLD)[b]	mrem/yr	2	12	0-30	100
Air sampling for radon decay products[c]	WL	3	0	0	0.02
Gamma exposure rate (PIC)[b]	mrem/yr	1	5	5	100

[a]DOE standards are specified to be above background.

[b]Calculated from exposure rate measurements assuming continuous occupancy. A natural background contribution of 100 mrem/yr has been subtracted.

[c]A background contribution of 0.005 WL has been subtracted.

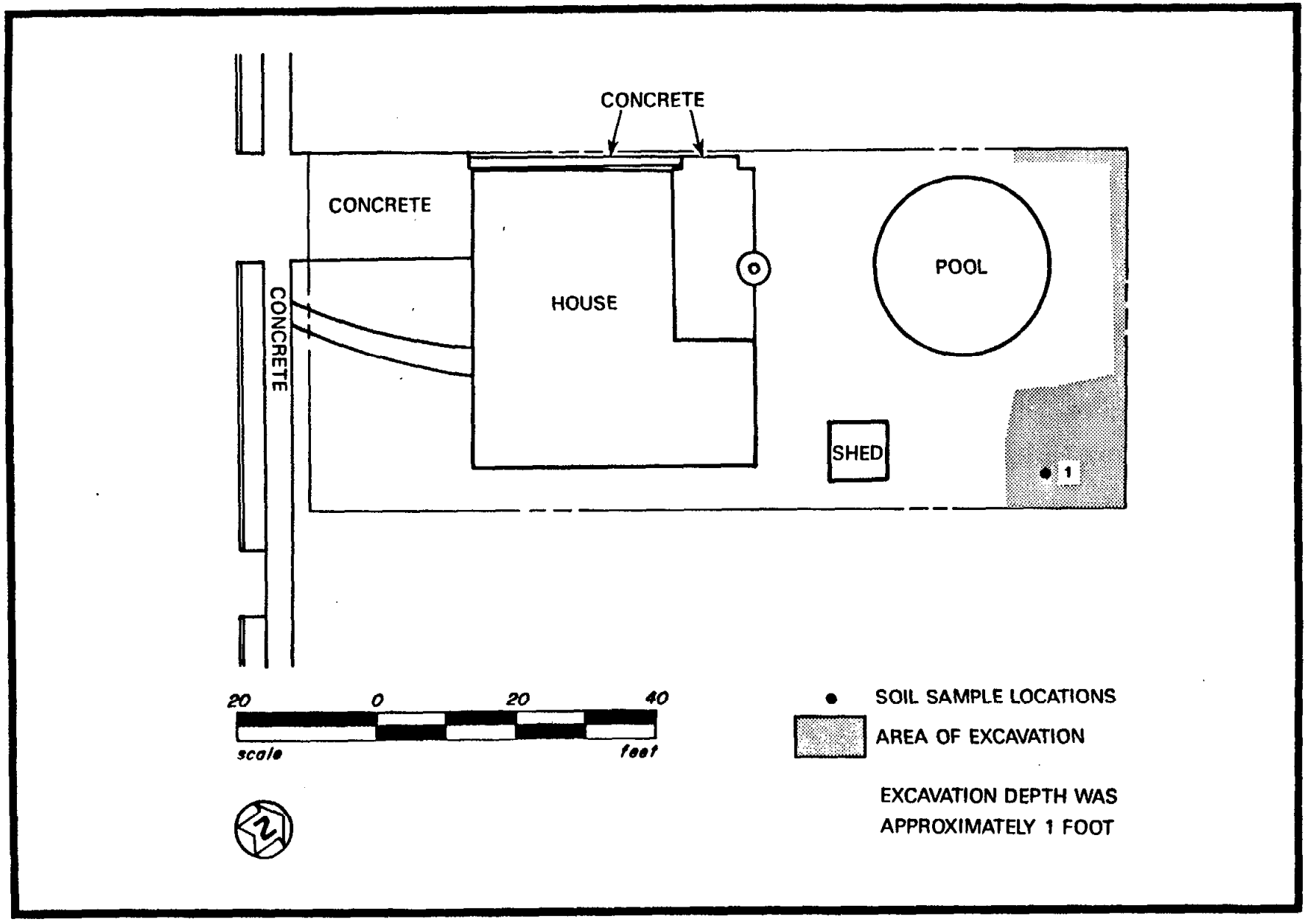


FIGURE 7 REMEDIAL ACTION AT 26 GROVE AVENUE

35439

TABLE 7

POST-REMEDIAL ACTION SOIL SAMPLE RESULTS FOR
26 GROVE AVENUE

Soil Sample Number	Uranium-238	Radium-226	Thorium-232
	picocuries per gram ± 2 sigma		
1	0.7 ± 0.3	0.5 ± 0.1	1.1 ± 0.01

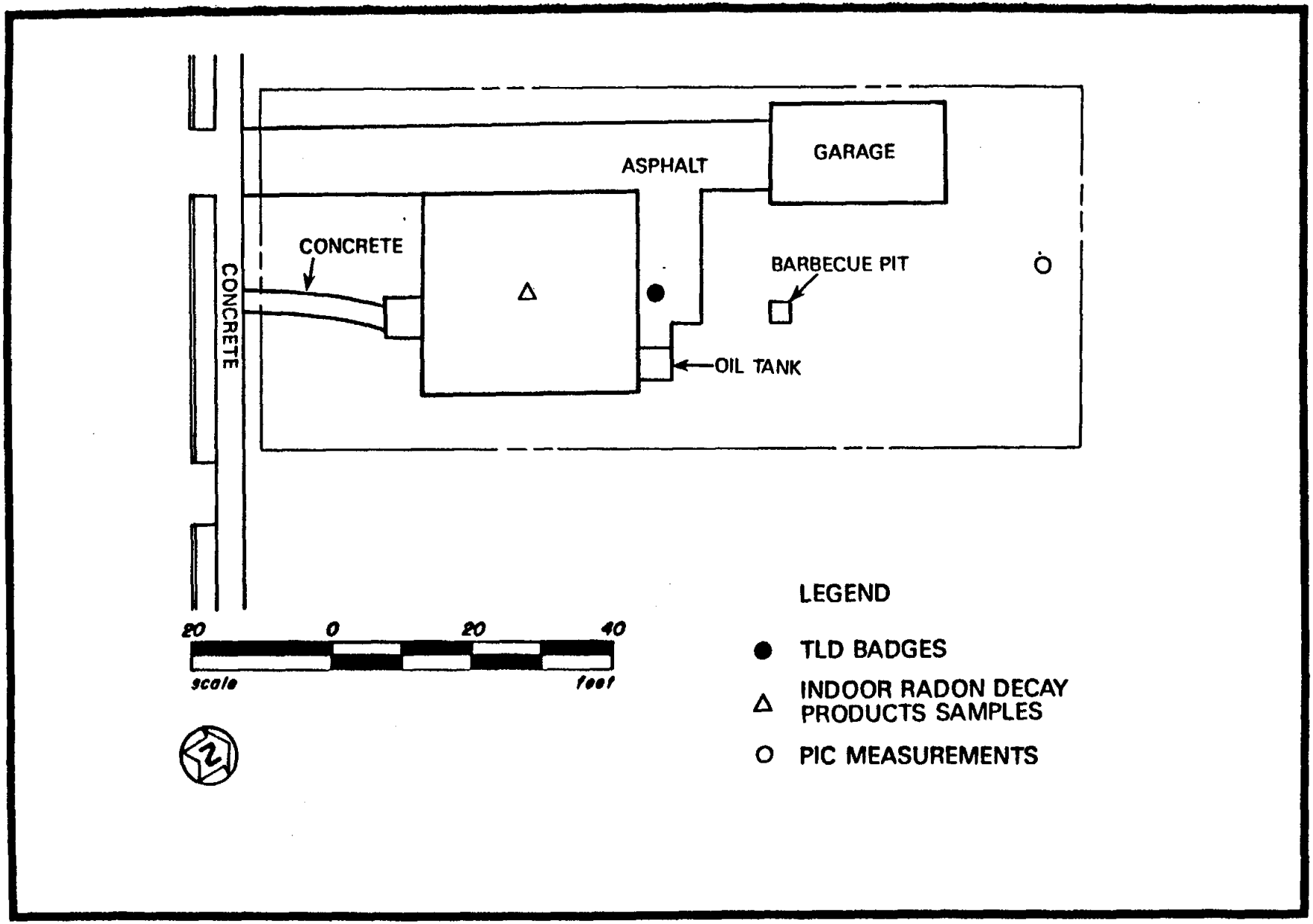


FIGURE 8 MONITORING LOCATIONS AT 30 GROVE AVENUE

35539

TABLE 8

REMEDIAL ACTION MONITORING RESULTS

FOR 30 GROVE AVENUE

Type of Measurement	Units	Number of Measurements	Average	Range	DOE Guideline[a]
Gamma exposure rate (TLD)[b]	mrem/yr	2	1	0-9	100
Air sampling for radon decay products[c]	WL	2	0	0-0	0.02
Gamma exposure rate (PIC)[b]	mrem/yr	1	5	0-0	100

[a]DOE standards are specified to be above background values.

[b]Calculated from exposure rate measurements assuming continuous occupancy. A natural background contribution of 100 mrem/yr has been subtracted.

[c]A background contribution of 0.005 WL has been subtracted.

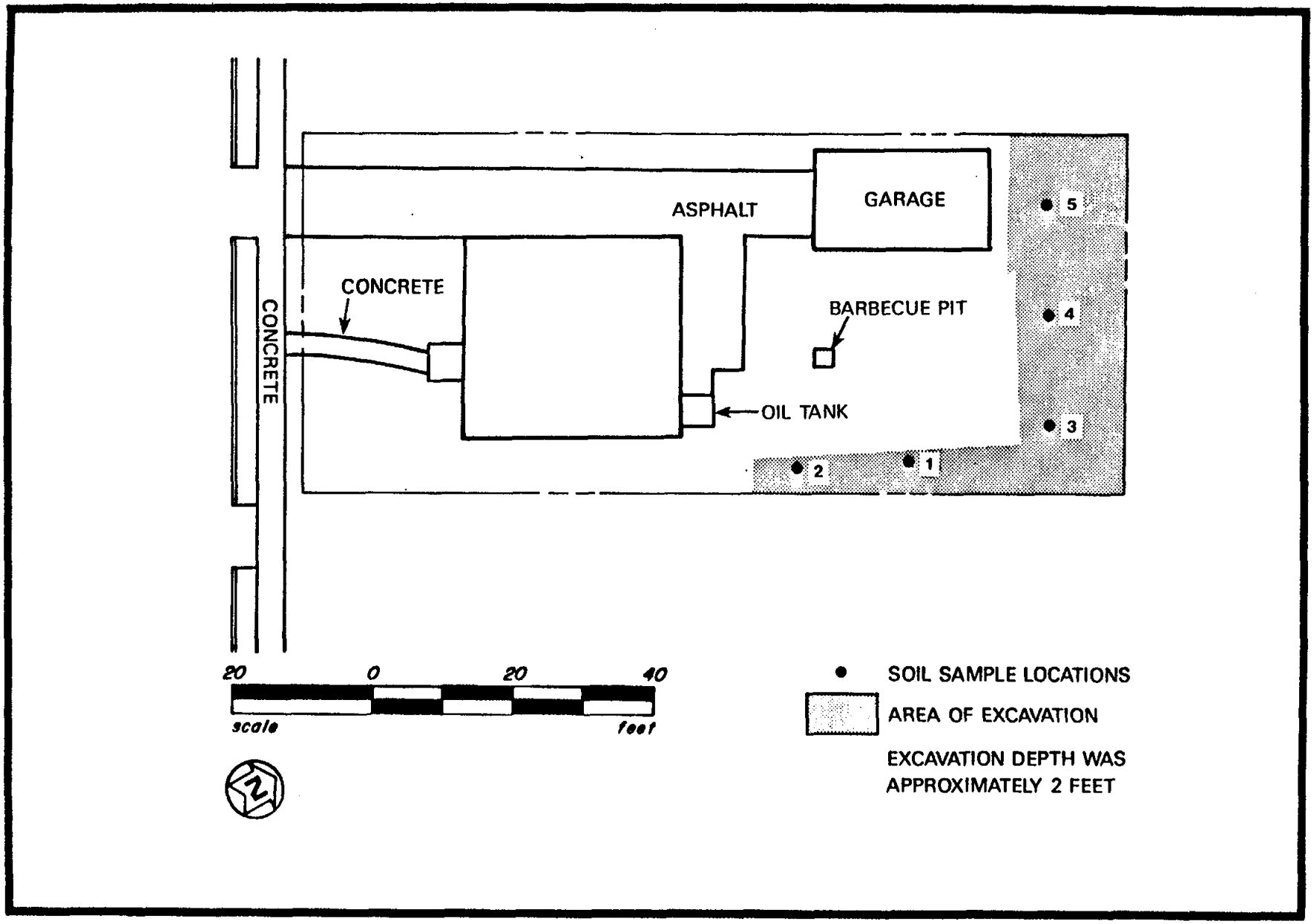


FIGURE 9 REMEDIAL ACTION AT 30 GROVE AVENUE

TABLE 9

POST-REMEDIAL ACTION SOIL SAMPLE RESULTS FOR
30 GROVE AVENUE

Soil Sample Number	Uranium-238	Radium-226	Thorium-232
	picocuries per gram ± 2 sigma		
1	1.1 ± 0.1	0.6 ± 0.1	1.0 ± 0.1
2	0.6 ± 0.2	0.6 ± 0.1	0.5 ± 0.1
3	0.8 ± 0.2	0.6 ± 0.1	0.8 ± 0.1
4	0.8 ± 0.3	0.8 ± 0.1	0.8 ± 0.1
5	0.1 ± 0.2	0.7 ± 0.1	1.1 ± 0.1

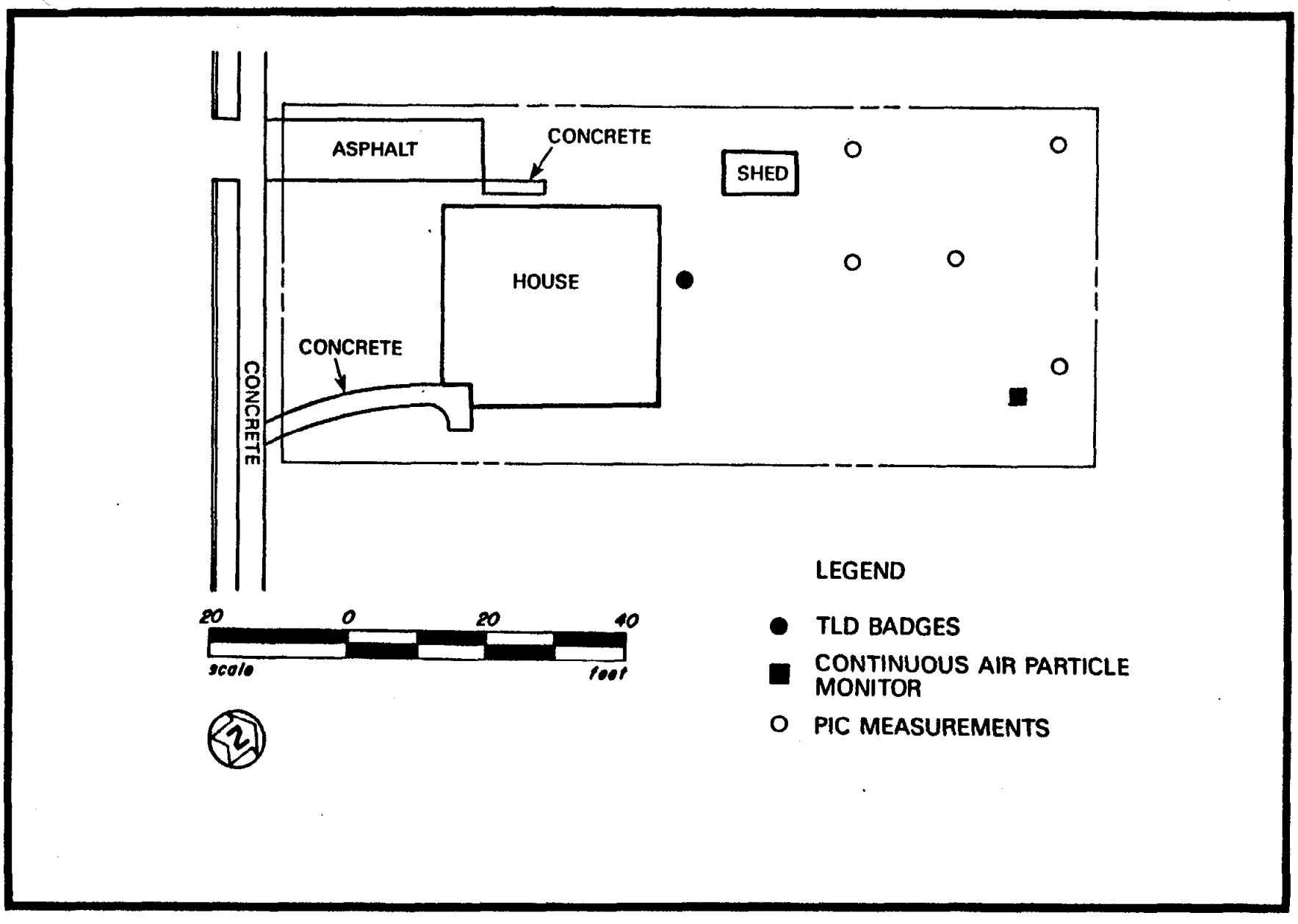


FIGURE 10 MONITORING LOCATIONS AT 34 GROVE AVENUE

35639

TABLE 10

REMEDIAL ACTION MONITORING RESULTS

FOR 34 GROVE AVENUE

Type of Measurement	Units	Number of Measurements	Average	Range	DOE Guideline[a]
Gamma exposure rate (TLD)[b]	mrem/yr	3	0	0-20	100
Gamma exposure rate (PIC)[b]	mrem/yr	5	0	0-0	100
Air sampling[c] for particulates	10^{-14} uCi/ml (gross alpha)	41	0.7	0.1-2	100

[a]DOE standards are specified to be above background values.

[b]Calculated from exposure rate measurements assuming continuous occupancy. A natural background contribution of 100 mrem/yr has been subtracted.

[c]Most restrictive limit for mixture of radionuclide present.

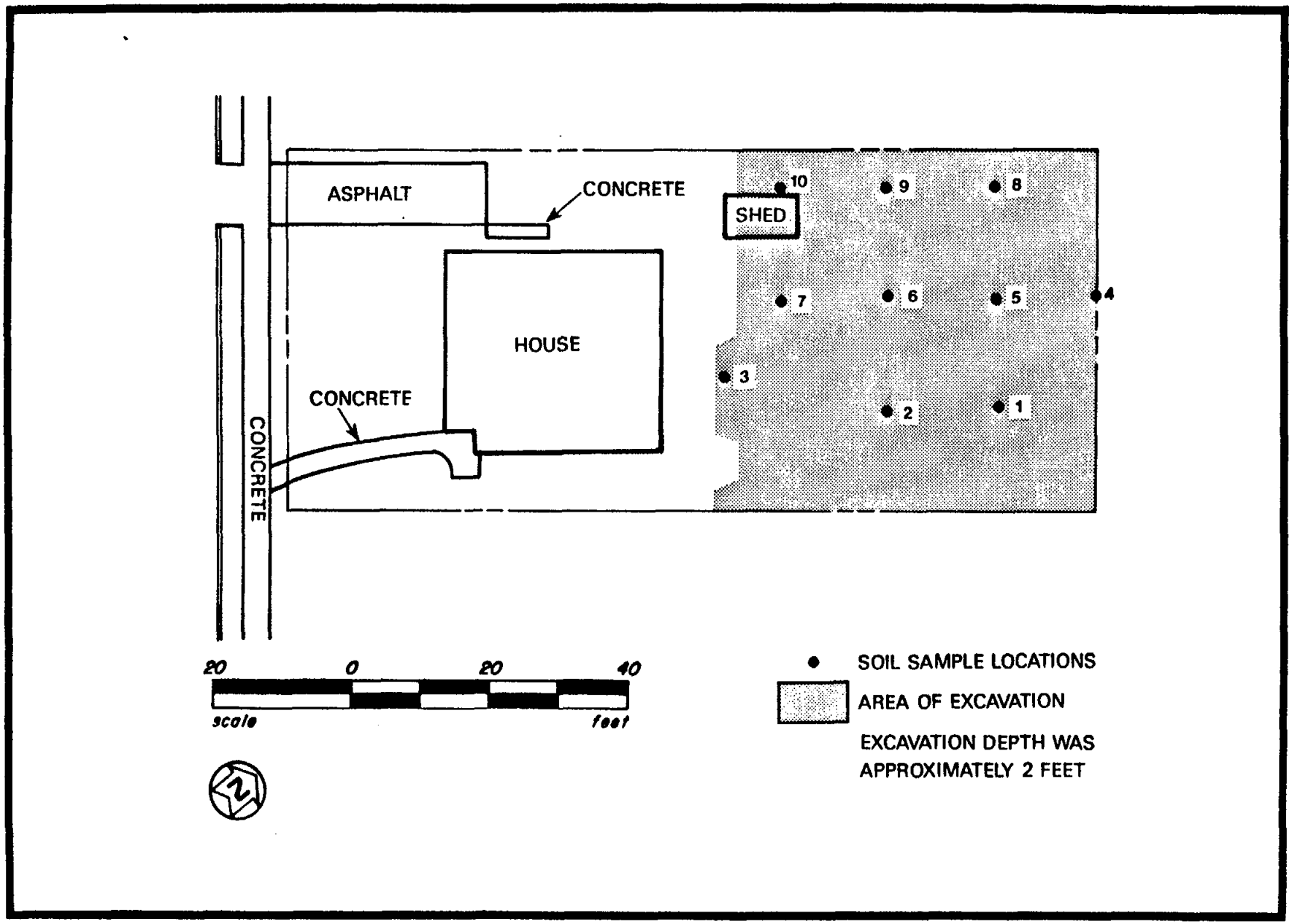


FIGURE 11 REMEDIAL ACTION AT 34 GROVE AVENUE

35539

TABLE 11

POST-REMEDIAL ACTION SOIL SAMPLE RESULTS FOR
34 GROVE AVENUE

Soil Sample Number	Uranium-238	Radium-226	Thorium-232
	picocuries per gram ± 2 sigma		
1	<5.0	0.8 ± 0.2	2.4 ± 0.4
2	<1.7	0.5 ± 0.7	1.2 ± 0.2
3	0.2 ± 0.4	0.6 ± 0.1	2.9 ± 0.2
4	<5.0	0.7 ± 0.5	1.6 ± 0.3
5	<2.2	0.7 ± 0.9	1.5 ± 0.2
6	<2.1	0.7 ± 1.1	0.9 ± 0.2
7	0.7 ± 0.3	0.9 ± 0.1	1.5 ± 0.1
8	<3.3	1.0 ± 0.2	3.8 ± 0.4
9	<5.0	0.8 ± 0.1	1.4 ± 0.2
10	<5.0	0.8 ± 0.1	2.1 ± 0.1

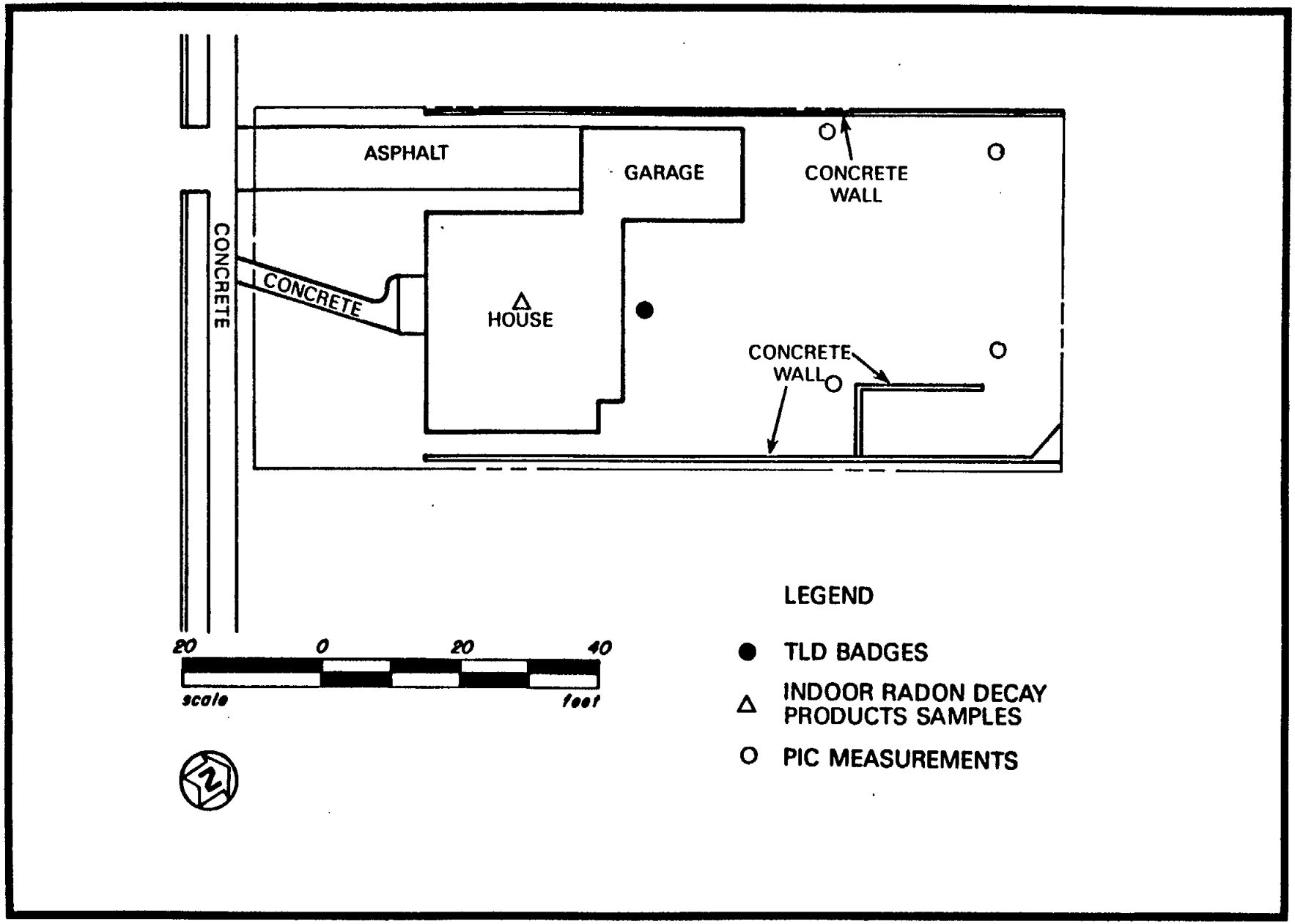


FIGURE 12 MONITORING LOCATIONS AT 38 GROVE AVENUE

35439

TABLE 12

REMEDIAL ACTION MONITORING RESULTS

FOR 38 GROVE AVENUE

Type of Measurement	Units	Number of Measurements	Average	Range	DOE Guideline[a]
Gamma exposure rate (TLD)[b]	mrem/yr	3	0	0-14	100
Air sampling for radon decay products[c]	WL	3	0	0-0.003	0.02
Gamma exposure rate (PIC)[b]	mrem/yr	4	0	0-0	100

[a]DOE standards are specified to be above background values.

[b]Calculated from exposure rate measurements assuming continuous occupancy. A natural background contribution of 100 mrem/yr has been subtracted.

[c]A background contribution of 0.005 WL has been subtracted.

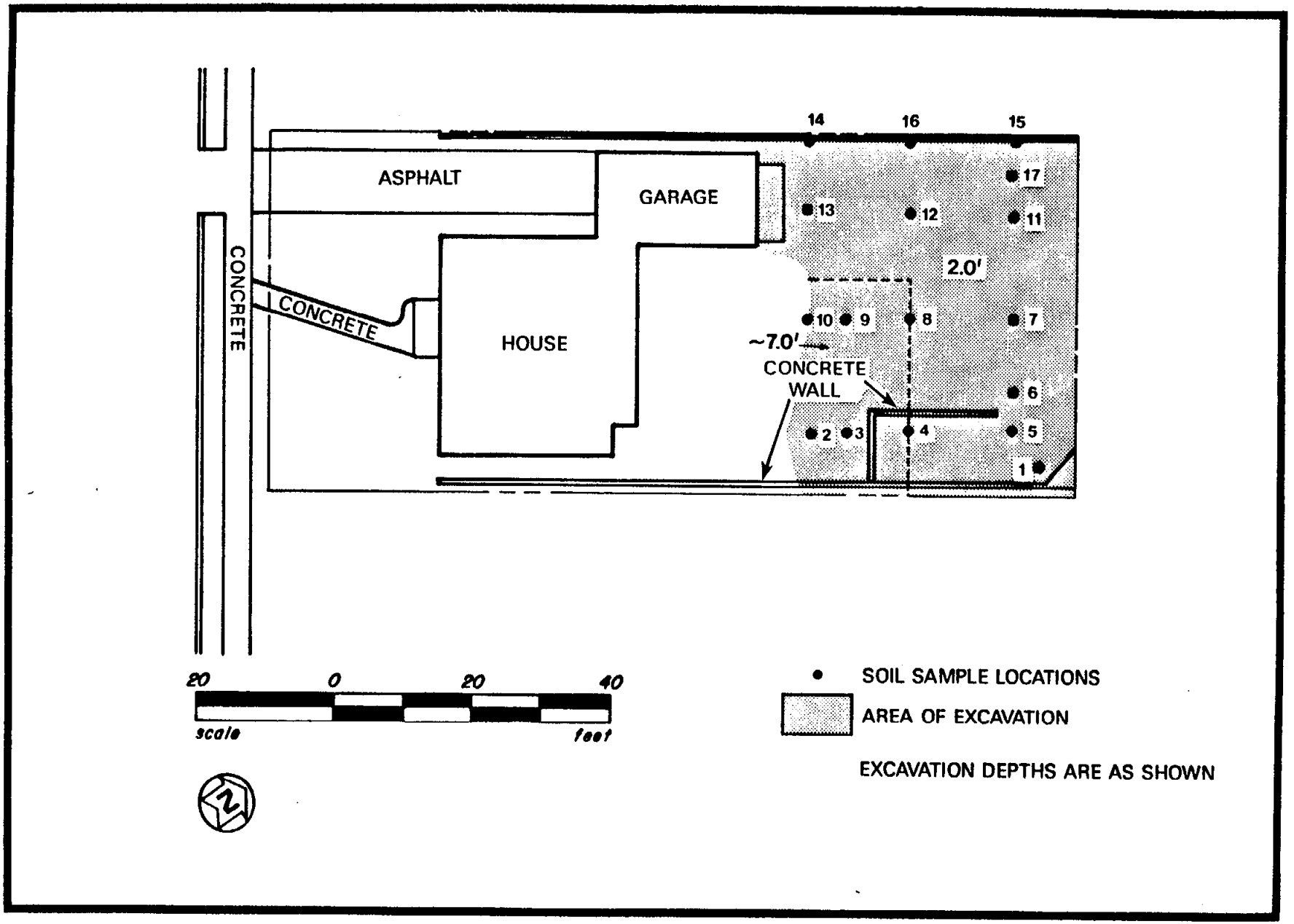


FIGURE 13 REMEDIAL ACTION AT 38 GROVE AVENUE

35739

TABLE 13

POST-REMEDIAL ACTION SOIL SAMPLE RESULTS FOR
38 GROVE AVENUE

Soil Sample Number	Uranium-238	Radium-226	Thorium-232
	picocuries per gram ± 2 sigma		
1	<8.3	0.5 ± 0.1	1.6 ± 0.1
2	<5.0	0.4 ± 0.1	0.3 ± 0.2
3	<1.1	0.4 ± 0.1	0.4 ± 0.1
4	<2.4	0.9 ± 0.1	2.5 ± 0.2
5	<2.2	0.4 ± 0.1	0.7 ± 0.3
6	<5.0	2.3 ± 0.1	14.1 ± 0.4
7	<2.7	0.3 ± 0.1	2.0 ± 0.2
8	<5.0	0.7 ± 0.2	1.1 ± 0.2
9	<1.3	<0.5	<1.5
10	<1.3	0.5 ± 0.2	0.5 ± 0.1
11	<2.1	0.4 ± 0.1	0.7 ± 0.2
12	<5.0	0.5 ± 0.1	0.6 ± 0.1
13	<5.0	0.5 ± 0.1	0.7 ± 0.1
14	<0.6	0.4 ± 0.1	0.4 ± 0.1
15	<1.3	0.4 ± 0.1	<1.5
16	<5.0	0.8 ± 0.1	1.1 ± 0.1
17	<5.0	0.8 ± 0.1	1.0 ± 0.1

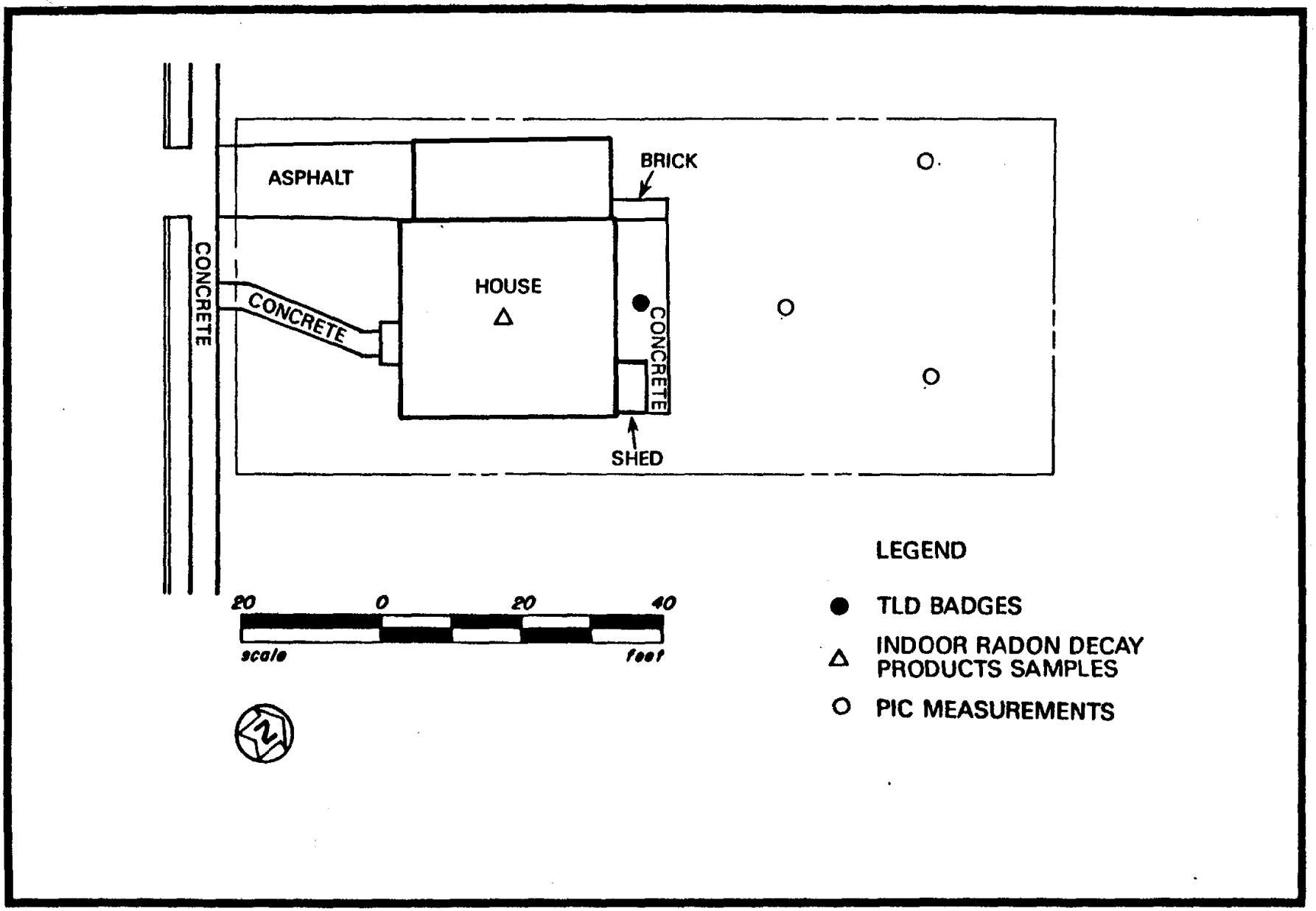


FIGURE 14 MONITORING LOCATIONS AT 42 GROVE AVENUE

35639

TABLE 14

REMEDIAL ACTION MONITORING RESULTS

FOR 42 GROVE AVENUE

Type of Measurement	Units	Number of Measurements	Average	Range	DOE Guideline[a]
Gamma exposure rate (TLD)[b]	mrem/yr	2	0	0-0	100
Air sampling for radon decay products[c]	WL	3	0	0-0	0.02
Gamma exposure rate (PIC)[b]	mrem/yr	3	0	0-0	100

[a]DOE standards are specified to be above background values.

[b]Calculated from exposure rate measurements assuming continuous occupancy. A natural background contribution of 100 mrem/yr has been subtracted.

[c]A background contribution of 0.005 WL has been subtracted.

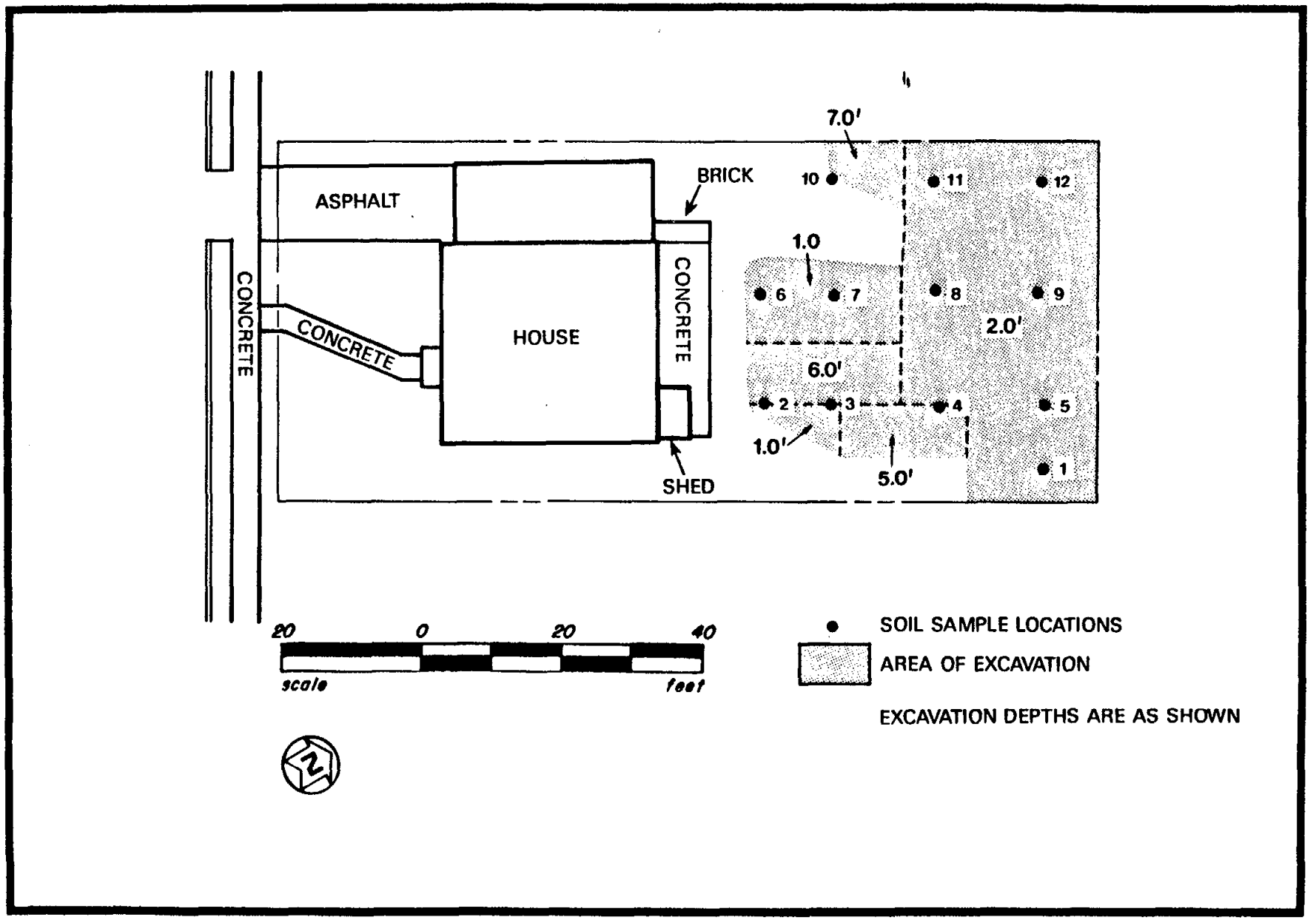


FIGURE 15 REMEDIAL ACTION AT 42 GROVE AVENUE

35439

TABLE 15

POST-REMEDIAL ACTION SOIL SAMPLE RESULTS FOR
42 GROVE AVENUE

Soil Sample Number	Uranium-238	Radium-226	Thorium-232
	picocuries per gram ± 2 sigma		
1	<1.7	0.4 ± 0.1	0.7 ± 0.1
2	<5.0	0.9 ± 0.3	3.9 ± 0.4
3	<1.9	0.7 ± 0.1	1.1 ± 0.2
4	<2.0	0.5 ± 0.1	0.8 ± 0.2
5	<1.8	0.7 ± 0.1	0.8 ± 0.1
6	<1.3	0.4 ± 0.1	0.3 ± 0.1
7	<2.0	0.4 ± 0.1	0.6 ± 0.3
8	<2.1	0.3 ± 0.1	1.6 ± 0.2
9	<5.0	0.8 ± 0.1	1.4 ± 0.3
10	<1.8	0.4 ± 0.1	0.5 ± 0.2
11	<1.6	0.2 ± 0.1	0.7 ± 0.1
12	<2.0	0.5 ± 0.2	1.2 ± 0.3

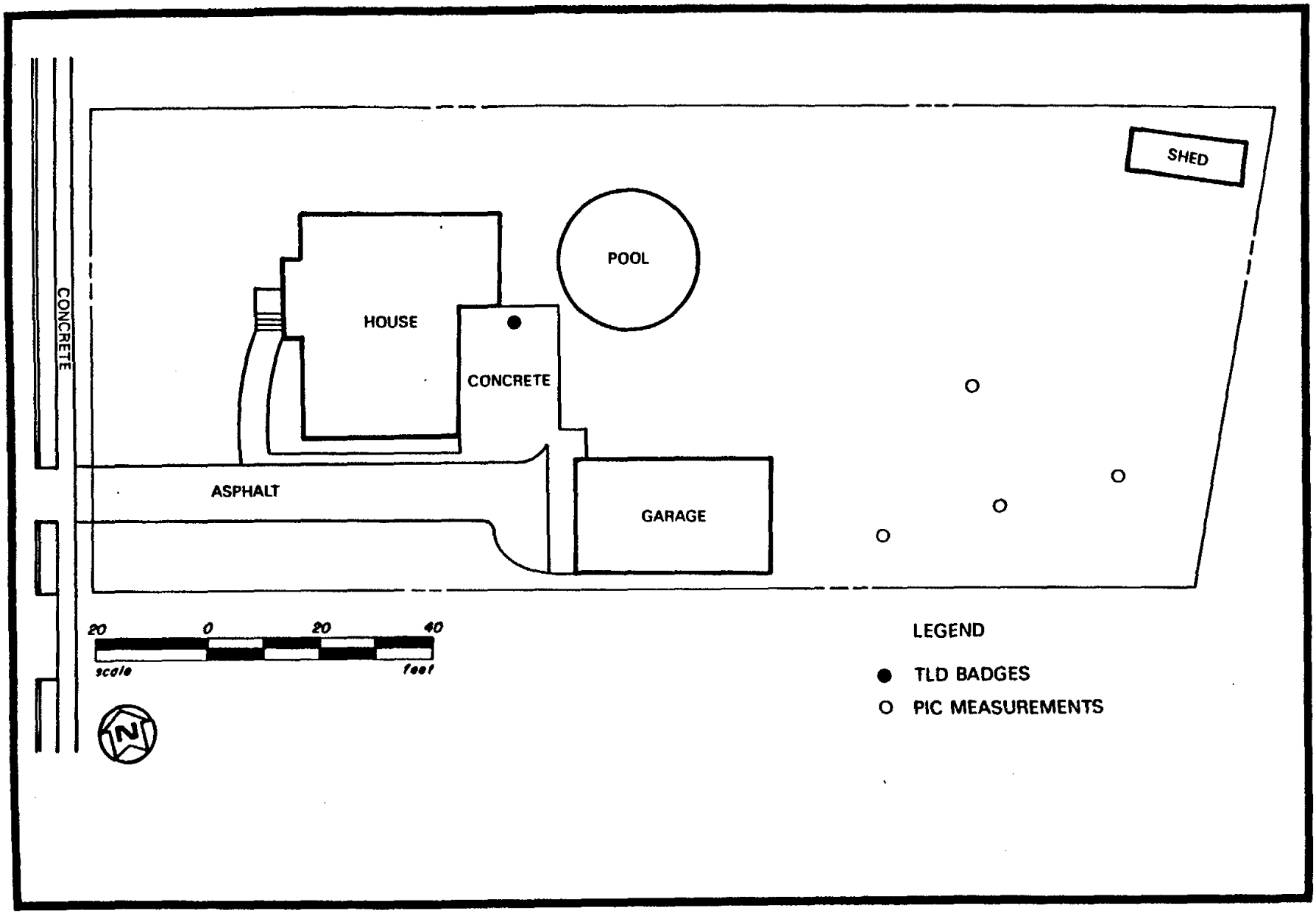


FIGURE 16 MONITORING LOCATIONS AT 86 PARKWAY

35439

TABLE 16

REMEDIAL ACTION MONITORING RESULTS

FOR 86 PARKWAY

Type of Measurement	Units	Number of Measurements	Average	Range	DOE Guideline[a]
Gamma exposure rate (TLD)[b]	mrem/yr	3	0	0-14	100
Gamma exposure rate (PIC)[b]	mrem/yr	4	0	0-0	100

[a]DOE standards are specified to be above background values.

[b]Calculated from exposure rate measurements assuming continuous occupancy. A natural background contribution of 100 mrem/yr has been subtracted.

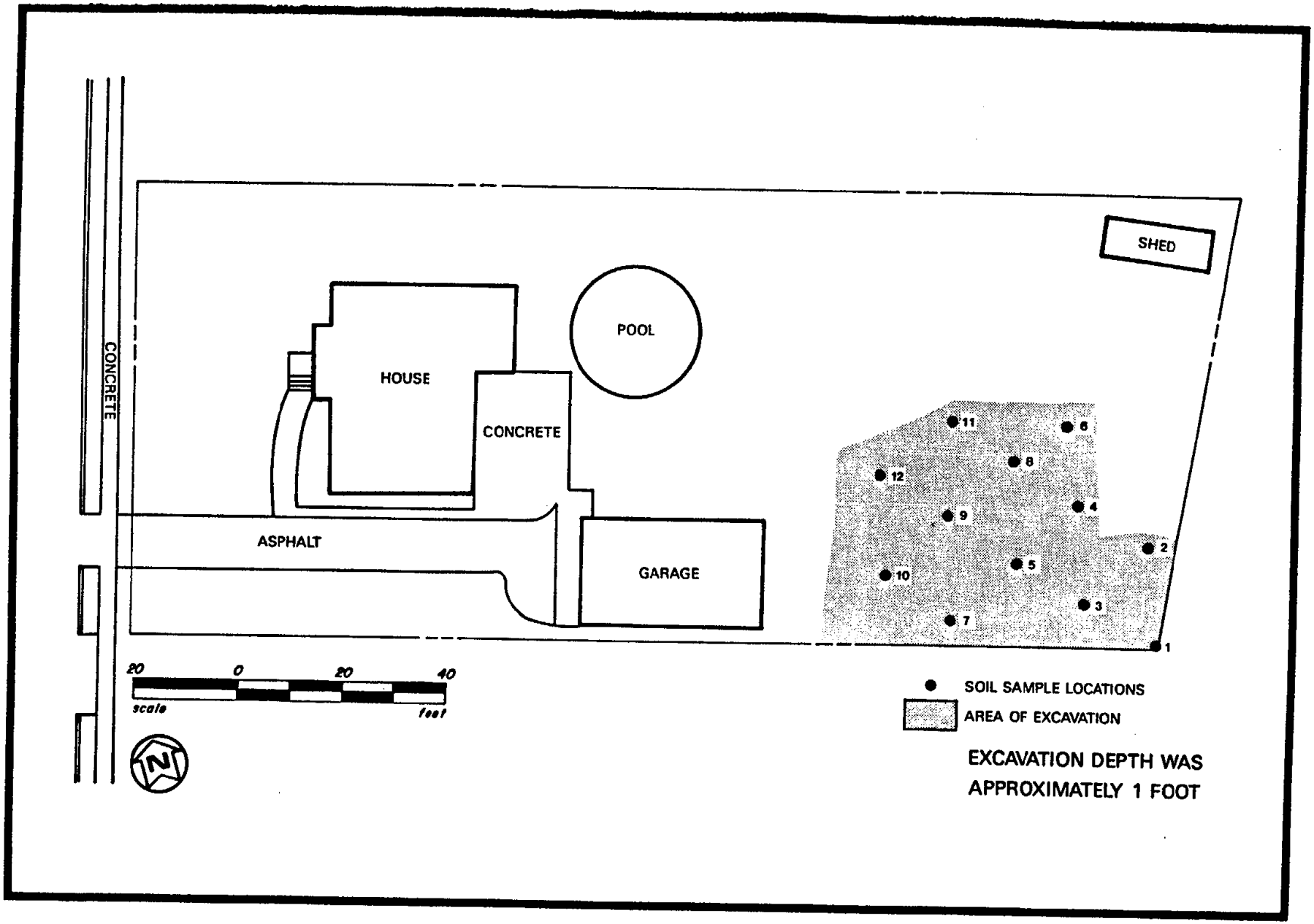


FIGURE 17 REMEDIAL ACTION AT 86 PARKWAY

35439

TABLE 17

POST-REMEDIAL ACTION SOIL SAMPLE RESULTS FOR
86 PARKWAY

Soil Sample Number	Uranium-238	Radium-226	Thorium-232
	picocuries per gram ± 2 sigma		
1	<1.5	0.4 ± 0.1	1.2 ± 0.1
2	<5.0	1.0 ± 0.2	2.0 ± 0.3
3	<2.2	0.4 ± 0.1	1.1 ± 0.3
4	1.8 ± 0.8	1.0 ± 0.1	1.3 ± 0.3
5	<5.0	0.7 ± 0.1	1.0 ± 0.2
6	<2.2	0.8 ± 0.1	1.0 ± 0.2
7	0.8 ± 0.3	0.5 ± 0.1	0.8 ± 0.1
8	<2.2	0.6 ± 0.1	1.4 ± 0.2
9	<5.0	0.8 ± 0.2	2.5 ± 0.4
10	<5.0	0.5 ± 0.1	0.9 ± 0.1
11	<5.0	1.1 ± 0.2	3.5 ± 0.4
12	<1.7	0.7 ± 0.1	0.8 ± 0.1

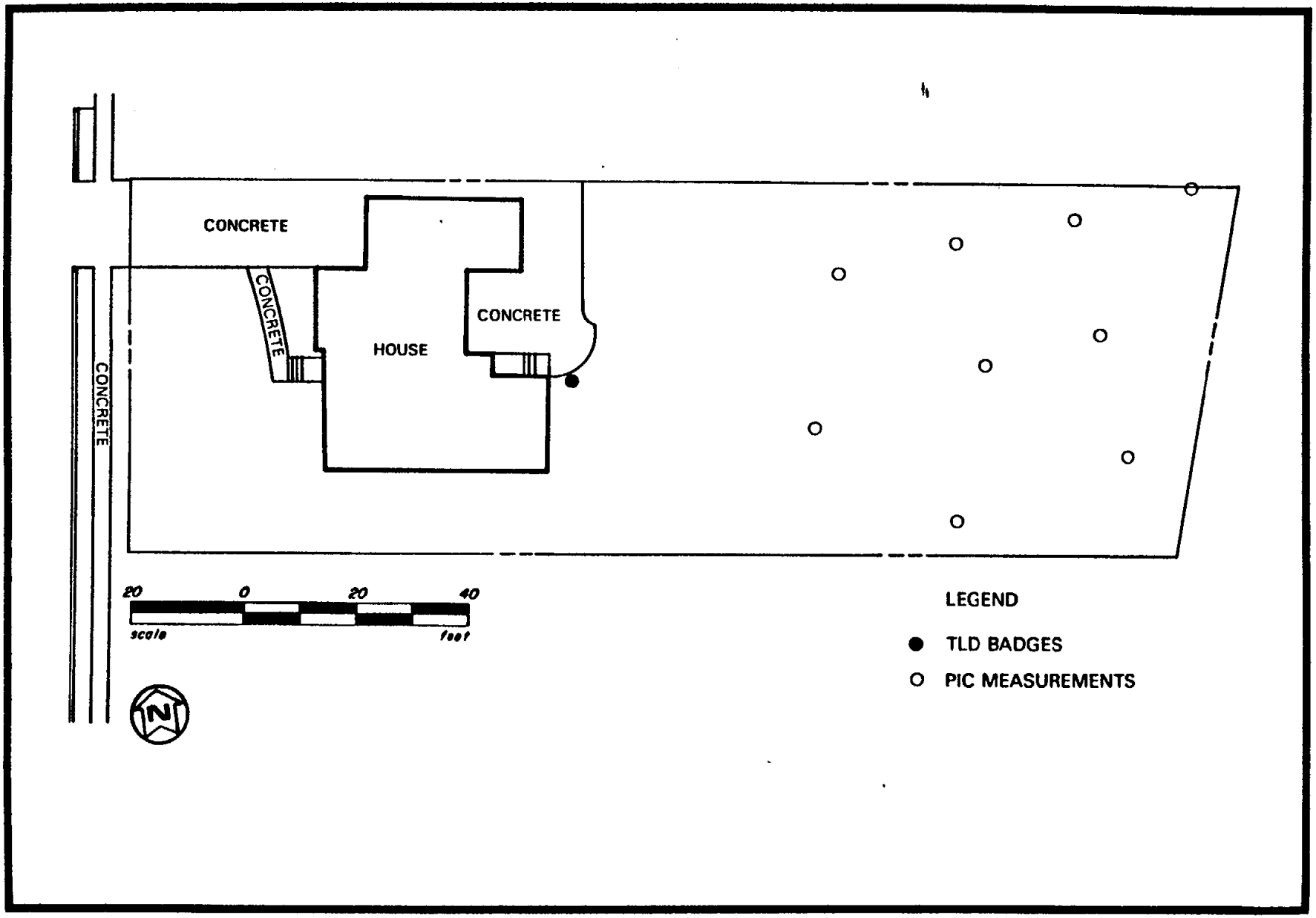


FIGURE 18 MONITORING LOCATIONS AT 90 PARKWAY

35439

TABLE 18

REMEDIAL ACTION MONITORING RESULTS

FOR 90 PARKWAY

Type of Measurement	Units	Number of Measurements	Average	Range	DOE Guideline[a]
Gamma exposure rate (TLD)[b]	mrem/yr	3	0	0-25	100
Gamma exposure rate (PIC)[b]	mrem/yr	9	0	0-5	100

[a]DOE standards are specified to be above background values.

[b]Calculated from exposure rate measurements assuming continuous occupancy. A natural background contribution of 100 mrem/yr has been subtracted.

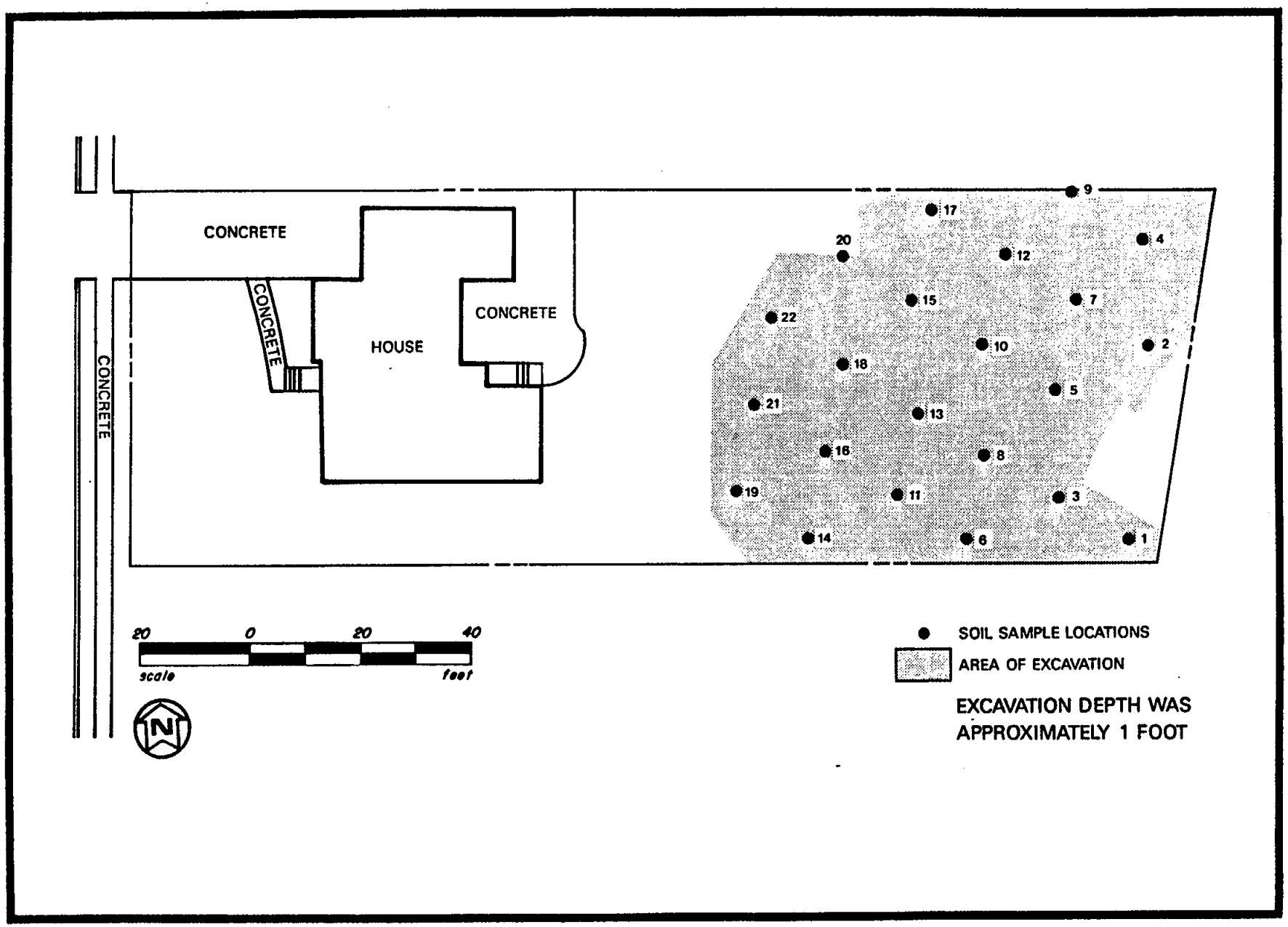


FIGURE 19 REMEDIAL ACTION AT 90 PARKWAY

357259

TABLE 19

POST-REMEDIAL ACTION SOIL SAMPLE RESULTS FOR
90 PARKWAY

Soil Sample Number	Uranium-238	Radium-226	Thorium-232
	picocuries per gram ± 2 sigma		
1	<2.5	0.6 ± 0.4	1.3 ± 0.3
2	<1.8	0.5 ± 0.1	0.9 ± 0.2
3	<1.7	0.6 ± 0.1	1.3 ± 0.1
4	<5.0	0.8 ± 0.1	2.0 ± 0.3
5	<2.0	0.6 ± 0.1	1.2 ± 0.2
6	1.1 ± 0.6	0.6 ± 0.1	0.6 ± 0.2
7	<5.0	1.1 ± 0.2	0.3 ± 0.1
8	<1.7	0.3 ± 0.1	0.4 ± 0.1
9	<2.5	0.6 ± 0.1	2.7 ± 0.2
10	<5.0	0.5 ± 0.1	2.0 ± 0.3
11	<1.6	0.6 ± 0.1	1.1 ± 0.1
12	<1.9	0.8 ± 0.1	0.8 ± 0.1
13	<1.8	0.6 ± 0.2	1.1 ± 0.2
14	<1.6	0.4 ± 0.1	0.7 ± 0.1
15	<1.7	0.5 ± 0.1	0.6 ± 0.1
16	<5.0	0.5 ± 0.1	1.2 ± 0.2
17	<5.0	0.8 ± 0.1	2.3 ± 0.3
18	<5.0	0.8 ± 0.1	1.0 ± 0.2
19	<2.4	0.6 ± 0.1	1.8 ± 0.3
20	<5.0	0.6 ± 0.1	1.9 ± 0.2
21	<1.6	0.3 ± 0.1	0.9 ± 0.1
22	<1.5	0.3 ± 0.1	0.6 ± 0.1

REFERENCES

1. Oak Ridge Associated Universities. Radiological Assessment of Ballod Associates Property (Stepan Chemical Company) Maywood, New Jersey, Oak Ridge, TN, July, 30, 1981.

2. Morton, Henry W. Natural Thorium in Maywood, New Jersey, Nuclear Safety Associates, Inc., Potomac, MD, September 29, 1982.

3. Bechtel National, Inc. Radiological Survey Report for 10 Grove Avenue, Rochelle Park, New Jersey, DOE/OR/20722-34, Oak Ridge, TN, September 1984.

4. Bechtel National, Inc. Radiological Survey Report for 22 Grove Avenue, Rochelle Park, New Jersey, DOE/OR/20722-37, Oak Ridge, TN, September 1984.

5. Bechtel National, Inc. Radiological Survey Report for 26 Grove Avenue, Rochelle Park, New Jersey, DOE/OR/20722-38, Oak Ridge, TN, September 1984.

6. Bechtel National, Inc. Radiological Survey Report for 30 Grove Avenue, Rochelle Park, New Jersey, DOE/OR/20722-39, Oak Ridge, TN, September 1984.

7. Bechtel National, Inc. Radiological Survey Report for 34 Grove Avenue, Rochelle Park, New Jersey, DOE/OR/20722-40, Oak Ridge, TN, September 1984.

8. Bechtel National, Inc. Radiological Survey Report for 38 Grove Avenue, Rochelle Park, New Jersey, DOE/OR/20722-41, Oak Ridge, TN, September 1984.

9. Bechtel National, Inc. Radiological Survey Report for 42 Grove Avenue, Rochelle Park, New Jersey, DOE/OR/20722-42, Oak Ridge, TN, September 1984.

10. Bechtel National, Inc. Radiological Survey Report for 86 Park Way, Rochelle Park, New Jersey, DOE/OR/20722-34, Oak Ridge, TN, September 1984.

11. Bechtel National, Inc. Radiological Survey Report for 90 Park Way, Rochelle Park, New Jersey, DOE/OR/20722-34, Oak Ridge, TN, September 1984.

12. U.S. Department of Energy. "U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites," Rev. 1, July 1985.

13. U.S. Code of Federal Regulations. 40 CFR 192, "Health and Environmental Protection for Uranium and Thorium Mill Tailings," Washington, DC, July 1985.

14. Department of Energy. Remedial Action Work Plan for the Maywood Site, ORO-850, Revision 1, Oak Ridge, TN, April 1985.

15. Letter, M. G. Yalcintas (ORNL) to A. J. Whitman (DOE). "Statement on Verification to be Added to the Post-Remedial Action Report," August 13, 1985.

16. Letter, M. G. Yalcintas (ORNL) to A. J. Whitman (DOE). "Verification Statement for Maywood Properties," December 5, 1985.

17. Letter, M. G. Yalcintas (ORNL) to E. DeLaney (DOE). "Verification Statement for Maywood Properties," February 18, 1986.

GLOSSARY

Alpha Radiation - See radiation.

Background Radiation - Background radiation refers to naturally occurring radiation emitted from either cosmic (e.g., from the sun) or terrestrial (e.g., from the earth) sources. Exposure to this type of radiation is unavoidable and its level varies greatly depending on geographic location; e.g., the state of New Jersey receives 100 mrem/yr, Colorado receives about 300 mrem/yr, and some areas in South America receive up to 7000 mrem/yr. Naturally occurring terrestrial radionuclides include uranium, radium, potassium, thorium, etc.

Beta Radiation - See radiation.

Contamination - Contamination is used here to mean radioactive materials in the soil above the DOE guidelines.

Dose - Dose is used to relate radiation exposure to an effect on the body and is measured in mrem. Examples of dose are: a dose of 500,000 mrem to the whole body in a short time causes death in 50 percent of the people who receive it; a dose of 5,000,000 mrem may be delivered to a cancerous tumor during radiation treatment; average background radiation results in an annual dose of about 100 mrem; a typical chest x-ray gives a dose of about 40 mrem; living in a brick house results in a dose of about 75 mrem/yr. DOE radiation protection standards limit the dose to members of the general public to 100 mrem/yr above background.

Exposure Rate - Exposure rate is the rate at which radiation imparts energy to the air. Exposure is typically measured in uR and the exposure rate is typically given as uR/h. The dose to the whole body can be approximated by multiplying the exposure rate by the number of hours of exposure. For example, if an individual was exposed to 20 uR/h for 168 hours per week (continuous exposure) for 52 weeks per year, the whole body dose would be 170 mrem.

Gamma Radiation - See radiation.

Gram - A gram is a metric unit for weight. It takes 454 grams to make 1 pound; 1 ounce equals 28 grams.

Leaching - Leaching is a slow, chemical process whereby the radionuclides from the ore residues are dissolved in water (runoff following precipitation) and seep into the surrounding soil. Storage piles of radioactive materials are usually covered with waterproof materials to prevent leaching.

Liter - Abbreviated l, liter is a unit of measure for volume. One liter is slightly more than one quart.

microroentgens - Microroentgens (uR) is a unit used to measure radiation exposure. For further information, see the definition of radiation exposure.

Monazite - Monazite is a mineral which contains unusually high concentrations of thorium and rare earth metals. Monazite is often found in sand and gravel deposits.

mrem - mrem is the unit used to measure the effect of radiation doses to the body. The DOE limit is 100 mrem above background in any one year for members of the general public. For comparison, a typical medical x-ray is about 40 mrem. Naturally occurring radioactive substances in the ground result in an average yearly exposure to everyone of about 100 mrem. To date, no difference can be detected in the health of population groups exposed to 100 mrem/yr and in the health of groups who are not exposed.

Picocuries - A picocurie is the unit of measure for radioactivity just as an ounce is a unit to measure weight. One picocurie means that one radioactive particle is released on the average of every 27 seconds.

Radiation - There are three primary types of radiation: alpha, beta, and gamma. Alpha radiation travels less than an inch in air before it stops and cannot penetrate the outer layer of skin on the body. Beta radiation can penetrate the outer layers of skin, but cannot reach the internal organs of the body. Gamma radiation is the most penetrating type and can usually reach the internal organs.

Radioactive Decay - Radioactive decay is the change in chemical composition of a radioactive material that accompanies the emission of alpha or beta particles from that material. The radioactive element becomes a different element, which may or may not be radioactive. For example, the following chain describes the radioactive decay of uranium-238: uranium-238 -- thorium-234 -- protactinium-234 -- uranium-234 -- thorium-230 -- radium-226 -- radon-222 -- polonium-218 -- lead-214 -- bismuth-214 -- polonium-214 -- lead-210 -- bismuth-210 -- polonium-210 -- lead-206. Lead-206 is stable; therefore the original atom of uranium-238 has become one of lead-206 and is no longer radioactive.

Radionuclide - Radionuclide is another word meaning a particular radioactive element. For example, radium-226 is a radionuclide, uranium-238 is another, thorium-232 another, and so on.

Radium-226 - Radium-226 is one of the radioactive materials found in the wastes from the Maywood Chemical Works plant. When it releases radiation, it becomes radon.

Radon - Radon is a noble gas generated when radium-226 radioactively decays. Because it is a gas, it seeps out of the soil containing the radium-226 and concentrates in confined areas. The pressure of radon can be used to infer the presence of radium-226.

Radon Daughters - When radon undergoes radioactive decay, it emits alpha radiation. After this occurs, it is no longer radon and has become polonium. This is also radioactive and decays to radioactive lead by emitting alpha radiation. This process continues (see

radioactive decay) until the material becomes stable lead and is no longer radioactive. The "parent" radionuclide for this chain of radioactive decay was the radon. All radioactive material resulting from the decay of the radon are called radon daughters.

Rare Earths - Rare earths refers to various types of metals present in the monazite sands. These were extracted from the monazite for their value. Rare earth metals include cerium, lanthanum, praeseodymium, and neodymium.

Remedial Action - Remedial action is a general term used to mean "cleanup of contamination." It refers to any action required so that a property can be released for unrestricted use as noncontaminated. In practice, this may mean removing grass and soil, cutting trees, removing asphalt, etc.

Thorium - Thorium is a naturally occurring element which is recovered from monazite for commercial purposes. Monazite contains from 3 to 9 percent thorium oxide. The principal use of thorium to date has been in the preparation of gas lantern mantels because thorium oxide burns with a brilliant white light. Thorium oxide is also commonly found in high quality glasses and camera lenses because of its good optical characteristics.

Unrestricted Use - Unrestricted use means that a property can be used for any purpose without regard to the radioactivity which used to be on the property. These uses could include anything - farming, a residence, a playground, etc.

Working Level - Working level is a unit to measure the energy expended in air by radon or its radioactive decay products. The term was derived for use with uranium mine workers and has become the accepted unit for environmental measurements.