

REPORT ON THE
INVESTIGATION OF CANCER INCIDENCE
IN MUNICIPALITIES ADJACENT TO THE
STEPAN CHEMICAL COMPANY/MAYWOOD INTERIM STORAGE SITE
IN MAYWOOD, BERGEN COUNTY, NEW JERSEY

NEW JERSEY DEPARTMENT OF HEALTH
DIVISION OF OCCUPATIONAL & ENVIRONMENTAL HEALTH

JULY 1987

INVESTIGATION OF CANCER INCIDENCE IN MUNICIPALITIES ADJACENT TO
THE STEPAN CHEMICAL COMPANY/MAYWOOD INTERIM STORAGE SITE IN
MAYWOOD, BERGEN COUNTY, NEW JERSEY

SUMMARY

At the request of a concerned Maywood resident, the Division of Occupational and Environmental Health, New Jersey Department of Health, conducted a cancer incidence evaluation of four communities and subpopulations juxtaposed with the former Maywood Chemical Works property, currently known as the Stepan Chemical Company/Maywood Interim Storage Site (SC/MISS) and other surrounding properties utilizing the Cancer Registry. This investigation did not provide evidence for elevated cancer incidences in the area when compared to the State of New Jersey.

Although experimental and epidemiologic data indicate that no amount of radiation exposure is entirely free from risk of cancer, it is improbable that any excess cancer could be detected in the examined populations due to the limitations of the analyses. These include small sample size and the inability to properly define exposed and non-exposed populations. However, with respect to the radiological wastes, the absence of significantly elevated cancer incidence rates in the four communities is reassuring since 60 years (representing the total period from the beginning of thorium processing) is sufficient time for the manifestation of cancer in these communities and/or block groups, if off-site radiation exposure were extensive.

While the original request for this investigation centered on the radiological wastes stored at the MISS, recent data indicates that non-radiological, chemical contaminants are also present in the area. The analyses which were performed for this report are capable of detecting a difference from the expected number of cancer cases, regardless of the source. The only factor which might influence the outcome in question, that is cancers, is latency from time of exposure. In the case of the MISS, data are not available on the extent that the population in the surrounding communities were exposed to radiological or non-radiological contaminants, if any occurred, or when these exposures began.

Although this investigation did not provide evidence for elevated cancer incidence in this area when compared to the whole State, the New Jersey Department of Health is supportive of efforts to expedite the mitigation of exposure to soil and water contaminants which have been identified, both at the Stepan Chemical Company/Maywood Interim Storage Site and in the surrounding communities.

I. INTRODUCTION

The Environmental Disease Prevention Program of the New Jersey Department of Health received a request in November, 1985 to determine if an excess incidence of cancer in Maywood, Bergen County, was associated with the Stepan Chemical/Maywood Interim Storage Site [SC/MISS], an 11.2 acre hazardous waste storage site juxtaposed with the borders of three densely populated municipalities. A search of the death certificates from 1978 through 1983 in the Borough of Maywood by a local resident revealed that of the 485 recorded deaths, 136 had cancer as the primary or secondary cause of death. This report describes an investigation into whether systematically collected cancer incidence data indicates any excess of that group of diseases in the municipalities adjacent to the SC/MISS when compared with the rest of New Jersey.

Background information on the SC/MISS and contaminants is provided for historical purposes. This report is not a risk assessment of the site. It only attempts to address the residents' concerns regarding cancer by utilizing existing cancer surveillance data.

II. BACKGROUND

Maywood Chemical Works was founded at the site in 1895. Thorium processing occurred from 1916 through 1957 using monazite ore (12% thorium and 1% uranium) and thorium-phosphorus. The wastes which were generated consisted mainly of a slurry of thorium-phosphorus which was stored off-site in unlined lagoons west of the property (now Ballod Property) (See Figure 1). In 1959, after termination of the processing of monazite ore for the manufacture of lantern mantles, the Maywood Chemical Works property was purchased by the Stepan Chemical Company. Stepan Chemical Company currently produces detergents, alkaloids, essential oils and lithiated compounds.

Site inspections conducted by the Atomic Energy Commission [AEC] between 1957 and 1963 identified the presence of thorium waste piles in several areas within the boundaries of the property. Between 1966 and 1968, approximately 17,000 cubic yards [cu. yd.] of thorium waste were consolidated and stored in the southern portion of the property. Additional radiation contamination at the northeast corner of the property was brought to the attention of the Nuclear Regulatory Commission [NRC] in late 1980. A summary of on-site radiation contamination is presented in Table 1-A.

The extent of offsite contamination was determined in 1981 by an aerial radiological survey of the four square miles surrounding the property. Elevated radiation levels in commercial (immediately south and west of the property) and residential properties (0.5 miles northeast and south of the property) were identified. Chemical contamination of on-site surface water and sediment was confirmed in 1981.

In 1982 and 1983, the Stepan Chemical Company site was placed on the U.S. Environmental Protection Agency's [EPA] National Priority List and added to the U.S. Department of Energy's [DOE] Formerly Utilized Sites Remedial Action Program [FUSRAP], respectively.

The DEP confirmed elevated alpha-radiation contamination in a Lodi municipal well. This finding precipitated radiological surveys of adjoining commercial and residential properties in Rochelle Park and in Lodi by DEP and DOE. Also in 1983, the MISS was lined with clay and covered with a Hypalon tarp.

The present Maywood Interim Storage Site [MISS] was prepared in 1984 by Bechtel National, Inc. (DOE's management contractor under FUSRAP) to include 4700 cubic yards of excavated thorium contaminated soil from eight Maywood residential properties, nine Rochelle Park residential properties, and part of the Ballod property. In 1985, the DOE designated thorium contaminated properties in Lodi as part of the Maywood FUSRAP. Eight Lodi residential properties and additional material from the Ballod property were remediated and stored at the MISS. The remediation basis for these properties were the clean-up standards for radium contaminated soil, radon progeny, and gamma radiation at all inactive DOE uranium processing sites were promulgated by EPA in 40CFR192. In addition, the DOE developed clean-up standards for radionuclides such as thorium which were not addressed by 40CFR192. (See Appendix A for a listing of standards.)

Water samples taken from the 15 monitoring wells around the MISS (Figure 2) indicate the presence of non-radiological, chemical contaminants (Table 1-B). Furthermore, analyses of water samples collected from Lodi municipal wells and of soil samples from properties adjacent to the Stepan Chemical Company confirmed the presence of chemical contamination. Presently, the data are not sufficient to allow an assessment of the relationship between the chemical contamination of the Stepan Chemical Company and the Lodi wells. The DEP has requested information from all nearby property owners in an attempt to identify the source of chemical contaminants of the Lodi municipal wells.

III. PRESENT STATUS

To date, DOE has completed remediation of 25 residential properties in Maywood, Rochelle Park and Lodi as well as one commercial property in Rochelle Park. Additional properties in Lodi are being evaluated, however none have been remediated since the MISS is not available for the storage of contaminants removed from additional Lodi properties.

Long term plans for the MISS (Figure 3) by DOE include maintaining the site in a safe and secure manner, monitoring the site for compliance with radiological standards, and the identification of a suitable permanent radiologically safe disposal site with final disposal.

Estimates of the total radiological contamination (262,200 cu. yd.) include 34,900 cu. yd. from prior remediations in 1984 and 1985, 81,000 cu. yd. from future adjacent remediation, 73,000 cu. yd. below-grade on the site, 14,000 cu. yd. from a leachate collection system, 20,000 cu. yd. beneath Route 17_{1,2} and 40,000 cu. yd. in AEC licensed burial areas on the Stepan property .

IV. METHODS

The municipalities included in this analysis are Maywood, Lodi, Rochelle Park and Saddle Brook (See Figure 4). Since an analysis of health data on the total population of any one of these municipalities could possibly mask an effect, through dilution, which may otherwise be observed in only those living nearest to the SC/MISS, an additional analysis was performed on a subpopulation of these municipalities closest to the site, using selected U.S. Census block groups. Our purpose was to evaluate whether the number of cancer cases which have been reported to the New Jersey Cancer Registry from these areas constitute an unusual occurrence.

Since October 1, 1978, every new cancer diagnosis in New Jersey is required by law to be reported to the New Jersey Department of Health Cancer Registry. The reporting had been completed for the years 1979 through 1983 at the time that this analysis was initiated. The Cancer Registry provided a listing of all cancer cases diagnosed in the four municipalities for these years. This listing was edited for duplication of records. The area within one mile of the boundaries of the site was identified for a concentrated analysis. This was refined to coincide with census block groups (Figure 3), for which the demographic variables of sex and age distribution were available. The U.S. Census DIME file for the New York SMSA was obtained and searched to obtain a listing of address ranges which correspond to the census blocks which are within this one mile radius. Cases from the Registry listing were then located by tract and block, either via the DIME file listing or manually.

A Standardized Incidence Ratio [SIR] by primary cancer site was calculated for each of the four municipalities as well as for the selected block groups for each sex. The observed number of cancers was compared to the number which one would expect to occur under the presumption that incidence rates in the State of New Jersey for 1982 would prevail in this population. (The year 1982 was chosen from the five years of available incidence data for New Jersey, 1979 - 1983, since published cancer rates were available.)

In addition, a Proportional Incidence Ratio [PIR] analysis was performed on some specific cancers. The PIR and a test of statistical significance were calculated whenever the SIR for a cancer type or group of related types was elevated. The additional PIR analysis was performed to test if an excess of some specific cancer types were not masked by a generalized underreporting of all cancers.

V. RESULTS

This investigation was conducted because of the suspicion that there was an elevated incidence of cancer in a neighborhood in Maywood adjacent to the MISS, based on death certificates and a door-to-door survey performed by a resident of Maywood. The resident's cancer mortality list was checked against the Cancer Registry. Of the 136 names on the list, only 41 (30%) were found in the Registry. This is probably due to diagnoses prior to 1979 or diagnoses out of state. No additional analysis was performed using the mortality data.

A description of the cancers diagnosed between 1979 and 1983 is presented in Tables 2-A through 2-E. Fifty-three percent of the cases were female. The race was reported to be white non-Hispanic for 98.4% of the cases, 0.3% were black, 0.2% were of Hispanic origin, and 0.5% reported "other" for race. Race was not reported for 0.6% of the cases.

Tables 3-A through 3-E present the findings for the five years of data which were analyzed. The observed number of cancer cases was not found to be significantly ($p=0.05$) greater than the expected number of cases. The following sub-categories were found to be significantly lower than the expected number of cases:

Maywood-all sites female
Rochelle Park-all sites male
Rochelle Park-all sites female
Rochelle Park-breast
Rochelle Park-prostate
Selected census blocks-all sites female.

When the four towns are examined for common patterns of incidence, three of the four (Maywood, Lodi and Saddle Brook) and the selected census blocks were found to have a SIR greater than 1.0 for male brain and other central nervous system cancers. Also, three of the four (Maywood, Rochelle Park and Saddle Brook) and the selected census blocks had a SIR greater than 1.0 for female brain and other central nervous system cancers. However, in none of these analyses was the excess statistically significant. When the four towns were combined for analysis, the observed number of cancers was still greater than the expected number [SIR=1.5 (95% Confidence Interval 0.8-2.6) for males and SIR=1.2 (0.6-2.1) for females], however the difference was still not statistically significant. Also, all four towns and the selected census blocks had a SIR less than 1.0 for prostate cancer which was not statistically significant.

The results of the Proportional Incidence Ratio analysis (Table 4-A) is unremarkable with the exception of cancers of the lower digestive tract in females -- colon, and rectum and anus (Table 4-B).

VI. DISCUSSION

Many types of cancer have been linked to external gamma radiation, which can penetrate all organs of the body. Because leukemia often has a shorter latency period than other cancers following exposure, it is often evaluated first in situations where gamma radiation exposure is of concern. In the area with the greatest suspected exposure, the selected black groups, there were no cases of childhood leukemia. Moreover, the analyses indicate that when the incidence of cancer in the individual municipalities of Maywood, Lodi, Rochelle Park and Saddle Brook are compared to the State of New Jersey, an excess is not found.

When many observations on subgroups are made, there is an increasing chance that one or more of the observed values will depart from the expected number to a "statistically significant" degree purely by chance alone. While a slight excess of brain and central nervous system cancers was found by SIR in both males and females, it was not consistent by

municipality and the excess was not statistically significant. The degree of excess in female digestive tract cancers by PIR analysis is of marginal statistical significance. There is no a priori reason to suspect an increase for these types of cancer. Dietary and other personal exposures contribute to the the risks of colon, rectal, and anal cancers and these types of cancers have not been found to be especially associated with radiation.

VII. CONCLUSION

The analyses of cancer registry data for the four municipalities and block groups juxtaposed with the SC/MISS do not provide evidence for elevated cancer incidences in this area when compared to the State of New Jersey. The high mortality rate calculated for this area by a Maywood resident reflects cancer deaths (old and new cases over a time period of 6 years - 1978 through 1983). This mortality rate also reflects duration of disease (survival) over the specified time period. Incidence is a direct measure of the number of new cases of a disease in a period of time.

Although experimental and epidemiologic data indicate that no amount of radiation exposure is entirely free of risk, it is improbable that any excess cancer could be detected in the examined populations due to the limitations of the analyses. These include small sample size and, because of the absence of exposure assessment information, the inability to properly define exposed and non-exposed populations. However, the absence of significantly elevated cancer incidence rates in the four communities is somewhat reassuring since 60 years (representing the total period from the beginning of thorium processing) is sufficient time for the manifestation of cancer in the four communities and/or block groups, if off-site radiation exposure were extensive.

It must be noted that this investigation is not definitive. It does not provide a final answer to the other questions raised concerning adverse health endpoints in these four communities that may be potentially attributable to the SC/MISS. Other potential adverse health outcomes, such as birth defects and other adverse reproductive outcomes, have not been investigated. However, the absence of adequate population exposure data and the limitations inherent in evaluating adverse reproductive outcomes, particularly in a small population does not suggest that such an investigation would be meaningful.

In examining the occurrence of the cancers reported, it is important to note that cancer is, unfortunately, a common disease and that cancer is not a single disease, but many different diseases which have many different causes. Because of the variety of cancers reported and the time span for dates of diagnosis, it is difficult to suspect a single causative agent. It is more likely that individual risk factors such as smoking, diet or occupational exposures played a greater role in the development of the diseases rather than the shared, common environment of the area adjacent to the Stepan Chemical Company/Maywood Interim Storage Site.

TABLE 1-A

Summary of 1984 and 1985 On-site Sampling Data from
Bechtel National, Inc.

SURFACE WATER

Concentrations (pCi/L)

	1984	1985	Standard*
Total Uranium	3.0 - 11	<3.0	600
Radium-226	<0.1 - 1.8	<0.1 - 1.0	100
Thorium-232	<0.1 - 0.8	<0.1 - <0.3	50

GROUND WATER

Concentrations (pCi/L)

	1984	1985	Standard*
Total Uranium	-	<3.0 - 63	600
Radium-226	-	<0.1 - 1.2	100
Thorium-232	-	<0.1 - 0.5	50

SEDIMENT

Concentrations (pCi/g)

	1984	1985	Standard*
Radium-226	0.4 - 1.3	0.2 - 0.9	0.2
Thorium-232	0.2 - 0.6	0.06 - 0.5	5 - 15
Uranium-234	0.2 - 0.9	0.2 - 0.7	5 - 75
Uranium-235	0.03 - 0.1	0.01 - 0.07	-
Uranium-238	0.1 - 0.6	0.2 - 0.6	-
Total Uranium	0.3 - 1.5	0.4 - 1.3	75

RADON

Weighted Average Concentrations (pCi/L)

	1984	1985	Standard*
Radon-220	ND - 9.9	0.02 - 3.2	10
Radon-222	0.6 - 2.7	0.2 - 0.5	3

EXTERNAL GAMMA DOSE RATES

Dose Rate (mrem/yr)

	1984	1985	Standard*
Background (offsite)	80	108	100
Fenceline **	90 - 763	15 - 627	100
On-site **	79 - 91	46 - 50	100

* Standards are available in Bechtel 1984 and 1985 reports.

** Measured background of 9 uR/hr (1984) and 12 uR/hr (1985) have been subtracted. Dose rate is based on continuous occupancy throughout the year.

CONCENTRATIONS OF CHEMICAL CONTAMINANTS IN GROUNDWATER AT THE MISS, 1985¹

Parameter/Unit	Range of Concentrations by Sampling Location (Monitoring Well No.) ²										
	1B	2A ³	2B ³	3A	3B	4B	5A	5B	6A	6B	7B
Methylene chloride (ug/l)	108	1087	169	233	267	302	ND	100	175	145	512
Trichloroethylene (ug/l)	66	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND/9
Bis (2-ethylhexyl) phthalate (ug/l)	44/190	24/350	ND/53	ND/110	54/75	12/29	29	120/1200	57/61	ND/290	ND/36
Chloroform (ug/l)	ND	39	ND	ND	ND	ND	ND	ND	31	ND	27
Toluene (ug/l)	ND	38	ND	33	31	20/55	ND	ND	25	26	16
Di-n-octyl phthalate (ug/l)	ND	41	27	ND	ND	ND	ND	ND	ND	ND	ND
Benzene (ug/l)	ND	ND	143/150	ND	ND	420/1240	ND	ND/660	ND	ND	ND/7
Tetrachloroethylene (ug/l)	ND/130	ND/110	ND/30	47/90	ND/25	ND/170	ND	ND/33	ND/26	ND/100	ND/110
Trans-1,2-Dichloroethylene (ug/l)	ND/7	ND	ND	ND	ND	1100/2964	ND	ND	ND	ND	ND/17
1,1,2,2-Tetrachloroethane (ug/l)	ND	ND	ND	ND	ND	13	ND	ND	ND	ND	ND
Vinyl Chloride (ug/l)	ND	ND	ND	ND	ND	ND/220	ND	ND	ND	ND	ND
Total organic carbon (mg/l)	2/100	21/305	15/130	27/165	67/70	18/79	33	17/30	10/78	10/23	12/62
Total organic halide (ug/l)	99/572	78/841	182/1332	58/381	51/553	498/1465	113	74/216	58/140	100/220	80/164
Specific conductance (umhos/cm)	724/937	7007/7683	7460/10130	763/1210	2555/3530	1222/1780	2428	3258/3375	1879/3000	2887/4185	5542/7450
pH (pH units)	6.9/7.4	6.8/7.3	6.8/7.3	3.9/5.6	5.9/6.3	6.3/7.1	5.46	6.7/6.9	6.9/7.3	9.0/9.5	7.1/7.5
Arsenic ⁴ (mg/l)	ND	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium ⁴ (mg/l)	0.05	0.07	ND	3.5	0.007	0.03	ND	0.03	0.06	0.08	0.007
Boron ⁴ (mg/l)	ND	2.2	2.7	0.1	0.3	0.13	ND	1.0	12	0.7	15
Calcium ⁴ (mg/l)	85	220	300	66	200	150	ND	190	190	20	220
Chromium ⁴ (mg/l)	ND	2.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron ⁴ (mg/l)	0.03	3.8	0.05	2.7	ND	ND	ND	ND	ND	ND	ND
Lead ⁴ (mg/l)	ND	0.04	ND	ND	ND	ND	ND	ND	0.07	2.7	0.05
Magnesium ⁴ (mg/l)	550	12	100	15	53	15	ND	ND	ND	ND	ND
Manganese ⁴ (mg/l)	26	0.58	0.42	1.9	15	3.4	ND	7.9	45	10	73
Potassium ⁴ (mg/l)	42	57	190	78	89	53	ND	0.1	0.29	0.23	0.8
Silicon ⁴ (mg/l)	3	19	8	14	5.8	7.5	ND	310	110	52	190
Sodium ⁴ (mg/l)	74	2800	2800	35	320	190	ND	86	78	48	35
Strontium ⁴ (mg/l)	0.12	0.57	0.38	ND	0.3	0.21	ND	290	65	870	1800
Tin ⁴ (mg/l)	0.05	ND	ND	ND	ND	ND	ND	0.45	1.5	0.12	0.25
Vanadium ⁴ (mg/l)	ND	3.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc ⁴ (mg/l)	ND	ND	ND	0.04	0.02	ND	ND	ND	ND	ND	ND

TABLE 1-P

¹ Does not include parameters for which concentrations were below limit of sensitivity of analytical method and therefore undetectable. See Table 4-2.
² ND - No detectable concentration. Where only one value is listed, only one sample was analyzed.
³ Upgradient well.
⁴ Analyzed for dissolved metal.

CHEMICAL CONTAMINANTS FOR WHICH CONCENTRATIONS IN GROUNDWATER AT THE MISS
WERE BELOW THE ANALYTICAL LIMIT OF SENSITIVITY^a

Acrolein	Diethylphthalate	Endrin
Acrylonitrile	Dimethylphthalate	Endrin aldehyde
Bromodichloromethane	2,4-Dinitrotoluene	Heptachlor
Bromoform	2,6-Dinitrotoluene	Heptachlor Epoxide
Bromomethane	1,2-Diphenylhydrazine	4,4'-DDT
Carbon Tetrachloride	Fluoranthene	4,4'-DDE
Chlorobenzene	Fluorene	4,4'-DDD
Chlorodibromomethane	Hexachlorobenzene	PCB 1016
Chloroethane	Hexachlorobutadiene	PCB 1221
2-Chloroethyl vinyl ether	Hexachloroethane	PCB 1232
Chloromethane	Hexachlorocyclopentadiene	PCB 1242
Dichlorodifluoromethane	Indeno (1,2,3-cd) pyrene	PCB 1248
1,1-Dichloroethane	Isophorone	PCB 1254
1,2-Dichloroethane	Naphthalene	PCB 1260
1,1-Dichloroethylene	Nitrobenzene	Toxaphene
1,2-Dichloropropane	n-Nitrosodimethylamine	Antimony
1,3-Dichloropropene	n-Nitrosodi-N-propylamine	Beryllium
Ethylbenzene	n-Nitrosodiphenylamine	Cadmium
1,1,1-Trichloroethane	Phenanthrene	Cobalt
1,1,2-Trichloroethane	Pyrene	Copper
Trichlorofluoromethane	1,2,4-Trichlorobenzene	Molybdenum
Acenaphthene	2,3,7,8-Tetrachlorodibenzo-p-dioxin	Nickel
Acenaphthylene	4-Chloro-3-methylphenol	Scandium
Benzo (a) anthracene	2-Chlorophenol	Selenium
Benzo (b) fluoranthene	2,4-Dichlorophenol	Silver
Benzo (k) fluoranthene	2,4-Dimethylphenol	Thallium
Benzo (a) pyrene	2,4-Dinitrophenol	
Benzo (g,h,i) perylene	2-Methyl-4,6-dinitrophenol	
Benzidine	2-Nitrophenol	
Bis (2-chloroethyl) ether	4-Nitrophenol	
Bis (2-chloroethoxy) methane	Pentachlorophenol	
Bis (2-chloroisopropyl) ether	Phenol	
4-Bromophenylphenylether	2,4,6-Trichlorophenol	
Butylbenzylphthalate	Aldrin	
2-Chloronaphthalene	BHC, alpha	
4-Chlorophenylphenylether	BHC, beta	
Chrysene	BHC, gamma	
Dibenzo (a,h) anthracene	BHC, delta	
DiButyl phthalate	Chlordane	
1,2-Dichlorobenzene	Dieldrin	
1,3-Dichlorobenzene	Endosulfan, alpha	
1,4-Dichlorobenzene	Endosulfan, beta	
3,3'-Dichlorobenzidine	Endosulfan sulfate	

TABLE 1-B (Cont.)

^aAnalysis for these parameters required to meet NJDEP permit requirements.

TABLE 2-A

Description of Reported Cancer Cases
MAYWOOD - BERGEN COUNTY

Primary Site	Range of Age at Diagnosis	Sex		Total
		M	F	
Buccal Cavity & Pharynx	37 - 73	3	0	3
Digestive System	38 - 91	35	27	62
Respiratory System	39 - 84	27	11	38
Bones & Joints	-	0	0	0
Soft Tissue	-	0	0	0
Skin (Excluding Basal Cell)	38 - 98	7	5	12
Breast	27 - 88	0	25	25
Female Genital Organs	25 - 72	0	9	9
Male Genital Organs	57 - 92	19	0	19
Urinary System	51 - 91	16	3	19
Eye	-	0	0	0
Brain & Other Nervous System	15 - 84	3	2	5
Endocrine System	27	0	1	1
Lymphomas	22 - 86	6	0	6
Multiple Myeloma	75	1	1	2
Leukemias	29 - 93	1	2	3
Miscellaneous				
Reticuloendothelial	-	0	0	0
Other Ill-defined Sites	-	0	0	0
Unknown Primary Site	35 - 77	2	5	7

Total	15 - 93	120	91	211

TABLE 2-B

Description of Reported Cancer Cases
LODI - BERGEN COUNTY

Primary Site	Range of Age at Diagnosis	Sex		Total
		M	F	
Buccal Cavity & Pharynx	29 - 79	12	1	13
Digestive System	32 - 92	67	65	132
Respiratory System	42 - 86	60	29	89
Bones & Joints	34	1	0	1
Soft Tissue	-	0	0	0
Skin (Excluding Basal Cell)	32 - 98	10	7	17
Breast	39 - 93	0	76	76
Female Genital Organs	21 - 91	0	56	56
Male Genital Organs	24 - 95	38	0	38
Urinary System	35 - 88	37	12	49
Eye	-	0	0	0
Brain & Other Nervous System	15 - 74	6	3	9
Endocrine System	29 - 72	1	6	7
Lymphomas	16 - 84	8	9	17
Multiple Myeloma	62 - 86	3	2	5
Leukemias	2 - 81	3	7	10
Miscellaneous				
Reticuloendothelial	-	0	0	0
Other Ill-defined Sites	-	0	0	0
Unknown Primary Site	49 - 83	8	4	12

Total	2 - 98	254	277	531

TABLE 2-C

Description of Reported Cancer Cases
SADDLE BROOK - BERGEN COUNTY

Primary Site	Range of Age at Diagnosis	Sex		Total
		M	F	
Buccal Cavity & Pharynx	9 - 74	7	3	10
Digestive System	46 - 90	46	35	81
Respiratory System	44 - 81	39	13	52
Bones & Joints	68	0	1	1
Soft Tissue	1 - 54	0	2	2
Skin (Excluding Basal Cell)	31 - 86	9	5	14
Breast	30 - 92	0	52	52
Female Genital Organs	14 - 84	0	31	31
Male Genital Organs	35 - 86	19	0	19
Urinary System	37 - 92	16	5	21
Eye	-	0	0	0
Brain & Other Nervous System	41 - 87	4	4	8
Endocrine System	17 - 70	3	3	6
Lymphomas	19 - 76	6	3	9
Multiple Myeloma	48 - 69	2	0	2
Leukemias	27 - 70	3	2	5
Miscellaneous				
Reticuloendothelial	51	0	1	1
Other Ill-defined Sites	55	0	1	1
Unknown Primary Site	52 - 74	4	1	5

Total	1 - 92	158	162	320

TABLE 2-D

Description of Reported Cancer Cases
ROCHELLE PARK - BERGEN COUNTY

Primary Site	Range of Age at Diagnosis	Sex		Total
		M	F	
Buccal Cavity & Pharynx	51 - 69	3	1	4
Digestive System	36 - 92	26	18	44
Respiratory System	43 - 81	28	7	35
Bones & Joints	-	0	0	0
Soft Tissue	-	0	0	0
Skin (Excluding Basal Cell)	52 - 88	9	3	12
Breast	29 - 77	0	25	25
Female Genital Organs	32 - 81	0	14	14
Male Genital Organs	60 - 94	9	0	9
Urinary System	55 - 91	9	4	13
Eye	-	0	0	0
Brain & Other Nervous System	3 - 63	0	2	2
Endocrine System	-	0	0	0
Lymphomas	30 - 71	1	1	2
Multiple Myeloma	79	1	0	1
Leukemias	85	1	0	1
Miscellaneous				
Reticuloendothelial	-	0	0	0
Other Ill-defined Sites	-	0	0	0
Unknown Primary Site	62	1	0	1

Total	3 - 94	88	75	163

TABLE 2-E

Description of Reported Cancer Cases
Selected Census Blocks Surrounding
Maywood Radiation Site

Primary Site	Range of Age at Diagnosis	Sex		Total
		M	F	
Buccal Cavity & Pharynx	53 - 74	7	2	9
Digestive System	47 - 89	33	39	70
Respiratory System	39 - 84	30	9	40
Bones & Joints	68	0	1	1
Soft Tissue	-	0	0	0
Skin (Excluding Basal Cell)	38 - 73	7	2	9
Breast	29 - 88	0	24	24
Female Genital Organs	14 - 81	0	14	14
Male Genital Organs	57 - 94	19	0	19
Urinary System	40 - 91	15	2	17
Eye	-	0	0	0
Brain & Other Nervous System	15 - 84	2	3	5
Endocrine System	38	1	0	1
Lymphomas	26 - 86	7	0	7
Multiple Myeloma	75	0	1	1
Leukemias	27 - 85	3	1	4
Miscellaneous				
Reticuloendothelial	-	0	0	0
Other Ill-defined Sites	55	0	1	1
Unknown Primary Site	35 - 74	4	2	6

Total	14 - 94	128	100	228

TABLE 3-A

Comparison of Observed and Expected
Cancers 1979 - 1983
Maywood - Bergen County

Sex - Type	Observed	Expected	SIR ¹	95% CI ² for SIR
Male - All Sites	120	139.2	0.86	0.7 - 1.0
Female - All Sites	91	140.4	0.65	0.5 - 0.8
Male - Colon	17	15.3	1.11	0.6 - 1.8
Male - Lung	24	28.5	0.84	0.5 - 1.3
Female - Breast	25	36.1	0.69	0.4 - 1.0
Male - Prostate	19	21.7	0.88	0.5 - 1.4
Female - Colon	13	15.6	0.83	0.4 - 1.4
Female - Lung	10	13.1	0.76	0.4 - 1.4
Male - Lymphoma	6	4.6	1.31	0.5 - 2.9
Female - Lymphoma	0	4.6	-	-
Male - Leukemia	1	2.6	0.38	0.0 - 2.1
Female - Leukemia	2	1.9	1.08	0.1 - 3.9
Female - Corpus Uteri	4	9.8	0.41	0.1 - 1.0
Male - Bladder	13	11.8	1.11	0.6 - 1.9
Female - Bladder	3	4.5	0.67	0.1 - 1.9
Male - Rectum & Anus	6	7.0	0.86	0.3 - 1.9
Female - Rectum & Anus	7	6.1	1.15	0.5 - 2.4
Male - Stomach	1	4.1	0.24	0.0 - 1.4
Female - Stomach	2	2.6	0.76	0.1 - 1.4
Male - Pancreas	5	3.2	1.56	0.5 - 3.6
Female - Pancreas	2	3.8	0.53	0.1 - 1.9
Male - Brain & CNS	3	1.7	1.80	0.4 - 5.3
Female - Brain & Cns	2	1.7	1.16	0.1 - 4.2
Male - Kidney & Urinary	3	3.5	0.86	0.2 - 2.5
Female - Kidney & Urinary	0	2.0	-	-

1980 U.S. Census Population: Male 4715, Female 5180.

1 SIR - Standardized Incidence Ratio of Observed to Expected number of Cancers (Age Standardized).

2 Approximately 5 percent of the SIR fall outside these limits. If 1.00 is included within this Confidence Interval, there is not a statistically significant departure of observed cancer incidence from State incidence rates.

TABLE 3-B

Comparison of Observed and Expected
Cancers 1979 - 1983
Lodi - Bergen County

Sex - Type	Observed	Expected	SIR ¹	95% CI ² for SIR
Male - All Sites	254	265.7	0.96	0.8 - 1.1
Female - All Sites	277	284.5	0.97	0.9 - 1.1
Male - Colon	29	28.6	1.02	0.7 - 1.5
Male - Lung	51	54.6	0.93	0.7 - 1.2
Female - Breast	76	72.4	1.05	0.8 - 1.3
Male - Prostate	34	38.9	0.87	0.6 - 1.2
Female - Colon	37	30.0	1.23	0.9 - 1.7
Female - Lung	28	25.9	1.08	0.7 - 1.6
Male - Lymphoma	8	9.6	0.83	0.4 - 1.6
Female - Lymphoma	9	9.7	0.93	0.4 - 1.8
Male - Leukemia	3	5.3	0.57	0.1 - 1.7
Female - Leukemia	7	3.9	1.80	0.7 - 3.7
Female - Corpus Uteri	14	19.6	0.71	0.4 - 1.2
Male - Bladder	31	22.2	1.40	0.9 - 2.0
Female - Bladder	9	8.8	1.02	0.5 - 1.9
Male - Rectum & Anus	17	13.2	1.29	0.7 - 2.1
Female - Rectum & Anus	8	11.8	0.68	0.3 - 1.3
Male - Stomach	7	7.0	1.00	0.4 - 2.1
Female - Stomach	8	4.6	1.75	0.8 - 3.4
Male - Pancreas	6	6.2	0.97	0.4 - 2.1
Female - Pancreas	6	7.4	0.81	0.3 - 1.8
Male - Brain & CNS	6	3.5	1.71	0.6 - 3.7
Female - Brain & CNS	3	3.6	0.83	0.2 - 2.4
Male - Kidney & Urinary	6	6.8	0.88	0.3 - 1.9
Female - Kidney & Urinary	3	4.0	0.76	0.2 - 2.2

1980 U.S. Census Population: Male 11346, Female 12610.

1 SIR - Standardized Incidence Ratio of Observed to Expected number of Cancers (Age Standardized).

2 Approximately 5 percent of the SIR fall outside these limits. If 1.00 is included within this Confidence Interval, there is not a statistically significant departure of observed cancer incidence from State incidence rates.

TABLE 3-C
 Comparison of Observed and Expected
 Cancers 1979 - 1983
 Saddle Brook - Bergen County

Sex - Type	Observed	Expected	SIR ¹	95% CI ² for SIR
Male - All Sites	158	157.2	1.01	0.9 - 1.2
Female - All Sites	162	167.1	0.97	0.8 - 1.1
Male - Colon	18	16.6	1.09	0.6 - 1.7
Male - Lung	35	33.3	1.05	0.7 - 1.5
Female - Breast	52	44.5	1.17	0.9 - 1.5
Male - Prostate	17	21.2	0.80	0.5 - 1.3
Female - Colon	20	16.9	1.18	0.7 - 1.8
Female - Lung	12	15.5	0.78	0.4 - 1.4
Male - Lymphoma	6	5.9	1.02	0.4 - 2.2
Female - Lymphoma	3	5.5	0.55	0.1 - 1.6
Male - Leukemia	3	3.0	0.99	0.2 - 2.9
Female - Leukemia	2	2.2	0.92	0.1 - 3.3
Female - Corpus Uteri	12	12.2	0.98	0.5 - 1.7
Male - Bladder	13	13.3	0.98	0.5 - 1.7
Female - Bladder	3	5.1	0.59	0.1 - 1.7
Male - Rectum & Anus	9	7.9	1.14	0.5 - 2.2
Female - Rectum & Anus	5	6.8	0.74	0.2 - 1.7
Male - Stomach	5	4.6	1.09	0.4 - 2.5
Female - Stomach	3	2.9	1.04	0.2 - 3.0
Male - Pancreas	4	3.8	1.05	0.3 - 2.7
Female - Pancreas	2	4.2	0.47	0.1 - 1.7
Male - Brain & CNS	4	2.2	1.86	0.5 - 4.8
Female - Brain & CNS	4	2.1	1.93	0.5 - 4.9
Male - Kidney & Urinary	4	4.2	0.95	0.3 - 2.4
Female - Kidney & Urinary	1	0.5	2.18	0.0 - 12.2

 1980 U.S. Census Population: Male 6769, Female 7315.

1 SIR - Standardized Incidence Ratio of Observed to Expected number of Cancers (Age Standardized).

2 Approximately 5 percent of the SIR fall outside these limits. If 1.00 is included within this Confidence Interval, there is not a statistically significant departure of observed cancer incidence from State incidence rates.

TABLE 3-D

Comparison of Observed and Expected
Cancers 1979 - 1983
Rochelle Park - Bergen County

Sex - Type	Observed	Expected	SIR ¹	95% CI ² for SIR
Male - All Sites	88	125.0	0.70	0.6 - 0.9
Female - All Sites	75	153.0	0.49	0.4 - 0.6
Male - Colon	12	14.2	0.84	0.4 - 1.5
Male - Lung	26	24.9	1.04	0.7 - 1.5
Female - Breast	25	39.3	0.64	0.4 - 0.9
Male - Prostate	8	21.3	0.37	0.2 - 0.7
Female - Colon	11	17.0	0.65	0.3 - 1.2
Female - Lung	7	14.6	0.48	0.2 - 1.0
Male - Lymphoma	1	3.6	0.28	0.0 - 1.6
Female - Lymphoma	1	5.0	0.20	0.0 - 1.1
Male - Leukemia	1	2.2	0.45	0.0 - 2.5
Female - Leukemia	0	2.0	-	-
Female - Corpus Uteri	6	10.7	0.56	0.2 - 1.2
Male - Bladder	7	10.6	0.66	0.3 - 1.4
Female - Bladder	3	4.9	0.61	0.1 - 1.8
Male - Rectum & Anus	7	6.3	1.11	0.4 - 2.3
Female - Rectum & Anus	3	6.7	0.45	0.1 - 1.3
Male - Stomach	3	3.4	0.88	0.2 - 2.6
Female - Stomach	0	2.6	-	-
Male - Pancreas	2	2.8	0.71	0.1 - 2.6
Female - Pancreas	2	4.2	0.48	0.1 - 1.7
Male - Brain & CNS	0	1.3	-	-
Female - Brain & CNS	2	1.9	1.06	0.1 - 3.8
Male - Kidney & Urinary	2	3.0	0.67	0.1 - 2.4
Female - Kidney & Urinary	1	2.2	0.45	0.0 - 2.5

1980 U.S. Census Population: Male 2616, Female 2987.

1 SIR - Standardized Incidence Ratio of Observed to Expected number of Cancers (Age Standardized).

2 Approximately 5 percent of the SIR fall outside these limits. If 1.00 is included within this Confidence Interval, there is not a statistically significant departure of observed cancer incidence from State incidence rates.

TABLE 3-E

Comparison of Observed and Expected
Cancers 1979 - 1983
Selected Census Blocks Surrounding
Maywood Radiation Site

Sex - Type	Observed	Expected	SIR ¹	95% CI ² for SIR
Male - All Sites	128	125.4	1.02	0.9 - 1.2
Female - All Sites	100	136.9	0.73	0.6 - 0.9
Male - Colon	14	13.8	1.01	0.6 - 1.7
Male - Lung	29	25.9	1.12	0.8 - 1.6
Female - Breast	24	35.1	0.68	0.4 - 1.0
Male - Prostate	18	19.2	0.94	0.6 - 1.5
Female - Colon	17	15.2	1.12	0.6 - 1.8
Female - Lung	8	12.7	0.63	0.3 - 1.2
Male - Lymphoma	7	4.1	1.69	0.7 - 3.5
Female - Lymphoma	0	4.5	-	-
Male - Leukemia	3	2.4	1.26	0.3 - 3.7
Female - Leukemia	1	1.8	0.55	0.0 - 3.1
Female - Corpus Uteri	4	9.5	0.42	0.1 - 1.1
Male - Bladder	11	10.4	1.06	0.5 - 1.9
Female - Bladder	2	4.1	0.49	0.1 - 1.8
Male - Rectum & Anus	4	6.4	0.63	0.2 - 1.6
Female - Rectum & Anus	9	5.9	1.54	0.7 - 2.9
Male - Stomach	6	3.7	1.61	0.6 - 3.5
Female - Stomach	4	2.6	1.56	0.4 - 4.0
Male - Pancreas	4	2.9	1.38	0.4 - 3.5
Female - Pancreas	3	3.6	0.82	0.2 - 2.4
Male - Brain & CNS	2	1.6	1.28	0.1 - 4.6
Female - Brain & CNS	3	1.7	1.74	0.4 - 5.1
Male - Kidney & Urinary	4	3.1	1.27	0.3 - 3.3
Female - Kidney & Urinary	0	0.4	-	-

1980 U.S. Census Population: Male 4515, Female 5086.

¹ SIR - Standardized Incidence Ratio of Observed to Expected number of Cancers (Age Standardized).

² Approximately 5 percent of the SIR fall outside these limits. If 1.00 is included within this Confidence Interval, there is not a statistically significant departure of observed cancer incidence from State incidence rates.

TABLE 4-A

PROPORTIONAL INCIDENCE RATIOS
 CANCER INCIDENCE IN SELECTED BLOCK GROUPS
 COMPARED TO NEW JERSEY

<u>SITE</u>	<u>OBSERVED NUMBER</u>	<u>EXPECTED NUMBER</u>	<u>PIR</u>	<u>POISSON P</u>
Male Lung	29	25.7	1.1	0.3
Female Colon	17	11.7	1.5	0.09
Male Lymphoma	7	4.2	1.7	0.1
Male Leukemia	3	2.3	1.3	0.4
Female Leukemia	1	1.6	0.6	0.5
Female Rectum & Anus	9	4.5	2.0	0.04
Male Stomach	6	3.8	1.6	0.2
Female Stomach	4	2.0	2.0	0.1
Male Pancreas	4	2.9	1.4	0.3
Male Brain & CNS	2	1.7	1.2	0.5
Female Brain & CNS	3	1.4	2.2	0.2
Male Kidney & Urinary	4	3.2	1.3	0.4
Male Prostate	18	18.7	0.9	0.5
Female Colon, Rectum & Anus Combined	26	16.2	1.6	0.02

COMPARED TO THE COMBINED INCIDENCE IN
 MAYWOOD, LODI, ROCHELLE PARK, AND SADDLE BROOK

Male Lung	29	28.0	1.0	0.5
Female Colon	17	14.0	1.2	0.2
Male Lymphoma	7	4.3	1.6	0.1
Male Leukemia	3	1.7	1.8	0.2
Female Leukemia	1	1.8	0.6	0.5
Female Rectum & Anus	9	4.0	2.3	0.02
Male Stomach	6	3.4	1.8	0.1
Female Stomach	4	2.3	1.8	0.2
Male Pancreas	4	3.7	1.1	0.5
Male Brain & CNS	2	2.5	0.8	0.5
Female Brain & CNS	3	1.9	1.5	0.3
Male Kidney & Urinary	4	3.3	1.2	0.4
Male Prostate	18	16.7	1.1	0.4
Female Colon, Rectum & Anus Combined	26	18.0	1.4	0.05

TABLE 4-B

PROPORTIONAL INCIDENCE RATIO
FOR COLON, RECTAL AND ANAL CANCERS
AMONG FEMALES IN THE SELECTED BLOCK GROUPS

	OBSERVED/EXPECTED RATIO (POISSON p)		
	COLON	RECTUM & ANUS	COLON, RECTUM & ANUS COMBINED
	-----	-----	-----
BLOCK GROUPS vs N.J.	1.5 (0.09)	2.0 (0.04)	1.6 (0.02)
BLOCK GROUPS vs 4 TOWNS	1.2 (0.2)	2.3 (0.02)	1.4 (0.5)

STANDARDIZED INCIDENCE RATIO
FOR COLON, RECTAL, AND ANAL CANCERS COMBINED
AMONG FEMALES IN THE SELECTED BLOCK GROUPS

	OBSERVED	EXPECTED	OBSERVED/ EXPECTED RATIO	95% CONFIDENCE INTERVAL
	-----	-----	-----	-----
BLOCK GROUPS vs N.J.	27	21.1	1.3	(0.8 - 1.9)

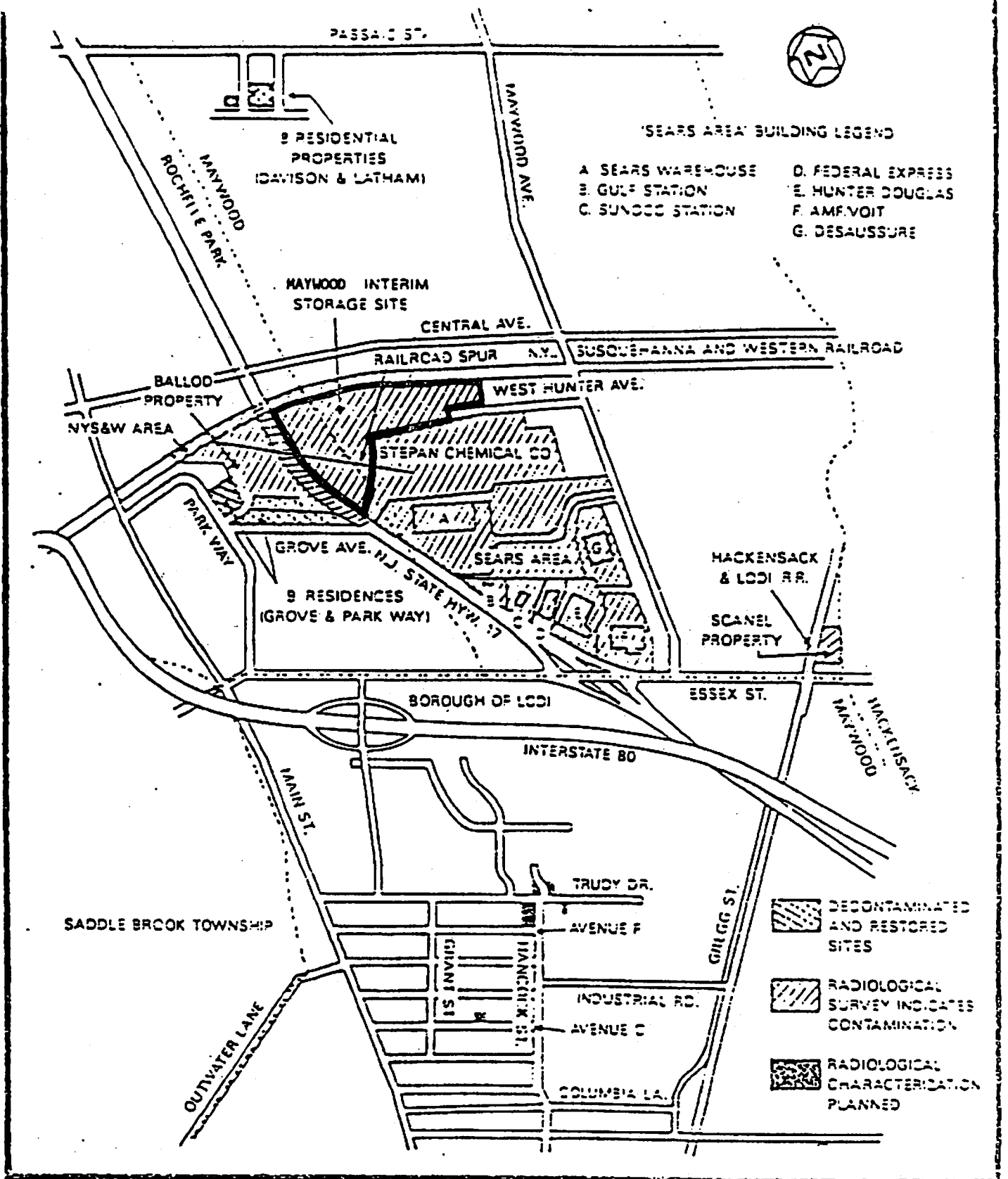
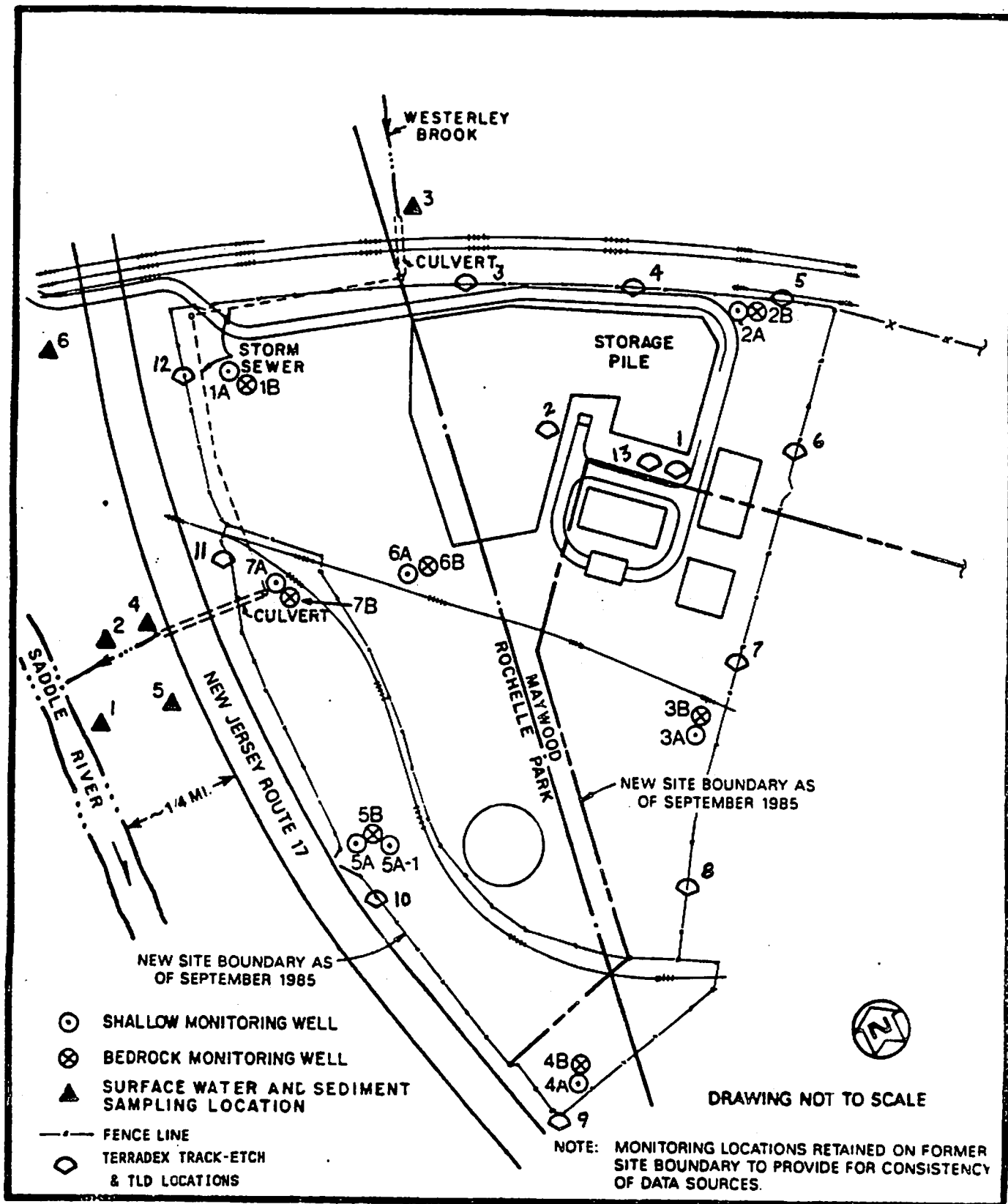


FIGURE 1 MAYWOOD INTERIM STORAGE SITE AND VICINITY PROPERTIES

1" = 1075'



Radon and External Gamma Radiation
FIGURE 2 SURFACE WATER, GROUNDWATER, AND SEDIMENT SAMPLING LOCATIONS AT THE MISS

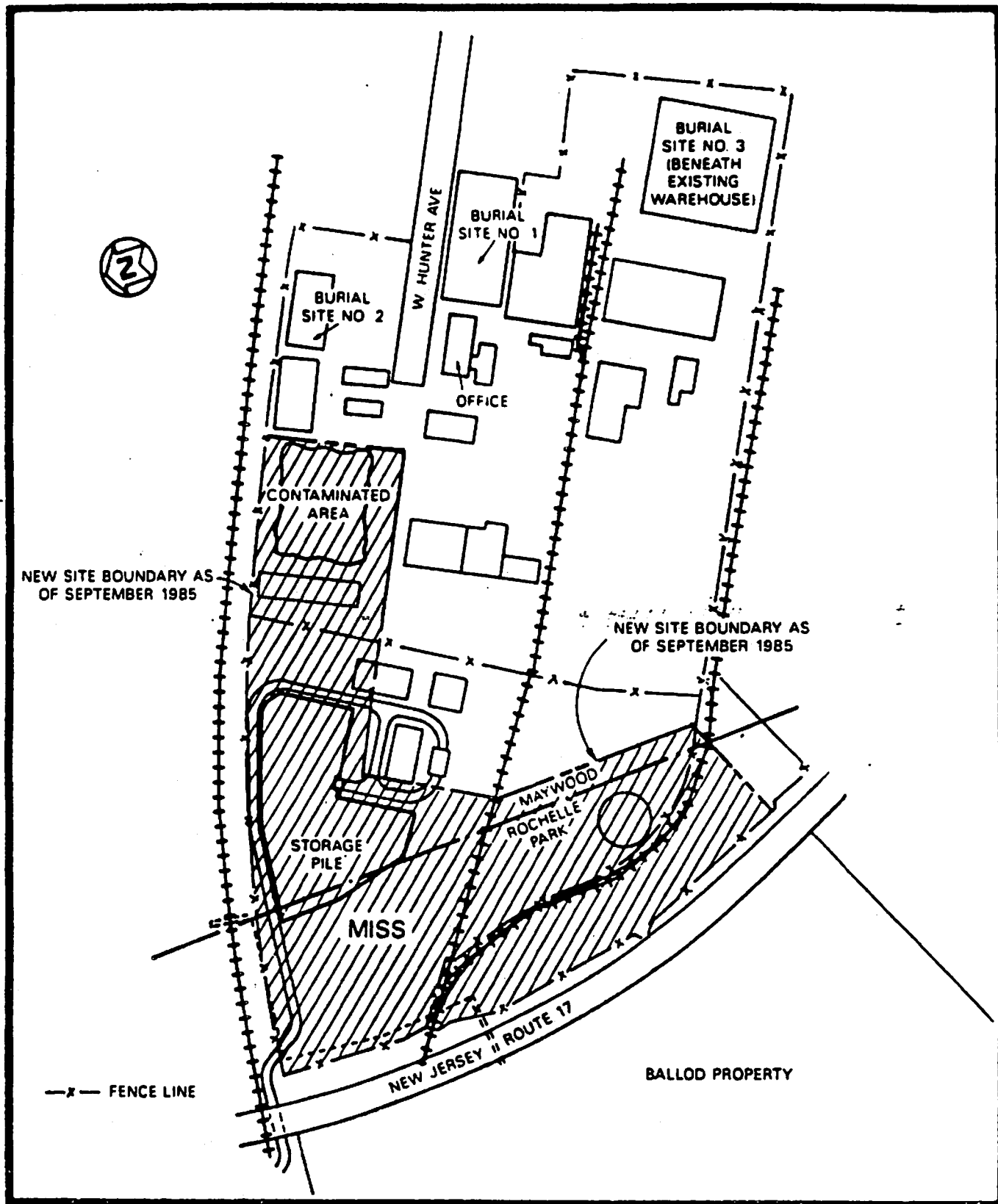
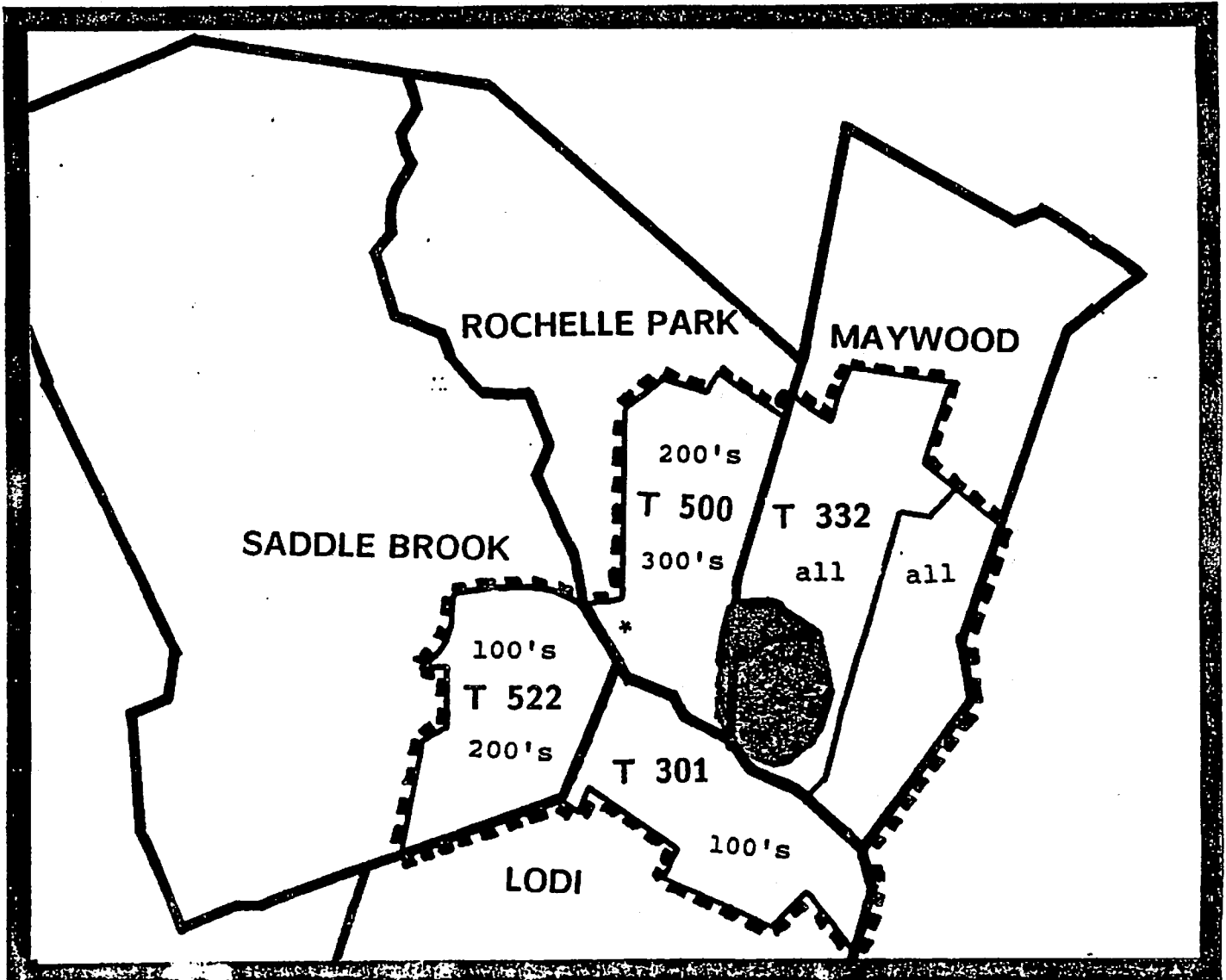


FIGURE 3 BURIAL SITE LOCATIONS ON THE STEPAN COMPANY PROPERTY

FIGURE 4

MAYWOOD INTERIM THORIUM STORAGE SITE
SURROUNDING MUNICIPALITIES
AND SELECTED U.S. CENSUS BLOCK GROUPS



LEGEND

T 500 - CENSUS TRACT

100's - BLOCK GROUP - - - - -

*Blocks 403-407
432-434



0 1 2 3 4 5 6
MILES



MAYWOOD INTERIM
STORAGE SITE

APPENDIX A

STANDARDS AND GUIDELINES FOR PROTECTION
AGAINST RADIATION FOR RADIUM CONTAMINATION

MODE OF EXPOSURE	EXPOSURE CONDITION	VALUE	CITATION
Whole Body Dose	To Radiation Workers	5,000 mrem/yr	10 CFR 20.101 NJAC 7:28-6.1 ICRP 26 (104) NCRP 39 (229) Proposed 10 CFR 20
	To Individuals in the General Population	500 mrem/yr	10 CFR 20.105 NJAC 7:28-6.2 ICRP 26 (119) NCRP 39 (245) NCRP 77 (10.2) Proposed 10 CFR 20
	To Large or Critical Population	170 mrem/yr	FRC 1 NCRP 39 (250) NRC TECH
	To General Population	100 mrem/yr	ICRP 26 (121) NCRP 77 (10.2) DOE Memo Proposed 10 CFR 20
External Gamma Radiation	Indoor Gamma Radiation Level (above background)	20 uR/hr	40 CFR 192.12
		10 uR/hr	RAC
Radon/Radon Progeny	Maximum Permissible Concentration in Controlled Areas	30 pCi/L (4 WLM/yr)	10 CFR 20 App. B
		30 pCi/L	NJAC 7:28-6.5
	Maximum Permissible Concentration in Unrestricted Areas	3 pCi/L (0.4 WLM/yr)	10 CFR 20 App. B DOE Memo
		1 pCi/L	NJAC 7:28-6.5
	Annual Average Radon Progeny Concentration (including background)	0.02 WL	40 CFR 192.12 DOE Memo
Annual Average Radon Concentration (excluding background) for Residential Properties	0.01 WL	Grand Junction	
Annual Average Radon Progeny Concentration (excluding background) for Commercial Properties	0.03 WL	Grand Junction	

MODE OF EXPOSURE	EXPOSURE CONDITION	VALUE	CITATION	
Radionuclides in Air	Maximum Permissible Concentration in Controlled Areas (sol + insol)		10 CFR 20 App. B NJAC 7:28-6.5	
	Ra-226	0.08 pCi/L		
	Nat-U	0.13 pCi/L		
	Th-230	0.012 pCi/L		
	Maximum Permissible Concentration in Unrestricted Areas (sol + insol)		10 CFR 20 App. B NJAC 7:28-6.5	
	Ra-226	0.005 pCi/L		
	Nat-U	0.005 pCi/L		
	Th-230	0.00038 pCi/L		
	Radionuclides in Water	Maximum Permissible Concentration in Controlled Areas (sol)		
		Ra-226	400 pCi/L	10 CFR 20, NJAC 7:28
Nat-U		1,000,000 pCi/L (20,000)	10 CFR 20, (NJAC 7:28)	
Th-230		50,000 pCi/L	10 CFR 20, NJAC 7:28	
Maximum Permissible Concentration in Unrestricted Areas (sol)				
Ra-226		30 pCi/L	10 CFR 20 NJAC 7:28, DOE Memo	
Nat-U		30,000 pCi/L (600)	10 CFR 20 (NJAC 7:28, DOE Memo)	
Th-230		2,000 pCi/L	10 CFR 20, NJAC 7:28, DOE Memo	
Maximum Contaminant Level for Drinking Water			40 CFR 141.26 NJAC 7:10-5	
Total Radium		5 pCi/L		
Gross Alpha (excluding radon and uranium)	15 pCi/L			
Gross Beta	50 pCi/L			

MODE OF EXPOSURE	EXPOSURE CONDITION	VALUE	CITATION
Radionuclides in Solids			
* Soil Contamination	Restricted Land Use, Covenants on Deeds, No Excavation, No Structures, No Agriculture Ra-226	100 pCi/g	NRC TECH
	Restricted Land Use, Covenants on Deeds, No Residential Structures Ra-226	20 pCi/g	NRC TECH
	Unrestricted Use, Concentration Average Over 100 Square Meters Ra-226, First 15 cm Layer	5 pCi/g	40 CFR 192.12, NRC TECH
	Ra-226, Subsequent 15 cm Layer	15 pCi/g	40 CFR 192.12, NRC TECH
	U-238	40 pCi/g	DOE/NJ
	U-238	150 pCi/g	DOE Memo
	Co-60	10 pCi/g	RAC
* Alpha Surface Contamination	Ra-226, Total	100 dpm/100 cm ²	NRC Guidelines
	Ra-226, Removable	20 dpm/100 cm ²	ANSI N13.12
	Nat-Th, Total	1,000 dpm/100 cm ²	NRC Guidelines
	Nat-Th, Removable	200 dpm/100 cm ²	ANSI N13.12
	Nat-U, Total	5,000 dpm/100 cm ²	NRC Guidelines
	Nat-U, Removable	1,000 dpm/100 cm ²	ANSI N13.12

Citations

- 10 CFR 20 Standards for Protection Against Radiation, U.S. Nuclear Regulatory Commission, November 1960 as amended, Standards.
- 40 CFR 141 Natural Interim Primary Drinking Water Regulations, U.S. Environmental Protection Agency, July 1976, Standards.
- 40 CFR 192 Health and Environmental Protection, Standards for Uranium and Thorium Mill Tailings, U.S. Environmental Protection Agency, January 1983, Standards.
- ANSI N13.12 Control of Radioactive Surface Contamination of Materials, Equipment and Facilities to be Released for Uncontrolled Use, American National Standards Institute, August 1981 Draft Standards.
- DOE Memo Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities, U.S. Department of Energy memorandum, August 1985, Standards.
- DOE/NJ Decontamination Criteria for the Former Kellex Site (Pierpont Property) Remedial Action, Jersey City, New Jersey, U.S. Department of Energy, June 1980, Standards.
- FRC 1 Background Material for the Development of Radiation Protection Standards, Report No. 1, Federal Radiation Council, 1960, Recommendations.
- Grand Junction Grand Junction Remedial Action Criteria, U.S. Surgeon General, December 1972, 37 FR 25918, Standards.
- ICRP 26 Recommendations of the International Commission on Radiological Protection, Report No. 26, January 1977 Recommendations.
- NCRP 39 Basic Radiation Protection Criteria, National Council on Radiation Protection and Measurements, January 1971 Recommendations.
- NCRP 77 Exposures from the Uranium Series with Emphasis on Radon and its Daughters, National Council on Radiation Protection and Measurements, March 1984, Recommendations.
- NJAC 7:10-5 New Jersey State Primary Drinking Water Regulations, New Jersey Department of Environmental Protection, 1979 Standards.
- NJAC 7:28: New Jersey Radiation Protection Code, New Jersey Department of Environmental Protection, September 1969 as amended Standards.

Citations

- NRC Guidelines Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Materials, U.S. Nuclear Regulatory Commission, July 1982, Guidelines.
- NRC TECH Disposal or Onsite Storage of Residual Thorium or Uranium from Post Operations, U.S. Nuclear Regulatory Commission Branch Technical Position, October 1981, Guidelines.
- Proposed 10 CFR 20 Standards for Protection Against Radiation, U.S. Nuclear Regulatory Commission, 1986, Proposed Rulemaking.
- RAC A Pathway Analysis Approach for Determining Acceptable Levels of Contamination from Cobalt-60 in Soil at the International Neutronics Irradiation Facility. Till, John E. and Robert E. Moore, Radiological Assessment Corp., Report No. 7/85, August 1985.

APPENDIX B

GAMMA RADIATION CONTAMINATION AND HEALTH EFFECTS

The identification of contaminants at the site is complete, and the available data indicate the presence of monazite ore (12% thorium and 1% uranium) wastes which contains mainly radium. These radioactive elements decay and emit alpha and beta particles and gamma photons in different proportions. Gross alpha and beta contamination of monitoring wells surrounding the property has been established through water sampling performed by DOE and DEP. At the perimeter of the site, gamma radiation above background levels has been measured (Table 1-A).

The alpha, beta, and gamma radiation, known collectively as "ionizing radiation", exert their damaging effects on living tissues by interacting directly with molecules and changing their behavior.

The human population is exposed to background levels of natural ionizing radiation from several sources such as cosmic radiation, terrestrial radiation, and radiation internal to the body. The population is also exposed to man-made radiation from medicinal, occupational, and environmental contamination sources. On the average, the annual population whole body dose from exposure to natural radioactivity is 80 millirem [mrem], and 40 mrem from medical sources.

Laboratory animal and epidemiologic studies have shown that ionizing radiation can induce several types of cancer depending on the type of radiation. In humans, exposure to high levels of gamma radiation is associated with increased incidence of the following types of cancer: chronic granulocytic leukemia, breast, brain, thyroid, bone, and lung.

Exposure to gamma radiation has been shown to cause genetic damage leading to heritable mutations and congenital malformations in laboratory organisms. With the exception of the induction of cancer among in utero exposed children and reciprocal translocations in spermatocytes of exposed males, epidemiologic studies have not provided conclusive evidence for a causal relationship between exposure to ionizing radiation and heritable mutations and congenital malformations. However, because of the well documentation of the effects of ionizing radiation exposure on the wide varieties of organisms in the animal and plant kingdom, one can only assume that humans are similarly affected.

The recommended annual dose limit to an individual of a population exposed to ionizing radiation is 500 mrem (excluding medical and natural radiation). The DOE standard for the general public was changed from 500 mrem/yr to 100 mrem/yr above background in order to incorporate the recommendations of the International Council on Radiation Protection and the National Committee on Radiation Protection and Measurements.

APPENDIX C

**TABLES FROM
BECHTEL NATIONAL, INC.
MISS ENVIRONMENTAL MONITORING
SUMMARY 1984**

TABLE I
TOTAL URANIUM, RADIUM-226, AND THORIUM-232 CONCENTRATIONS
IN SURFACE WATER AT THE MISS, 1984

Sampling Location ^a	Number of Samples ^b	Concentrations (pCi/l) ^c				Percent of Standard ^e
		Baseline	Minimum	Maximum	Average ^d	
<u>Total Uranium</u>						
1	4	3	3	3	3	0.5
2	4	3	3	3	3	0.5
3	4	3	3	3	3	0.5
5 ^f	2	3	3	3	3	0.5
6 ^f	1	11	-	-	-	-
<u>Radium-226</u>						
1	4	<0.1	<0.1	1.0	0.4	1.0
2	4	0.1	<0.1	0.5	0.2	0.7
3	4	<0.1	<0.1	1.8	0.7	2.0
5 ^f	2	0.4	0.7	0.7	0.7	2.0
6 ^f	1	<0.1	-	-	-	-
<u>Thorium-232</u>						
1	4	<0.2	<0.1	0.8	0.4	1.0
2	4	<0.1	<0.1	0.8	0.5	2.0
3	4	0.1	0.1	0.8	0.4	1.0
5 ^f	2	<0.1	<0.1	<0.1	0.1	0.0
6 ^f	1	0.6	-	-	-	-

^aSampling locations shown in Figure 2. Location 4 is via a manhole and was not accessible because the cover was welded shut.

^bSampling included baseline and 2nd, 3rd, and 4th quarters.

^cAll results include background.

^dIn computing the average, quarterly values that are less than the limit of sensitivity are considered as being equal to the limit of sensitivity. Average values are reported without the notation "less than."

^ePercent of standard determined using quarterly samples only. Does not include baseline sample. DOE CG for release to uncontrolled areas is 600 pCi/l for uranium, 30 pCi/l for radium-226, and 2000 pCi/l for thorium-232.

^fSamples collected only when water is present during sampling period.

TABLE 2

URANIUM, RADIUM-226, AND THORIUM-232 CONCENTRATIONS IN SEDIMENT AT THE MISS, 1984^a

Sampling Location ^b	Number of Samples	Concentrations (pCi/g)					Total Uranium
		Radium-226	Thorium-232	Uranium-234	Uranium-235	Uranium-238	
1	1	0.9	0.5	0.6	0.04	0.4	1.0
2	1	0.5	0.3	0.2	0.03	0.1	0.3
3	1	0.4	0.2	0.9	0.1	0.6	1.5
6	1	1.3	0.6	0.4	0.03	0.3	0.7

^aThere are no specific limits for radium, thorium, or uranium in sediment. However, decontamination of MISS is being conducted to the DOE FUSRAP proposed guidelines for radionuclides in soil. For comparative purposes, these proposed guidelines are 5 pCi/g in the upper 6 in and 15 pCi/g below 6 in. for radium and thorium, and 75 pCi/g for uranium (Ref. 3). Location 3 is upstream of the MISS and represents background.

^bSampling locations shown in Figure 2.

TABLE 3
RADON CONCENTRATIONS AT THE MISS, 1984^a

Sampling Location ^b	Concentrations (pCi/l) ^c			Percent of Standard ^d
	08/30/84-09/25/84	09/25/84-12/19/84	Average	
<u>Radon-220</u>				
1	14.71	1.42	8.1	81
2	1.10	3.15	2.1	21
3	1.09	3.19	2.1	21
4	1.70	1.08	1.4	14
5	4.28	15.55	9.9	99
6	1.47	0.71	1.1	11
7	1.07	-0.69 ^e	0.2	2
8	0.42	0.82	0.6	6
9	-0.57 ^e	0.0 ^e	-0.3 ^e	0
10	4.27	0.0 ^e	2.1	21
11	-3.20 ^e	0.0 ^e	-1.6 ^e	0
12	2.59	0.20	1.4	14
13	f	1.23	1.2	12
14 ^g	-0.03 ^e	-1.82 ^e	-0.9 ^e	0
<u>Radon-222</u>				
1	0.95	0.78	0.9	30
2	1.28	0.25	0.8	27
3	1.11	0.78	0.9	30
4	0.95	0.57	0.8	27
5	2.11	0.57	1.3	43
6	1.44	0.94	1.2	40
7	0.78	1.0	0.9	30
8	0.62	0.52	0.6	20
9	1.44	0.48	1.0	33
10	0.78	0.89	0.8	27
11	4.70	0.68	2.7	90
12	1.83	1.05	1.4	47
13	f	0.68	0.7	23
14 ^g	0.62	2.01	1.3	44

^aSampling program was initiated in August 1984.

^bSampling locations shown in Figure 3. Location 13 is quality control station for Location 1.

^cAll results include background.

^dDOE CG for radon-220 is 10 pCi/l (annual average above background) for uncontrolled areas. DOE CG for radon-222 is 3 pCi/l (annual average above background) for uncontrolled areas.

^eA negative or zero value indicates the absence of radon-220.

^fQC station for Location 1 not installed until 09/25/84.

^gBackground station located at the Department of Health, Patterson, NJ.

TABLE 4
EXTERNAL GAMMA EXPOSURE RATES AT THE MISS, 1984^a

Sampling Location ^b	Exposure Rates (uR/h) ^c		
	08/30/84-09/26/84	09/26/84-12/19/84	Average
<u>Boundary</u>			
3	46.5	16.7	31.6
4 ^d	34.6	25.3	30.0
5	67.8	34.8	51.3
6	56.7	25.5	41.1
7	39.1	13.1	26.1
8	42.8	13.5	28.2
9	42.5	16.0	29.3
10	113.3	79.3	96.3 ^e
11	f	19.4	19.4
12	f	33.0	33.0
<u>On-Site</u>			
1	f	19.5	19.5
2	f	19.3	19.3
13	f	18.2	18.2
<u>Background</u>			
14 ^g	—	—	—

^aSampling program was initiated in August 1984.

^bSampling locations shown in Figure 3.

^cAll results include background, which is approximately 9 uR/h (Ref. 5).

^dExposed 111 days: badge missing on 09/26/85, found on the ground on 12/19/85.

^eLocation 10 is situated in an area of known contamination.

^fTLD not installed until 09/26/84.

^gBackground station established at the Department of Health, Patterson, NJ on 09/19/84, but TLD not installed.

**TABLES FROM
BECHTEL NATIONAL, INC.
MISS ENVIRONMENTAL MONITORING
SUMMARY 1985**

TABLE 3-1
CONCENTRATIONS OF THORON AND RADON AT THE MISS, 1985

Sampling Location ^a	Number of Measurements	Concentrations ^b (n x 10 ⁹ uCi/ml) ^c			Percent of - Standard ^d (Annual Average)
		Minimum	Maximum	Average	
<u>Thoron (Rn-220)</u>					
1	4	<MDA ^e	1.5	0.5	5
2	3 ^f	0.4	0.9	0.6	6
3	4	<MDA	0.7	0.3	3
4	4	<MDA	0.9	0.5	5
5	4	1.4	5.3	3.2	32
6	4	0.2	2.0	1.0	10
7	4	0.1	0.5	0.3	3
8	4	<MDA	0.1	0.02	0.2
9	4	<MDA	0.7	0.2	2
10	3 ^f	1.4	3.7	2.7	27
11	3 ^f	0.1	0.3	0.2	2
12	4	0.5	2.2	1.2	12
13 ^g	3 ^f	<MDA	8.0	2.9	29
14 ^h	4	<MDA	0.2	0.1	1
<u>Radon (Rn-222)</u>					
1	4	0.1	0.5	0.3	10
2	3 ^f	0.04	0.3	0.2	7
3	4	0.2	0.4	0.3	10
4	4	0.1	0.8	0.4	13
5	4	0.2	1.0	0.5	17
6	4	0.1	0.4	0.2	7
7	4	0.1	0.4	0.2	7
8	4	0.1	0.6	0.3	10
9	4	0.1	0.4	0.2	7
10	3 ^f	0.1	0.9	0.4	13
11	3 ^f	0.2	0.3	0.2	7
12	4	0.04	0.5	0.2	7
13 ^g	3 ^f	0.1	0.5	0.3	10
14 ^h	4	0.1	0.5	0.4	13

^aSampling locations shown in Figure 3-1. Location 13 is quality control station for Location 1.

^bAll results include background.

^cMultiply n (the listed concentration) by 10⁹ to obtain uCi/ml.

^dDOE limit for thoron (radon-220) is 10 pCi/l (annual average above background) for uncontrolled areas. DOE limit for radon-222 is 3 pCi/l (annual average above background) for uncontrolled areas.

^eNo detectable thoron (radon-220) or less than minimum detectable activity (MDA).

^fDetectors missing; no data for affected sampling period.

^gQC station for Location 1.

^hBackground monitoring station at the Department of Health, Paterson, New Jersey.

TABLE 3-2
EXTERNAL GAMMA DOSE RATES AT THE MISS, 1985

Sampling Location ^a	No. of Measurements	Dose Rate (mrem/qtr) ^b			Total mrem/yr	Percent of Standard ^c
		Minimum	Maximum	Average		
<u>Boundary</u>						
3	4	4	9	7	27	27
4	4	24	40	33	130	130
5	4	44	87	68	272	272
6	4	18	31	27	106	106
7	4	0	10	4	15	15
8	4	2	7	4	15	15
9	4	4	17	10	38	38
10 ^d	3 ^{e, f}	143	185	157	627	627
11	4	12	17	14	57	57
12	4	37	51	45	180	180
<u>On-Site</u>						
1	4	10	13	12	48	48
2	3 ^{e, f}	10	14	13	50	50
13	3 ^{e, f}	6	18	11	46	46
<u>Background</u>						
14 ^g	4	25	29	27	108	108

^aSampling locations are shown in Figure 5. Location 13 is a QC TLD for Location 1.

^bMeasured background has been subtracted. Dose rate is based on continuous occupancy throughout the year.

^cThe DOE radiation protection standard is 100 mrem/yr.

^dLocation 10 is in an area of known contamination (Ref. 3).

^eLocation 10 TLD missing 2nd quarter; Location 2 TLD missing 3rd quarter; Location 13 TLD missing 1st quarter.

^fWhere quarterly data were not obtained for a particular sampling location, the quarterly average for that location was used in calculating total mrem/yr.

^gBackground monitoring location at the Department of Health, Paterson, New Jersey.

TABLE 3-3
 CONCENTRATIONS OF DISSOLVED TOTAL URANIUM, RADIUM-226,
 AND THORIUM-232 IN SURFACE WATER AT THE MISS, 1985

Sampling Location ^a	Number of Samples	Concentration ^b ($n \times 10^9$ uCi/ml) ^c			Percent of Standard ^e (Annual Average)
		Minimum	Maximum	Average ^d	
<u>Total Uranium</u>					
1	4	<3.0	<3.0	3.0	0.5
2	4	<3.0	<3.0	3.0	0.5
3	4	<3.0	<3.0	3.0	0.5
5 ^f	0	-	-	-	-
6 ^f	0	-	-	-	-
<u>Radium-226</u>					
1	4	0.1	0.4	0.2	0.2
2	4	0.1	0.6	0.4	0.4
3	4	<0.1	1.0	0.4	0.4
5 ^f	0	-	-	-	-
6 ^f	0	-	-	-	-
<u>Thorium-232</u>					
1	4	<0.1	<0.3	0.2	0.4
2	4	<0.1	<0.2	0.1	0.2
3	4	<0.1	<0.2	0.1	0.2
5 ^f	0	-	-	-	-
6 ^f	0	-	-	-	-

^aSampling locations shown in Figure 3-2. Location 4 is accessible only by way of a manhole; no samples could be collected because the cover was welded shut.

^bAll results include background.

^cMultiply n (the listed concentration) by 10^9 to obtain uCi/ml.

^dIn computing the average, quarterly values that are less than the limit of sensitivity are considered equal to the limit of sensitivity. Average values are reported without the notation "less than (<)."

^ePercent of standard determined using average of quarterly samples only. DOE DCG is 6×10^7 uCi/ml (600 pCi/l) for uranium in water, 1×10^{-7} uCi/ml (100 pCi/l) for radium-226 in water, and 5×10^{-8} uCi/ml (50 pCi/l) for thorium-232 in water. See Appendix B for discussion of revised concentration guides.

^fSamples collected only if standing water is present at the time of sampling.

TABLE 3-4
 CONCENTRATIONS OF DISSOLVED TOTAL URANIUM IN GROUNDWATER AT THE MISS, 1985

Sampling Location ^a	Number of Samples	Concentration ^b (n x 10 ⁹ uCi/ml) ^c			Percent of Standard ^e (Annual Average)
		Minimum	Maximum	Average ^d	
1A	1 ^f	27	27	27	5.0
1B	3	<3	<3	3	0.5
2A	4	<3	4	3	0.5
2B	4	<3	17	12	2.0
3A	4	<3	<3	3	0.5
3B	4	<3	<3	3	0.5
4A	2 ^f	<3	<3	3	0.5
4B	4	<3	<3	3	0.5
5A	1 ^f	63	63	63	11.0
5A-1	0 ^f	-	-	-	-
5B	4	<3	<3	3	0.5
6A	4	<3	17	9	2.0
6B	4	<3	8	5	0.8
7A	0 ^f	-	-	-	-
7B	4	<3	19	12	2.0

^aSampling locations are shown in Figure 3-2.

^bAll results include background.

^cMultiply n (the listed concentration) by 10⁹ to obtain uCi/ml.

^dIn computing the average, quarterly values that are less than the limit of sensitivity are considered equal to the limit of sensitivity. Average values are reported without the notation "less than (<).".

^ePercent of standard determined using the average value. The DOE DCG for uranium in water is 6 x 10⁻⁷ uCi/ml (600 pCi/l).

^fShallow well to monitor overburden. These wells typically do not contain water.

TABLE 3-5
 CONCENTRATIONS OF DISSOLVED THORIUM-232 IN GROUNDWATER AT THE MISS, 1985

Sampling Location ^a	Number of Samples	Concentration ^b ($n \times 10^9$ uCi/ml) ^c			Percent of Standard ^e (Annual Average)
		Minimum	Maximum	Average ^d	
1A	1 ^f	<0.1	<0.1	0.1	0.2
1B	3 ^g	<0.1	<0.1	0.1	0.2
2A	4	0.2	0.3	0.3	0.6
2B	4	<0.1	<0.5	0.2	0.4
3A	4	<0.1	<0.1	0.1	0.2
3B	4	<0.1	0.5	0.2	0.4
4A	2 ^f	<0.1	<0.1	0.1	0.2
4B	4	<0.1	<0.2	0.1	0.2
5A	1 ^f	<0.1	<0.1	0.1	0.2
5A-1	0 ^f	-	-	-	-
5B	4	<0.1	<0.4	0.2	0.4
6A	4	<0.1	<0.4	0.2	0.4
6B	4	<0.2	0.4	0.3	0.6
7A	0 ^f	-	-	-	-
7B	4	<0.1	<0.3	0.2	0.4

^aSampling locations are shown in Figure 3-2.

^bMultiply n (the listed concentration) by 10^9 to obtain uCi/ml.

^cAll results include background.

^dIn computing the average, quarterly values that are less than the limit of sensitivity are considered equal to the limit of sensitivity. Average values are reported without the notation "less than (<)."

^ePercent of standard determined using the computed average value. The DOE DCG for thorium-232 in water is 5×10^{-8} uCi/ml (50 pCi/l).

^fShallow well to monitor overburden. These wells typically do not contain water.

^gAnalysis results not available for first quarter samples.

TABLE 3-6
CONCENTRATIONS OF DISSOLVED RADIUM-226 IN GROUNDWATER AT THE MISS, 1985

Sampling Location ^a	Number of Samples	Concentration ^b (n x 10 ⁹ uCi/ml) ^c			Percent of Standard ^e (Annual Average)
		Minimum	Maximum	Average ^d	
1A	1 ^f	0.1	0.1	0.1	0.1
1B	3 ^g	0.1	0.9	0.6	0.6
2A	4	<0.1	0.9	0.4	0.4
2B	4	<0.1	0.6	0.3	0.3
3A	4	<0.1	1.2	0.4	0.4
3B	4	<0.1	0.5	0.3	0.3
4A	2 ^f	0.1	0.6	0.4	0.4
4B	4	0.1	0.6	0.3	0.3
5A	1 ^f	0.2	0.2	0.2	0.2
5A-1	0 ^f	-	-	-	-
5B	4	0.1	0.7	0.3	0.3
6A	4	<0.1	0.3	0.2	0.2
6B	4	0.2	0.5	0.4	0.4
7A	0 ^f	-	-	-	-
7B	4	0.1	0.5	0.3	0.3

^aSampling locations are shown in Figure 3-2.

^bAll results include background.

^cMultiply n (the listed concentration) by 10⁹ to obtain uCi/ml.

^dIn computing the average, quarterly values that are less than the limit of sensitivity are considered equal to the limit of sensitivity. Average values are reported without the notation "less than (<)."

^ePercent of standard determined using the computed average value. The DOE DCG is 1×10^{-7} uCi/ml (100 pCi/l) for radium-226 in water.

^fShallow well to monitor overburden. These wells typically do not contain water.

^gAnalysis results not available for first quarter samples.

TABLE 3-7
CONCENTRATIONS OF URANIUM IN SEDIMENTS AT THE MISS, 1985^a

Sampling Location ^b	Number of Samples	Concentrations [pCi/g (dry)]		
		Minimum	Maximum	Average
<u>Uranium-234</u>				
1	4	0.20	0.30	0.27
2	4	0.28	0.30	0.30
3	4	0.20	0.70	0.42
<u>Uranium-235</u>				
1	4	<0.02	<0.03	0.02
2	4	0.01	<0.07	0.04
3	4	<0.02	0.02	0.03
<u>Uranium-238</u>				
1	4	0.20	0.30	0.26
2	4	0.22	0.40	0.36
3	4	0.20	0.60	0.38
<u>Total Uranium^c</u>				
1	4	0.42	0.63	0.55
2	4	0.51	0.77	0.70
3	4	0.42	1.32	0.83

^aThere are no specific limits for uranium in sediment.

^bSampling locations shown in Figure 3-2. Location 3 is upstream of the MISS and represents background. No sediment was available at sampling Locations 4, 5, and 6.

^cTotal uranium was determined by summing concentrations of all three isotopes.

TABLE 3-8
 CONCENTRATIONS OF RADIUM-226 AND THORIUM-232 IN SEDIMENTS
 AT THE MISS, 1985^a

Sampling Location ^b	Number of Samples	Concentrations [pCi/g (dry)]		
		Minimum	Maximum	Average
<u>Radium-226</u>				
1	4	0.30	0.50	0.43
2	4	0.30	0.50	0.40
3	4	0.20	0.90	0.45
<u>Thorium-232</u>				
1	4	0.11	<0.40	0.29
2	4	<0.10	0.50	0.21
3	4	0.06	0.50	0.25

^aThere are no specific limits for radium, thorium, or uranium in sediment. However, decontamination of MISS is being conducted in accordance with DOE FUSRAP guidelines for radionuclides in soil. For radium and thorium, these guidelines are 5 pCi/g in the upper 15 cm (6 in.) and 15 pCi/g at depths greater than 15 cm (6 in.) (Ref. 16).

^bSampling locations shown in Figure 3-2. Location 3 is upstream of the MISS and represents background. No sediment was available at sampling Locations 4, 5, and 6.

REFERENCES

1. Maywood Interim Storage Site Environmental Monitoring Summary - Calendar Year 1984, Bechtel National, Inc., June 1985.
2. Maywood Interim Storage Site Annual Site Environmental Report - Calendar Year 1985, Bechtel National, Inc., May 1986.
3. National Research Council Committee on the Biological Effects of Ionizing Radiation, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980", National Academy Press, 1980.