

# Health Consultation

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Radiological Contamination at Two Residences  
in the Glen Ridge Radium Site

GLEN RIDGE RADIUM SITE

GLEN RIDGE, ESSEX COUNTY, NEW JERSEY

CERCLIS NO. NJD980785646

JULY 21, 2000

**U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES**  
**Public Health Service**  
**Agency for Toxic Substances and Disease Registry**  
**Division of Health Assessment and Consultation**  
**Atlanta, Georgia 30333**

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In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared By:

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Under a Cooperative Agreement with the  
Agency for Toxic Substances and Disease Registry

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## Summary

The New Jersey Department of Health and Senior Services (NJDHSS), through the Agency for Toxic Substances and Disease Registry (ATSDR), has been requested by the United States Environmental Protection Agency Region 2 to review and comment on the results of radiological monitoring and surface soil samples that were collected from two properties in Essex County, NJ in 1998 and 1999. The two properties under investigation are located at 79 and 80 Brighton Avenue in Bloomfield, a part of the previously defined Glen Ridge Radium NPL Site (CERCLIS No. NJD980785646). These two properties have not been investigated previously; however, the adjacent properties located at 84 and 88 Brighton Avenue were remediated as part of the original Glen Ridge NPL Site.

A radiological survey was taken in 1998 of the 80 Brighton Avenue property. Elevated gamma radiation was measured at the surface and in boreholes up to six feet deep at numerous locations on the property; a similar survey taken at 79 Brighton Avenue in 1999 showed elevated levels of gamma radiation at several surface and borehole locations. Analyses of soil samples at 80 Brighton Avenue by laboratory and "Quick Count" methods showed many subsurface locations where the activity of the soil exceeded 5 pCi/gram for radium-226 and thorium-232. Only one of the soil samples taken at 79 Brighton Avenue exceeded 5 pCi/gram (for thorium-232).

Using assumptions regarding quantities of fruits and/or vegetables ingested, and the fractional uptake of metals by plants' root systems, dose equivalents have been calculated for the worst case (*i.e.*, the highest measured activities for radium and thorium in the soils) exposure for ingestion of vegetables grown in the back yard garden of each residence. Until remediation of contaminated soils has been accomplished, individuals should limit ingestion of fruits and vegetables grown in the soils of 80 Brighton Avenue to about 15 kilograms per year per person. Ingestion of "home grown" fruits and vegetables from the property of 79 Brighton Avenue is less problematical, but should be limited to about 50 kilograms per year per person. Ingestion of these amounts of "home grown" vegetables/fruit would limit excess radiation exposure to about 15 mrem per year.

It is expected that remediation of the two properties will be accomplished in the summer of 2000, and, consequently, little or no produce is expected to be grown on these properties.

The data that were provided show that soils of the two properties were found to be contaminated with radium and thorium during the time frame 1998 and 1999. Based on these data and the likelihood of these radiological materials having existed on the properties for approximately 70 years, it may be concluded that the two properties constitute a **public health hazard**.

## **Purpose and Health Issues**

USEPA Region 2 has requested that NJDHSS (through ATSDR) evaluate the potential effects of exposure by ingestion of fruits and vegetables that have been grown in soil that may have been contaminated with radioactive materials, specifically, radium and thorium. This review has been prompted by concerns regarding the safety of ingesting produce grown in the back yard gardens of two properties that have not been previously investigated.

## **Background and Environmental History**

### **Site Description**

In 1979, the New Jersey Department of Environmental Protection (NJDEP) initiated a program to identify and investigate locations within the State where radium processing facilities formerly existed (NJDEP, 1980). Because of concern about the possibility of past disposal of radium byproducts and waste material at locations distant from the processing facilities, NJDEP requested that the U. S. Environmental Protection Agency (USEPA) conduct an aerial survey to detect any elevated gamma radiation levels that might exist. In 1981, USEPA conducted a helicopter survey of 12 square miles of Essex County. The survey identified approximately 53 areas of elevated gamma radiation. One of the sites that was identified was the U. S. Radium property, located in Orange (Essex), New Jersey. Further investigation by NJDEP and USEPA identified three distinct areas within the nearby residential communities of Montclair, West Orange, and Glen Ridge (Essex County), where the disposal of waste material from U. S. Radium appeared to have occurred. Based on initial field investigations by the New Jersey Department of Environmental Protection (NJDEP) in Montclair and Glen Ridge, the Centers for Disease Control (CDC) determined that the major health threat was from elevated radon concentrations that were discovered in 22 homes at the two sites, that the risks were sufficient to pose an imminent and substantial danger to public health, and that the hazard warranted the initiation of a removal action. (CDC, 1983) CDC also outlined additional studies needed by the USEPA and the NJDEP to further determine the concentrations of radiological materials in indoor air, ground water and soils, to investigate possible uptake by garden vegetables, and to evaluate all potential health risks related to the radiological materials.

Preliminary investigations conducted by NJDEP, USEPA, and their contractors in 1984 found that radium-contaminated materials had been deposited in several neighborhoods of both study areas (NUS, 1984), and that a number of homes had radon concentration in excess of the background concentration for the area. (NJDEP, 1984) The radiological materials were believed to have been discarded from U. S. Radium in Orange, NJ, a manufacturing facility that processed carnotite ores to extract radium to be used in medical devices and in luminous paint for watch dials and scientific instruments.

## **U. S. Radium**

The former U. S. Radium plant property was identified during an initial survey (NJDEP, 1980) of former uranium processing sites by the New Jersey Department of Environmental Protection (NJDEP). In 1981 an aerial survey (USEPA, 1981) was conducted which identified the U. S. Radium site and several other former radium processing sites in New Jersey. The plant site was placed on the National Priorities List (NPL), *i.e.* Superfund, in September, 1983.

The U. S. Radium Corporation site (CERCLIS No. NJD980654172) is located in the City of Orange (Essex County), New Jersey (74° 14' 44" West Longitude and 40° 46' 53" North Latitude), approximately 12 miles west of New York City (see Figure 1). It consists of: (1) the former plant site at High and Alden Streets (about 2 acres in area); (2) the so-called Vicinity Properties located close to the plant site, which encompasses about 300 residential and light industrial properties contained within about 25 acres (9 city blocks); and (3) the so-called Satellite Properties, which are approximately 50 non-contiguous residential and commercial properties located in Orange and a few properties in the adjacent communities East Orange and South Orange.

From about 1915 through 1926 the U. S. Radium Corporation, until 1921 named the Radium Luminous Materials Corporation, extracted radium from carnotite ore at the facility located at High and Alden Streets in Orange. Several other smaller facilities in the so-called Satellite Properties area were also used. Approximately 0.5 - 2 tons of carnotite ore were processed each day for the 11 years the plant operated. The carnotite ore  $[K_2(UO_2)_2(VO_4)_2 \cdot 3H_2O]$ , delivered by train from Paradox Valley, Colorado, contained about 2-4%  $UO_2$ . A ton of carnotite ore yielded about 5-7 milligrams of radium. The carnotite was digested with nitric and sulfuric acids to yield radium barium sulfate (also known as whitecake) and was further processed to yield radium bromide. However, large amounts of radioactive "tailings" were discarded as waste material on the property of the facility as well as at other properties in the area. The purified radium was primarily used for medical purposes. In addition, luminous paint which contained radium (used to paint dials on instruments and watches) was also manufactured on the property. The majority of the painting activities was apparently done at the main facility, but dial painting was also done by over 100 workers (mostly women) at several of the Satellite Properties as piece work. Due to the discovery of higher yield ore (pitchblende) from the Belgian Congo (next Zaire, now Republic of Congo), the radium extraction and processing activities ceased in 1926. Even though law suits alleging health risks associated with the dial painting were filed in the mid-1920's (several people subsequently died from radium poisoning), the dial painting operations at the High and Alden Street facility continued until approximately 1940, when the company moved to New York City.

## **Montclair, West Orange, and Glen Ridge (MWG) Radium Sites**

The Montclair, West Orange (CERCLIS No. 980785653), and Glen Ridge Radium Sites (MWG) (CERCLIS No. NJD980785646) (see Figure 1) consist of three noncontiguous areas that were



separated into discrete study areas for the purpose of investigation. The sites are believed to contain discarded materials from the nearby U. S. Radium manufacturing site. The sites were added to the National Priorities List (NPL) , *i.e.*, Superfund, in 1984. The Montclair study area consists of approximately 100 acres located in the Townships of Montclair and West Orange. The properties are mainly one-and two-family homes. There are no parks, and the only commercial properties are two gasoline stations.

The West Orange study area consists of about 20 acres in the Township of West Orange. Properties in this study area include single family residences, a bus company, and a garden condominium complex. There are no parks or other commercial properties.

The Glen Ridge study area (see Figure 2) consists of approximately 90 acres in the Townships of Glen Ridge and East Orange. The residences in this area are exclusively single family homes; there is an actively used recreational park (Barrow's Field) in the area.

### **Summary of Previous Health Assessment Activities**

Several health assessment activities have been conducted at the MWG Radium Sites. In 1983 the Center for Environmental Health, part of the Centers for Disease Control, published a Health Advisory (CDC, 1983) that presented risk assessments for deaths from radiogenic cancers due to exposure to radium by: (1) indoor inhalation of radon; (2) exposure to external gamma radiation; (3) ingestion of radiologically contaminated soils; and (4) ingestion of plants that were grown in contaminated soils. The primary risk was determined to be lung cancer that was caused by exposure to indoor radon.

In 1985 ATSDR published a preliminary health assessment (ATSDR, 1985) in which it reviewed USEPA's RI/FS Draft Work Plan for remedial actions (CDM, 1985), and recommended that contaminated soils be removed in order to ensure the public health.

In 1986 CDC issued a revised health assessment (CDC, 1986) that considered the health risks from short- and long-term exposure to these radionuclides and gamma radiation, and considered other potential exposure pathways.

In 1988 ATSDR published a health consultation that reviewed the State Remedial Plan and the Draft Feasibility study. (ATSDR, 1988) The Draft Supplemental Feasibility Study was published in 1989. (CDM, 1989)

In 1992 a Site Review and Update was published by ATSDR (and amended in 1993) (ATSDR, 1992) that agreed with the conclusion of CDC's preliminary health assessment, and recommended that a public health assessment be conducted for the combined Montclair, West Orange, and Glen Ridge sites.

The Public Health Assessment that was published by ATSDR in 1995 (ATSDR, 1995) declared that the MWG sites were considered to have been a public health hazard in the past, that residents in the three areas may have been chronically exposed to radon and/or radium/thorium, and that the remedial actions conducted by USEPA had been appropriate and had been effective at eliminating the human exposure pathways that had been identified. The ingestion of vegetation grown in contaminated soils was not considered in the pathways analysis.

An ATSDR Record of Action (AROA) that briefly discusses the issue of ingestion of fruits and vegetables was issued in 2000. (ATSDR, 2000) This AROA contains a preliminary discussion of the two properties that are addressed in this Health Consultation.

### **Site Visits**

The properties in question, located at 79 and 80 Brighton Avenue in Bloomfield (Essex County), were not visited for the purpose of this Health Consultation.

### **Community Concerns**

Concern has been expressed by occupants and neighbors of the two residences regarding ingestion of crops, including tomatoes and strawberries, that have been grown in back yard gardens on the two properties.

### **Statement of Issues**

This Health Consultation will evaluate radiological contamination of two properties that are located in the Glen Ridge Radium Site. The two properties constitute part of the list of properties that remain to be remediated in the Glen Ridge study area. The issue of primary concern is the nature and degree of hazard to public health that might be incurred by ingestion of vegetables and/or fruits that are grown in the back yard gardens of the properties located at 79 and 80 Brighton Avenue, Bloomfield.

Soil naturally contains several radioactive elements. Surface soil in New Jersey has an average activity of approximately 1 pCi[0.037 Bq]/gram (NJDEP, 1999) for radium, uranium, and thorium. Plants that are grown in soils that contain radioactive materials absorb radioactive metals through the root system. Eating produce grown in soils with these concentrations of radioactive elements does not present a significant risk to public health. However, soil that is suspected of containing elevated concentrations of radioactive materials (*e.g.*, elevated surface gamma radiation measurements) should be sampled and the activities of radioactive elements determined. The dose equivalent that results from ingestion of plants that are grown in contaminated soils can be estimated from the known activity of radioactive materials in the soil, and the amount of produce that is ingested.

## Discussion

### Natural (Background) Radiation

The average person in the United States is annually exposed to approximately 360 millirem of background radiation (NCRP, 1987). (Background radiation was previously called natural radiation, but it has been redefined to include common manmade sources of radiation such as diagnostic X-rays, nuclear medicines, and consumer products). Approximately 82% of background radiation comes from naturally occurring sources, including radon, cosmic rays, and terrestrial and internal (within the body) sources. More than half of the average human exposure to background radiation is due to the radioactive decay of radon by alpha particle emission.

As shown in Table 1, background radiation includes approximately equal components of terrestrial radiation (*i.e.*, gamma rays from natural radionuclides in the soil) and cosmic rays. The 1981 aerial survey of the Orange/Montclair/West Orange/Glen Ridge vicinity (USEPA, 1981) determined that cosmic radiation contributes about half of the total background of radiation (about 8 uR/hr) in the area. Thus, the average individual in the vicinity will receive an exposure of about 70 mrem/yr from cosmic rays and terrestrial gamma rays.

The background concentrations of U-238 and Ra-226 in the soil in the vicinity of the MWG and U.S. Radium sites are 1.8 pCi/gram and 1 pCi/gram, respectively. These may be compared with the concentrations of radionuclides determined to be present in contaminated areas. Similarly, the concentrations of radionuclides present in soil samples may also be compared to those regulated by the Nuclear Regulatory Commission as "source materials" (CFR, a), defined as those which contain more than 0.05% by weight (500 ppm) of Ra-226 or U-238 (equivalent to specific activities of 480 pCi/gram for Ra-226 or 165 pCi/gram for U-238).

About half of the exposure to internal radiation (radiation from a source within the body) is due to radioactive potassium (K-40), a naturally occurring (approximately 0.01% natural abundance) radionuclide ( $T_{1/2} = 1.26 \times 10^9$  years) which primarily emits beta radiation, but is also a source of gamma radiation.

The manmade component of background radiation (approximately 18% of the total) includes exposures such as those from diagnostic X-rays, dental X-rays, mammograms, and smoke detectors. For comparison, the average chest X-ray (WSJ, 1995) today exposes the patient to approximately 15 millirem (down from about 75 millirem in the 1930's). Similarly, the dose equivalent of dental X-rays is now about 250 millirem (down from about 2 rem in the 1930's). A screening mammogram now requires about 250 millirem, or about a tenth of the dose equivalent for one done 20 years ago.

## **Remedial History**

The Record of Decision (ROD) for Montclair/West Orange (USEPA, 1989a) and Glen Ridge (USEPA, 1989b) provided for the removal of contaminated materials (uranium, radium, and thorium) from the most highly contaminated areas and instituted engineering controls for residential properties that were contaminated with radon. An additional ROD was issued for the Glen Ridge Site in 1990 (USEPA, 1990) that provided for removal of contaminated materials at residential and public properties and streets that were not included in the 1989 ROD.

Remedial actions over the past 10 years have been conducted in phases at the three study areas. Activities at the Glen Ridge study area are in the midst of Phase VIA, which includes removal of contaminated materials at the last of the residential properties. The two residences under consideration in this case have been added to the properties that are currently under remediation. Remedial activities at Barrow's Field have been completed and the recreational facilities are in the process of being restored for use. Remediation of streets in the study area is currently under way.

Criteria for remediation of uranium/radium soil tailings are given in 40 CFR 192 Subpart B (CFR, b) as 5 pCi/gram soil for surface (less than 2 feet below the surface) soils and 15 pCi/gram for subsurface (more than 2 feet below the surface) soils. Remediation criteria for external gamma radiation are given in 40 CFR 1020 (CFR, c) as no greater than 20 uR/hour above background.

## **Environmental Contamination at 79 and 80 Brighton Avenue**

In July 1997 CDM Federal, under contract to USEPA, performed a comprehensive radiological investigation at the two properties, including survey of exterior gamma radiation levels at the surface, as well as at various depths in boreholes. Interior floor and wall gamma radiation was also surveyed in the basements of the two residences, but these results were not provided. Concentrations of radium-226 (Ra-226), uranium-238 (U-238), thorium-232 (Th-232), and potassium-40 (K-40) in the subsurface soil were determined from samples taken at various depths in boreholes on the two properties. Determinations of concentrations of radium and thorium in the boreholes were also accomplished by the "Quick Count" method. The results of these surveys and sampling were reported to USEPA by CDM Federal on October 8, 1999. (CDM, 1999)

### **Exterior Gamma Radiation Measurements**

In July 1997 CDM Federal measured the exterior gamma radiation at 28 locations at 80 Brighton Avenue to be between about 5,000 and 27,000 counts per minute (cpm) at the surface. The highest surface measurement of about 100,000 cpm was found in the front yard during the walkover survey of the property. Eight of the 28 surface measurements taken outside the residence exceeded 10,000 cpm. Subsurface gamma radiation measurements were as high as about 97,000 cpm in boreholes that were augured to a depth of about 6 feet throughout the property. Four boreholes were also

augured inside the basement of the residence, with gamma radiation measured between about 9,000 and 19,000 cpm on the basement floor, and as high as about 42,000 cpm in the boreholes.

Gamma measurements taken at 79 Brighton in July 1997 ranged from about 5,000 to about 8,000 cpm at the surface, and as high as about 23,000 cpm in subsurface measurements taken in 19 boreholes drilled outside the residence. Two boreholes were augured inside the basement of the residence, with gamma measurements of 6,000 and 7,000 cpm on the basement floor, and measurements of about 12,000 cpm in the boreholes.

### **Radionuclides in Soil**

Soil samples were taken at 80 Brighton Avenue in March and November 1998; additional samples were taken at 79 Brighton Avenue in March and May 1999. As indicated in the data that were provided, the soil samples from borings on the two properties were analyzed for U-238, Ra-226, Ra-228, and Th-232. These isotopes are members of the naturally occurring U-238 and Th-232 decay series. The concentration (*i.e.*, activity) of K-40, a naturally occurring isotope of potassium that is a beta emitter, was also determined. Thirty eight (38) soil samples were taken from boreholes at 80 Brighton Avenue, and four (4) samples were analyzed at 79 Brighton Avenue. Additional "Quick Count" results were reported for radium-226 and thorium-232 activities.

### **80 Brighton Avenue**

The highest results for 80 Brighton Avenue from the laboratory analyses was for the sample taken just beneath the asphalt (0 - 0.5 ft) of the driveway, which showed 2,199 pCi[81 Bq]/gram of Th-232 and 10 pCi[0.37 Bq]/gram of Ra-226. This single sample was unusual for the 38 samples; nevertheless, several additional measurements from other boreholes at this property exceeded 5 pCi[0.2 Bq]/gram for Ra-226 or Th-232. Results from boreholes taken in the area of the back yard where a garden might be planted show radium and thorium to be present at levels as high as 12.4 pCi[0.46 Bq]/gram for Ra-226 and 22.5 pCi[0.83 Bq]/gram for Th-232 (results from "Quick Count" for sample taken at 1.0-1.5 ft depth in borehole BG2468). "Quick Counts" that were taken in the 4 boreholes that were drilled inside the basement showed Th-232 activity as high as 9.35 pCi[0.34 Bq]/gram (at a depth of 1.0-1.5 feet in borehole BG2602).

### **79 Brighton Avenue**

Results for 79 Brighton Avenue showed the highest activity (5.02 pCi[0.18 Bq]/gram Ra-226) to be in a sample taken from a depth of 2.0 - 2.5 feet in a borehole (BG 2733) in the back yard next to the garage. All other measurements of activity (samples and "Quick Counts") were less than 5 pCi[0.18 Bq]/gram. No samples or "Quick Counts" were taken from the two boreholes in the basement.

## **Pathways Analysis**

An exposure pathway (ATSDR, 1992b) is the process by which an individual is exposed to contaminants that originate from a source of contamination. A completed exposure pathway consists of five elements:

- (1) Source of contamination;
- (2) Environmental media and transport mechanisms;
- (3) Point of exposure;
- (4) Route of exposure; and
- (5) Receptor (exposed) population.

A completed exposure pathway must include each of the elements that link a contaminant source to a receptor population.

There are several potential pathways that may cause internal exposure to radioactive materials. Possible modes of exposure include: ingestion of surface soil, ingestion of soluble radioactive elements contained in drinking water, and inhalation of resuspended soil particles. Other routes of exposure include indoor inhalation of radon, and whole body external gamma radiation. Ingestion of vegetables that are grown in radioactive soils, resulting in the uptake of radioactive elements into fruits and vegetables, is the primary concern in the back yard garden scenario that is being evaluated here. Other pathways have not been evaluated in this review.

## **Public Health Implications**

### **Radium**

Radium-226 (Ra-226) is a naturally occurring element that is found in New Jersey; it is a daughter of the uranium-238 (U-238) decay chain that also includes radon-222 that ends with lead-206. Radium is sometimes found at low concentrations in water and soils. The uranium and radium that have been found above background levels in the MWG radium sites are likely to have been deposited there after disposal of slag from carnotite [ $K_2(UO_2)_2(VO_4)_2 \cdot 3H_2O$ ] ores and other process by-products from the U.S. Radium plant in Orange, NJ between about 1915 and 1926. The half-life of radium-226, the most common isotope, is 1600 years. Radium, which is chemically similar to calcium, is digested (it is estimated that about 20% is absorbed in the gut) and then replaces calcium in the bones; excess radium in the bones can cause bone and bone marrow cancers. (ATSDR, 1990b)

## **Thorium**

Thorium-232 (Th-232) is the mother species of the thorium decay chain that includes an isotope of radium (radium-226) and ends in the stable element lead-208 after six alpha and 4 beta decays. The half life of Th-232, the most common isotope, is 14 billion years. It is less abundant than uranium, but has been used in New Jersey in the manufacturing of gas lantern mantles. The primary source of thorium is from monazite [(Ce, La, Th)PO<sub>4</sub>] ore. It is believed that the thorium found at the MWG sites came from monazite tailings that originated at the Welsbach and General Gas Mantle Sites (WGGMS) located in Camden, NJ. About 0.02% of thorium that is ingested is absorbed by the gastrointestinal system, so very little stays in the body. (ATSDR, 1990c) Thorium is essentially inert chemically, but it does deposit in the bones in the body.

## **Criteria for Gamma Radiation Exposure**

Ionizing radiation is a known (USEPA Weight of Evidence Group A) carcinogen. The effects of exposure to radiation can be both stochastic (random occurrence; without threshold) and non-stochastic (non-random occurrence; with threshold). Cancer is a stochastic effect caused by exposure to radiation, meaning that the probability of cancer depends on the amount of exposure. It has been assumed that there is a linear relationship, without threshold, which relates exposed dose with the probability of stochastic health effects. However, at low dose, the linear relationship between dose and effect, as well as the lack of threshold, are difficult to verify, since there are correspondingly few effects. Other effects of exposure to radiation, such as cataracts, are non-stochastic, *i.e.* the severity of the effect depends upon the amount of exposure. The goal for limiting exposure to radiation is to minimize stochastic effects, while preventing non-stochastic effects. (ATSDR, 1999a)

The maximum permissible dose from occupational exposure to gamma radiation has declined substantially over the years - from 0.1 rem/day in 1934, to 0.3 rem/week in 1950, to 0.1 rem/week in 1956, to "as low as is reasonably achievable (ALARA)" in 1977. As of May 21, 1991 the Nuclear Regulatory Commission established the total effective annual dose equivalent to be 5 rem/year for occupational exposure of adults. Similarly, in 1993 the US Department of Energy established a limit on total effective dose equivalent of 5 rem/year for occupational exposure of employees at DOE facilities (20 CFR 835.202).

For members of the general public, the recommended limit on exposure to ionizing radiation is lower. On June 22, 1990 the International Commission on Radiological Protection (ICRP) (ICRP, 1991) recommended that chronic exposure to members of the general public be limited to 100 millirem per year above background. As of May 21, 1991 this exposure limit was adopted by the Nuclear Regulatory Commission (as stated in 10 CFR 20.1301). Similarly, in 1993 the National Council on Radiation Protection and Measurement (NCRP)(NCRP, 1993) recommended the same exposure limit. On March 23, 1993 the US Department of Energy proposed (FR, 1993) the

establishment of similar standards, *i.e.*, the ALARA policy and a limit on effective dose equivalent of 100 millirem per year, for protection of the public and the environment against radiation.

Other regulations which may be applicable to radiologically contaminated sites include 40 CFR 192 (USEPA Protection Standards for Uranium and Thorium Mill Tailings), and 10 CFR 1020 (USDOE Grand Junction Remedial Action Criteria for Uranium Mill Tailings). These regulations established standards for required remedial actions based on an external gamma radiation of 20 uR/hr above background (equivalent to 170 mrem/yr), and of 50 or 100 uR/hr above background, respectively.

### **Criteria for Exposure to Alpha Radiation**

Nuclides which are gaseous and emit alpha particles can pose a significant health risk (*viz.*  $Q=1$  for gamma, but  $Q=20$  for alpha) if they were to be inhaled. Radon, specifically, is of concern since it has been estimated to cause the majority of background radiation exposure in the United States (see Figure 1). The radon-222 progeny from the U-238 series are species which are solid at ambient temperature. (ATSDR, 1990a) These radionuclides would stay in the lungs where they would further decay to emit more alpha particles and other forms of radiation.

The action level for exposure to alpha radiation, which has been established by USEPA and adopted by NJDEP, is 4 pCi/liter for radon and 0.02 WL for radon progeny (USEPA, 1990). Since the average indoor radon concentration in New Jersey has been determined to be  $1.35 \pm 3$  pCi/liter (1 standard deviation) (NJDEP, 1996), radon concentrations which exceed the action level are not uncommon.

Since Rn-222 is created by the decay of Ra-226, it is useful to relate the concentration of Rn-222 to the amount of Ra-226 in the soil. There are little data on Ra-226 concentration in the soil of New Jersey. Since the average Ra-226 concentration in the soil throughout the world is about 1 pCi/gram, and the average indoor Rn-222 concentration is about 1 pCi/liter, the NJDEP Bureau of Environmental Radiation has assumed that 1 pCi/gram Ra-226 in the soil will result in 1 pCi/liter of Rn-222 in the air in a structure. (NJDEP, 1996) Based on this assumption, the indoor radon concentration would probably exceed the action level of 4 pCi/liter if there were more than 4 pCi/gram of Ra-226 in the soil under a structure.

For non-gaseous sources of alpha radiation such as radon progeny, the criterion for alpha activity on surfaces has been proposed as 20 disintegrations per minute (dpm) per 100 cm<sup>2</sup> for removable particles, with 300 dpm/100 cm<sup>2</sup> being the maximum allowable alpha activity.(FR, 1993)

### **Risk of Cancer Associated with Exposure to Ionizing Radiation**

Limits on exposure to chemical contaminants are usually established in order to limit the risk of adverse health effects to an additional one per million exposed individuals over a lifetime, *i.e.* the 10<sup>-6</sup> rule. However, this rule of thumb is not applied to radiological contaminants, since the risk due



to exposure to background radiation exceeds this guideline. For example, according to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 1988) the risk of a cancer fatality associated with exposure to low levels of radiation is 0.7 to 3.5 per 10,000 health effects per rad of exposure. Similarly, BEIR-V (NAS, 1990) predicts a lifetime risk of a radiation-induced cancer fatality for the general population of 5 per 10,000 per rem. Therefore, exposure to a dose equivalent of 100 millirem above background each year over a lifetime would result in a risk of about 50 additional radiation-induced cancer fatalities per million exposed individuals.

The Health Effects Assessment Summary Tables (HEAST) (USEPA, 1994) present the risks associated with external exposure, ingestion, and inhalation for individual radionuclides. [For example, for Th-232 the risk per pCi ingested is  $3.28\text{E-}11$ , the risk by inhalation is  $1.93\text{E-}8$  per pCi, and the risk associated with external exposure to radiation is  $1.97\text{E-}11$  per year per pCi per gram of soil. Similarly, for U-238+D the risk per pCi is  $6.2\text{E-}11$  for ingestion,  $1.24\text{E-}8$  for inhalation, and  $5.25\text{E-}8$  per year per pCi per gram of soil for external exposure.] However, since the contamination which exists contains several nuclides from both the Th-232 and U-238 decay series, the risk of excess cancer caused by exposure to radiation is due to exposure to all radionuclides in both series. Therefore, the risk of fatal cancer which would be caused by exposure to 100 millirem above background per year over a lifetime is taken to be 50 per million individuals exposed.

### **Estimated Exposure Dose from Ingestion of Fruits and Vegetables from Back Yard Garden**

In order to determine the dose of radiation an individual would receive from eating vegetation that has been contaminated with radionuclides, the following must be determined: (1) the concentration of the radionuclide in the soil in which the vegetation is grown; (2) how much of the radionuclide is taken up by the vegetation [known as the Transport Factor (TF)]; and (3) how much of the vegetation an individual eats. The data which have been provided in this case show the concentrations of radionuclides that were found at different depths as much as six feet below the surface. Any transport of radiological species from contaminated soils to backyard garden crops would take place via the root structure of plants and fruits (*i.e.*, from soil within the top 1-2 feet of the surface). In contrast to most exposure pathways, exposure via this pathway is not dependent upon the time spent at the location, but rather is based on the amount of vegetation that is grown at the location and consumed by an individual. Estimates of vegetative intake vary widely. Although the total amount of consumption of a particular group of foods is known fairly well, there is great variability in the estimates of the percentage of foods that are grown on contaminated soil. It seems unlikely that 100% of a person's diet would be "home grown", so the percentage of consumed home grown food must be estimated.

The effective dose equivalent (mrem/year) from ingesting fruit or vegetables is the product of the activity of the radioactive element in the soil  $C$  (pCi/g), the dose conversion factor  $DCF$  (mrem/pCi), the amount of contaminated produce that is ingested per year  $I$  (kg/yr), and the fraction of transfer from soil to plant  $B_{iv}$  (pCi/g plant wet/pCi/g soil dry), *i.e.*,

$$\text{Annual dose equivalent (mrem/yr)} = C \text{ [pCi/g soil]} \times \text{DCF [mrem/pCi]} \times I \text{ [kg/yr]} \times B_{iv} \text{ [pCi/g plant wet/pCi/g soil dry]} \times 1000 \text{ g/kg,}$$

The highest of the 4 measurements (and 12 "Quick Count" determinations) of soil activity at 79 Brighton Avenue was 5 pCi[0.18 Bq]/gram Ra-226 and 4.37 pCi[0.16 Bq]/gram Th-232 at a depth of 2.0-2.5 feet.

The highest measurement in soil in the root growth zone (up to about 2 feet deep) on the 80 Brighton Avenue property was 12.4 pCi[0.46 Bq]/gram for Ra-226 and 22.5 pCi[0.83 Bq]/gram for Th-232 at a depth of 1.0-1.5 feet.

The Table below estimates exposures that might result from ingestion of fruits and vegetables that are grown in soil that contains the maximum activities of radium and thorium that were found in the samples taken at 80 and 79 Brighton Avenue, respectively. The exposures shown in the Table are calculated based on estimated dose conversion and composite uptake (soil to vegetable/fruit transfer) factors, and estimates of the total amount of fruits and vegetables grown in such soil that a person might consume over the course of a year.

**Estimated Maximum Annual Dose Equivalent from Ingesting Fruits/Vegetables from Gardens at 79/80 Brighton Avenue, Bloomfield, NJ**

Location	Nuclides	Dose Equivalent (mrem/yr) [mSv/yr]	Maximum Concentration (pCi/gram) [Bq/gram]	Dose Conversion Factor (mrem/pCi) [mSv/Bq]	Ingestion (kg/yr)	Transfer Factor (pCi/plant wet/pCi/soil dry)
80 Brighton	Ra-226	11-113	12.4 [0.46]	$1.3 \times 10^{-3}$	18-176	0.04
	Th-232	[0.11-11.3] 1-10 [0.01-0.1]	22.5 [0.83]	$2.7 \times 10^{-3}$	18-176	0.001
79 Brighton	Ra-226	4-40	4.37 [0.16]	$1.3 \times 10^{-3}$	18-176	0.04
	Th-232	[0.04-0.4] 0.2-2 [0.002-0.02]	5.02 [0.18]	$2.7 \times 10^{-3}$	18-176	0.001

<sup>a</sup> Eckerman et al, USEPA *Federal Guidance Report 11* (1988)

<sup>b</sup> USEPA, *Risk Assessment Guidance for Superfund* (1991)

<sup>c</sup> Wang et al, *A Compilation of Radionuclide Transfer Factors* (1993)

## **Conclusions**

The data which have been provided for the gamma radiation survey measurements and soil samples are assumed to represent the range of contamination of soils at the two properties in the Glen Ridge Radium Site. The measurements show that radiological contamination of the soil on the two properties exists at levels as high as 2199 pCi thorium/gram of soil and 10 pCi radium /gram of soil from carnotite ore tailings and other process by-products from the U. S. Radium factory site. Radiological contamination of these properties, as well as the other properties of the MWG sites, is likely to have existed for more than 70 years. Based on these data and the long period of time the contaminants have been present, it may be concluded that the two properties, 79 and 80 Brighton Avenue, Bloomfield, pose a **public health hazard**.

Most individuals would likely not eat only produce from a back yard garden, but rather would likely consume both "store bought" and "home grown" produce. Ingestion of about 10% of total fruits and vegetables that are grown in the back yard gardens at 80 and about 30% at 79 Brighton Avenue could potentially result in an exposure of a few mrem/yr in excess of normal background exposure. Such exposure would not pose a significant risk to public health. However, ingestion of a greater percentage of "home grown" fruits and vegetables would result in proportionally greater absorbed dose.

## **Recommendations**

### **Recommendations to Cease/Reduce Exposure**

The following actions are recommended to minimize exposure to radioactive materials in the soils of the properties at 79 and 80 Brighton Avenue:

- (1) Ingestion of fruits and vegetables grown in the back yard gardens should be limited to about 15 kilograms per year per person at 80 Brighton Avenue and to about 50 kilograms per year per person at 79 Brighton Avenue until the soils have been removed or covered.
- (2) Efforts should be made to minimize resuspended dust during remedial activities.

### **Recommendation for Site Characterization**

- (1) Soils should be sampled and analyzed for radium and thorium as part of the remediation process at the two properties.

## **Public Health Action Plan**

The Public Health Action Plan (PHAP) contains a description of the actions to be taken by ATSDR and/or NJDHSS at or in the vicinity of these two properties subsequent to the completion of this Public Health Consultation. The purpose of the PHAP is to ensure that this Consultation not only identifies public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of ATSDR and NJDHSS to monitor this plan to ensure that the plan is implemented. ATSDR will provide an annual follow-up to this PHAP, outlining the actions which have been completed, and those actions in progress. This report will be placed in repositories that contain copies of this Consultation, and it will be provided to persons who request it. The public health actions to be implemented by ATSDR/NJDHSS are as follows:

### **Actions Undertaken:**

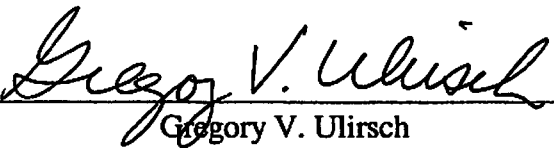
- (1) The environmental sampling data and remedial activities which have been conducted have been evaluated within the context of human exposure pathways and other relevant public health factors.
- (2) ATSDR/NJDHSS will continue to coordinate with USEPA regarding anticipated interim and final remedial actions.

### **Actions Planned:**

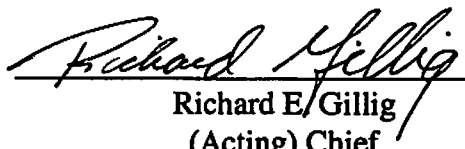
ATSDR and NJDHSS will coordinate as deemed necessary with the appropriate environmental (USEPA and NJDEP) and public health agencies (Bloomfield Department of Health) to develop plans to implement the recommendations contained in this Consultation.

**Certification**

The Health Consultation for the Glen Ridge Radium site was prepared by the New Jersey Department of Health and Senior Services (NJDHSS) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). This document is in accordance with approved methodology and procedures existing at the time this document was initiated.

  
\_\_\_\_\_  
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The Division of Health Assessment and Consultation, ATSDR, has reviewed this Health Consultation and concurs with its findings.

  
\_\_\_\_\_  
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## **Appendices**

### **Description of Comparison Values**

### **ATSDR's Interim Public Health Hazard Categories**

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**Description of Comparison Values**

## **Description of Comparison Values**

ATSDR's comparison values are media-specific concentrations that are considered to be 'safe' under default conditions of exposure. They are used as screening values in the preliminary identification of size-specific chemical substances that the health assessor has selected for further evaluation of potential health effects.

Generally, a chemical is selected for evaluation because its maximum concentration in air, water, or soil at the site exceed one of ATSDR's comparison values. However, it cannot be emphasized strongly enough that comparison values are not thresholds of toxicity. While concentrations at or below the relevant comparison value may reasonable be considered safe, it does not automatically follow that any environmental concentration that exceeds a comparison value would be expected to produce adverse health effects. Indeed, the whole purpose behind conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health problems before they become actual health hazards. The probability that adverse health outcomes will actual occur as a result of exposure to environmental contaminants depends on site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure, and not solely on environmental concentrations.

Screening values based on non-cancer effects are generally based on the level at which no health adverse health effects (or the lowest level associated with health effects) found in animal or (less often) human studies, and include a cumulative margin of safety (variously called safety factors, uncertainty factors, and modifying factors) that typically range from 10-fold to 1,000-fold or more. By contrast, cancer-based screening values are usually derived by linear extrapolation with statistical models from animal data obtained at high exposure doses, because human cancer incidence data for very low levels of exposure are rarely available. Cancer risk estimates are intended to represent the upper limit of risk, based on the available data.

Listed and described below are the types of comparison values that the ATSDR and the NJDHSS used in this Public Health Assessment:

**Cancer Risk Evaluation Guides (CREGs)** are estimated concentrations of contaminants in an environmental medium (such as drinking water) that are expected to cause no more than one excess cancer case for every million persons who are continuously exposed to the concentration for an entire lifetime (equaling a risk of  $1 \times 10^{-6}$ ). These concentrations are calculated from the USEPA's cancer slope factors, which indicate the relative potency of carcinogenic chemicals. Only chemicals that are know or suspected of being carcinogenic have CREG comparison values.

**Environmental Media Evaluation Guides (EMEGs) and Reference Dose Media Evaluation Guides (RMEGs)** are estimates of chemical concentrations in an environmental medium (such as drinking water) that are not likely to cause an appreciable risk of deleterious, non-cancer health effects, for fixed durations of exposure. These guides may be developed for special sub-populations such as children. EMEGs are based on ATSDR's minimal risk level (MRL) while RMEGs are based on the USEPA's reference dose (RfD).

Other health-based guides may also be used as comparison values, including drinking water maximum contaminant levels (MCLs) established by the USEPA or the NJDEP.

**ATSDR's Interim Public Health Hazard Categories**

**ATSDR's Interim Public Health Hazard Categories**

<b>Category/Definition</b>	<b>Data Sufficiency</b>	<b>Criteria</b>
<p><b>A. Urgent Public Health Hazard</b></p> <p>This category is used for site where short-term exposures (&lt; 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.</p>	<p>The determination represents a professional judgment based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.</p>	<p>Evaluation of available relevant information* indicated that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards.</p>
<p><b>B. Public Health Hazard</b></p> <p>this category is used for sites that pose a public health hazard due to the existence of long-term exposures (&gt; 1 yr) to hazardous substances of conditions that could result in adverse health effects.</p>	<p>This determination represents a professional judgment based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.</p>	<p>Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical or safety hazards.</p>

<p><b>C. Indeterminate Public Health Hazard</b></p> <p>This category is used for sites in which “critical” data are <i>insufficient</i> with regard to extent of exposure and/or toxicologic properties at estimated exposure levels.</p>	<p>This determination represents a professional judgment that critical data are missing and ATSDR has judged the data are insufficient to support a decision. This does not necessarily imply all data are incomplete, but that some additional data are required to support a decision.</p>	<p>The health assessor must determine, using professional judgment, the “criticality” of such data and likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support their decision with clear narrative that explains the limits of the data and the rationale for the decision.</p>
<p><b>D. No Apparent Public Health Hazard</b></p> <p>This category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.</p>	<p>This determination represents a professional judgment based on critical data which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.</p>	<p>Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.</p>
<p><b>E. No Public Health Hazard</b></p> <p>This category is used for sites that, because of the absence of exposure, do <b>NOT</b> pose a public health hazard</p>	<p>Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are now occurring, and none are likely to occur in the future.</p>	

\* Such as environmental and demographic data; health outcome data; exposure data; community health concerns information; toxicologic, medical and epidemiologic data; monitoring and management plans.

## **ATSDR Plain Language Glossary of Environmental Health Terms**

<b>Absorption:</b>	How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.
<b>Acute Exposure:</b>	Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.
<b>Additive Effect:</b>	A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.
<b>Adverse Health Effect:</b>	A change in body function or the structures of cells that can lead to disease or health problems.
<b>Antagonistic Effect:</b>	A response to a mixture of chemicals or combination of substances that is less than might be expected if the known effects of individual chemicals, seen at specific doses, were added together.
<b>ATSDR:</b>	The Agency for Toxic Substances and Disease Registry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.
<b>Background Level:</b>	An average or expected amount of a chemical in a specific environment. Or, amounts of chemicals that occur naturally in a specific environment.
<b>Biota:</b>	Used in public health, things that humans would eat – including animals, fish and plants.
<b>CAP:</b>	See Community Assistance Panel.
<b>Cancer:</b>	A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control
<b>Carcinogen:</b>	Any substance shown to cause tumors or cancer in experimental studies.
<b>CERCLA:</b>	See Comprehensive Environmental Response, Compensation, and Liability Act.



**Chronic Exposure:** A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be chronic.

**Completed Exposure Pathway:** See Exposure Pathway.

**Community Assistance Panel (CAP):** A group of people from the community and health and environmental agencies who work together on issues and problems at hazardous waste sites.

**Comparison Value: (CVs)** Concentrations or the amount of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.

**Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA):** CERCLA was put into place in 1980. It is also known as Superfund. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

**Concern:** A belief or worry that chemicals in the environment might cause harm to people.

**Concentration:** How much or the amount of a substance present in a certain amount of soil, water, air, or food.

**Contaminant:** See Environmental Contaminant.

**Delayed Health Effect:** A disease or injury that happens as a result of exposures that may have occurred far in the past.

**Dermal Contact:** A chemical getting onto your skin. (see Route of Exposure).

<b>Dose:</b>	The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as “amount of substance(s) per body weight per day”.
<b>Dose / Response:</b>	The relationship between the amount of exposure (dose) and the change in body function or health that result.
<b>Duration:</b>	The amount of time (days, months, years) that a person is exposed to a chemical.
<b>Environmental Contaminant:</b>	A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than that found in Background Level, or what would be expected.
<b>Environmental Media:</b>	Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. Environmental Media is the second part of an Exposure Pathway.
<b>U.S. Environmental Protection Agency (EPA):</b>	The federal agency that develops and enforces environmental laws to protect the environment and the public’s health.
<b>Epidemiology:</b>	The study of the different factors that determine how often, in how many people, and in which people will disease occur.
<b>Exposure:</b>	Coming into contact with a chemical substance.(For the three ways people can come in contact with substances, see Route of Exposure.)
<b>Exposure Assessment:</b>	The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.
<b>Exposure Pathway:</b>	A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:

1. Source of Contamination,
2. Environmental Media and Transport Mechanism,
3. Point of Exposure,
4. Route of Exposure, and
5. Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a Completed Exposure Pathway. Each of these 5 terms is defined in this Glossary.

<b>Frequency:</b>	How often a person is exposed to a chemical over time; for example, every day, once a week, twice a month.
<b>Hazardous Waste:</b>	Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.
<b>Health Effect:</b>	ATSDR deals only with Adverse Health Effects (see definition in this Glossary).
<b>Indeterminate Public Health Hazard:</b>	The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.
<b>Ingestion:</b>	Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See Route of Exposure).
<b>Inhalation:</b>	Breathing. It is a way a chemical can enter your body (See Route of Exposure).
<b>LOAEL:</b>	Lowest Observed Adverse Effect Level. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.
<b>Malignancy:</b>	See Cancer.
<b>MRL:</b>	Minimal Risk Level. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

- NPL:** The National Priorities List. (Which is part of Superfund.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.
- NOAEL:** No Observed Adverse Effect Level. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.
- No Apparent Public Health Hazard:** The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.
- No Public Health Hazard:** The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.
- PHA:** Public Health Assessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.
- Plume:** A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney or contaminated underground water sources or contaminated surface water (such as lakes, ponds and streams).
- Point of Exposure:** The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). For examples: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.
- Population:** A group of people living in a certain area; or the number of people in a certain area.

**PRP:** Potentially Responsible Party. A company, government or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of a site.

**Public Health Assessment(s):** See PHA.

**Public Health Hazard:** The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

**Public Health Hazard Criteria:** PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each are defined in the Glossary. The categories are:

- Urgent Public Health Hazard
- Public Health Hazard
- Indeterminate Public Health Hazard
- No Apparent Public Health Hazard
- No Public Health Hazard

**Receptor Population:** People who live or work in the path of one or more chemicals, and who could come into contact with them (See Exposure Pathway).

**Reference Dose (RfD):** An estimate, with safety factors (see safety factor) built in, of the daily, life-time exposure of human populations to a possible hazard that is not likely to cause harm to the person.

**Route of Exposure:** The way a chemical can get into a person's body. There are three exposure routes:

- breathing (also called inhalation),
- eating or drinking (also called ingestion), and
- or getting something on the skin (also called dermal contact).

**Safety Factor:** Also called Uncertainty Factor. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known.

These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

- SARA:** The Superfund Amendments and Reauthorization Act in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from chemical exposures at hazardous waste sites.
- Sample Size:** The number of people that are needed for a health study.
- Sample:** A small number of people chosen from a larger population (See Population).
- Source (of Contamination):** The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an Exposure Pathway.
- Special Populations:** People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.
- Statistics:** A branch of the math process of collecting, looking at, and summarizing data or information.
- Superfund Site:** See NPL.
- Survey:** A way to collect information or data from a group of people (population). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.
- Synergistic effect:** A health effect from an exposure to more than one chemical, where one of the chemicals worsens the effect of another chemical. The combined effect of the chemicals acting together are greater than the effects of the chemicals acting by themselves.
- Toxic:** Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

<b>Toxicology:</b>	<b>The study of the harmful effects of chemicals on humans or animals.</b>
<b>Tumor:</b>	<b>Abnormal growth of tissue or cells that have formed a lump or mass.</b>
<b>Uncertainty Factor:</b>	<b>See Safety Factor.</b>
<b>Urgent Public Health Hazard:</b>	<b>This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.</b>

### **Other Abbreviations**

<b>cpm</b>	<b>Counts per minute</b>
<b>ICRP</b>	<b>International Commission on Radiation Protection</b>
<b>NCRP</b>	<b>National Council on Radiation Protection and Measurements</b>
<b>NJDEP</b>	<b>New Jersey Department of Environmental Protection</b>
<b>NJDHSS</b>	<b>New Jersey Department of Health and Senior Services</b>
<b>mrem</b>	<b>millirem</b>
<b>pCi/g</b>	<b>picoCuries per gram</b>
<b>PHAP</b>	<b>Public Health Action Plan</b>
<b>ppm</b>	<b>parts per million</b>
<b>Ra-226</b>	<b>Radium-226</b>
<b>Rn-222</b>	<b>Radon-222</b>
<b>RI/FS</b>	<b>Remedial Investigation/Feasibility Study</b>
<b>ROD</b>	<b>Record of Decision</b>
<b>Th-232</b>	<b>Thorium-232</b>
<b>U-238</b>	<b>Uranium-238</b>

## **Background Information about Radioactivity**

Ionizing radiation is emitted by radioactive isotopes of elements that may be in gaseous, liquid, or solid form in the environment. Depending on the specific element and physical form of the elements, individuals may be exposed to the effects of alpha, beta, or gamma radiation in several ways, either externally or internally. Exposure to ionizing radiation is cumulative, that is, the effects of exposure to sources of ionizing radiation depend upon the total effective dose, rather than the exposure time or rate of exposure. External exposure to gamma radiation is usually the most significant route of exposure, since radioactive elements are in the air, water, and soil around us all the time. Alpha radiation has little penetrating power, so this type of radiation is not expected to be a significant source of external radiation. However, both alpha and gamma radiation can cause significant exposure when radioactive species are ingested or inhaled. Beta radiation has less penetrating power than gamma radiation, but it can cause both internal and external exposures.

On the average, an individual who resides in the United States is exposed to approximately 360 millirem (mrem) [3.6 milliSieverts(mSv)](NCRP, 1987) per year. Approximately 82% of this exposure results from natural background radiation, and the remaining 18% results from manmade sources. Fifty-five per cent (55%) of natural radiation results from exposure to indoor radon, and eleven percent (11%) is due to natural internal sources. Other included significant exposures from naturally occurring sources come from soil (8%) and cosmic rays (8%). (see Table 1)

The average person's exposure from manmade sources includes medical diagnostic (X-rays 11%) and nuclear medicine (radiopharmaceuticals 4%) exposures and exposures to consumer products (e.g., smoke detector, 3%). Allowable exposure by the general public to radiation from all additional (manmade) sources is limited by regulatory (USEPA, NRC, and DOE) and advisory organizations (ICRP, NCRP) to 100 mrem[1 mSv] per year in excess of background exposure.

## **The Language and Units of Ionizing Radiation**

The definitions of radiation (USPHS, 1970) and some associated terms are given in Table 2. As used in this document, "radiation" means ionizing radiation, i.e. particles and photons which are capable of ionizing matter. Ionizing radiation includes particulates [alpha particles, beta particles, neutrons, and protons] and photons [gamma rays, X-rays, and cosmic rays]. It does not include so-called non-ionizing radiation, such as microwaves, radiowaves, or infrared, visible, and ultraviolet light.

Ionizing radiation is generally quantified by its activity (measured in becquerel or Curie) and/or its specific activity, as defined in Table 2. A radioactive element (radionuclide), e.g., radium-226 (Ra-226), radon-222 (Rn-222), thorium-232 (Th-232), uranium-238 (U-238), is also characterized by its half life ( $T_{1/2}$ ). Other definitions in Table 2 include: absorbed dose (in units of Roentgen, rad, or Gray); dose equivalent (units of rem or Sievert); and dose rate (measured in counts per minute (cpm) or  $\mu\text{R/hr}$ ).



Some of the common mathematical conversion factors relating activity, dose, and dose equivalent are given in Table 3. Other useful mathematical relationships and conversions include:

(1) Specific Activity(Curies/gram) =  $N \times 1.873 \times 10^{-11}/T_{1/2}$ , where N is the number of radioactive atoms per gram of material (Note: 1 picoCurie (pCi) =  $10^{-12}$  Curie, and 1 microCurie =  $10^{-6}$  Curie); and

(2) Dose Equivalent (rem, Sievert) = dose (rad, Gray) x Q, where Q is the quality factor [Q = 1 for gamma, X-ray, and beta; Q = 10 for neutrons and protons; Q = 20 for alpha]. Note: 1 millirem (mrem) = 0.001 rem, and 1 urem =  $10^{-6}$  rem

The relationships between dose and dose equivalent for gamma radiation are given by:

$$\begin{aligned} 1 \text{ uR/hr (air)} &= 0.869 \text{ urad/hr (air)} \\ &= 0.96 \text{ urad/hr (tissue)} = 0.96 \text{ urem/hr (tissue)} \end{aligned}$$

Therefore, the absorbed dose rate for gamma radiation in uR/hr for air is taken to be equal to (within 4%) the dose equivalent rate in urem/hour for tissue.

Non-volatile radionuclides, such as radon progeny, which decay by emission of alpha particles are characterized by Working Levels (WL). Gaseous species, such as Rn-222, are quantified in terms of pCi/liter of air.

**Tables**

Table 1. Background Radiation in United States (mrem/yr) (NCRP, 1987)

Source	Percentage	Dose Equivalent (mrem/yr)
Radon	55	198
Cosmic rays	8	29
Terrestrial	8	29
Internal	11	40
Medical	11	40
Nuclear medicine	4	14
Consumer products	3	11
Other	<1	4
<b>Total</b>	<b>100</b>	<b>365</b>

Table 2. The Language of Ionizing Radiation (USPHS, 1970)

Term	Definition
Radioactivity	a property of some nuclides of spontaneously emitting particles or gamma radiation, <b>emitting</b> X-radiation after orbital electron capture, or undergoing spontaneous fission
Activity	the mean number of decays per unit time of a radioactive nuclide
Specific activity	the activity per gram of compound, element, or nuclide
Half life	the time required for a radioactive substance to lose 50% of its activity by decay
Dose, whole body dose, absorbed dose	the mean energy imparted by ionizing radiation to an irradiated medium per unit mass
Effective dose, effective dose equivalent	the product of the absorbed dose in tissue, quality factor, and any other modifying factors at the location of interest
Working Level	any combination of radon daughters in 1 liter of air which will result in emission of $1.3 \times 10^5$ MeV of potential alpha energy

Table 3. The Units of Ionizing Radiation (USPHS, 1970; Schleien, 1991)

Unit	Measures	Conversion factor
Becquerel (Bq)	activity	1 dis/sec; $2.7 \times 10^{-11}$ Ci
Curie (Ci) picoCurie(pCi)	activity	$3.7 \times 10^{10}$ dis/sec 0.037 dis/sec
Roentgen (R)	absorbed dose	0.00869 J/kg (air) 0.0096 J/kg (tissue)
Gray (Gy)	absorbed dose	1 J/kg; 100 rad
Rad	absorbed dose	100 erg/g; 0.01 Gy
Sievert (Sv)	dose equivalent	100 rem
Rem	dose equivalent	0.01 Sievert

**Figures**



Figure 1 Montclair, West Orange, Glen Ridge (MWG) and U. S. Radium Sites

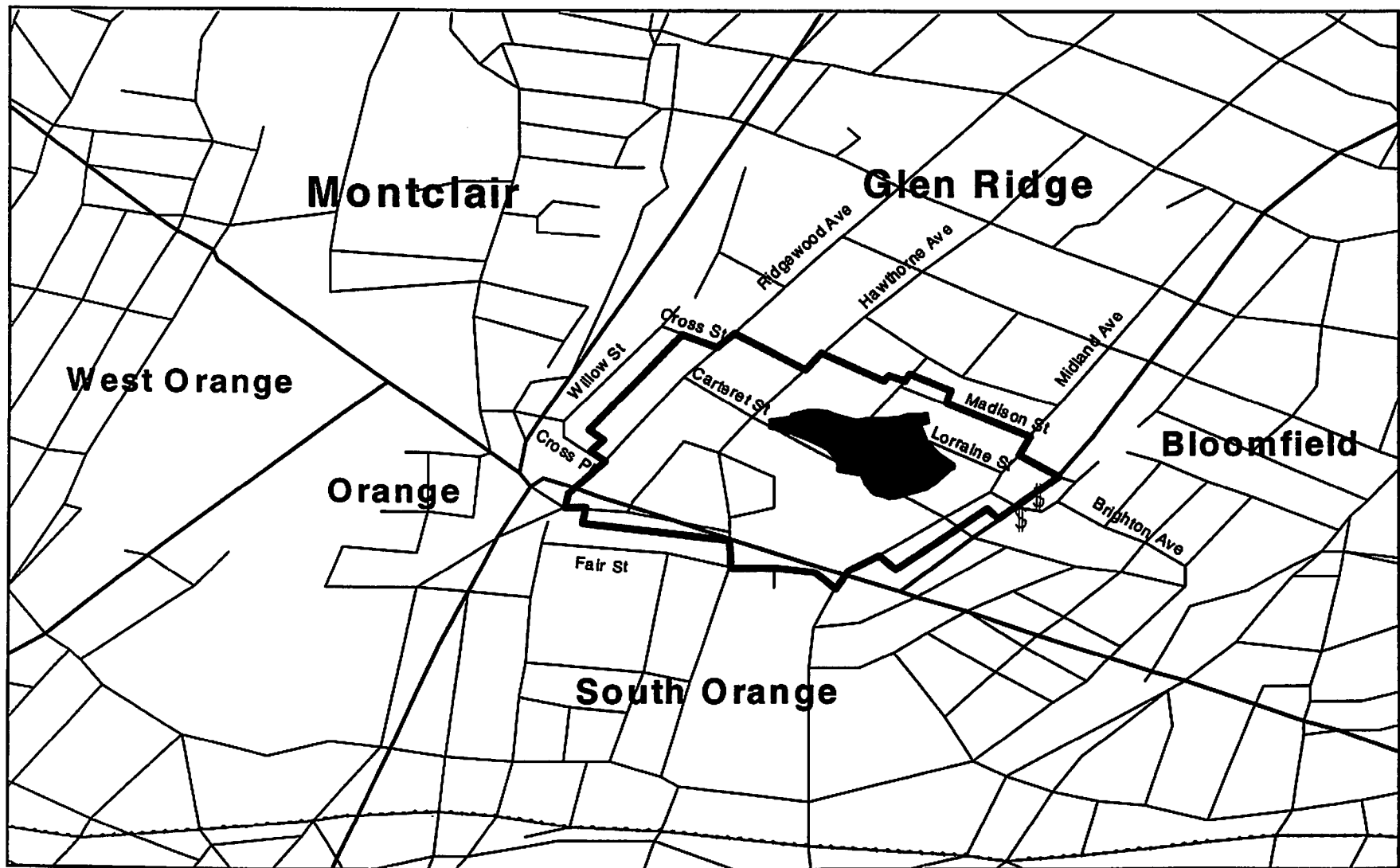


Figure 2 Glen Ridge Study Area