VARIABILITY OF SOIL-GAS RADON IN THE LARAMIE BASIN, WYOMING, WITH AN EVALUATION OF ENVIRONMENTAL EFFECTS ON SOIL-GAS RADON LEVELS

by

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INTRODUCTION

Soil-gas radon data may be used to characterize the radon occurrence potential of areas underlain by various types of soil or bedrock. Previous researchers have attempted to generally characterize an area based upon a single soil-gas radon traverse, or a series of traverses in different locations (Reimer, 1990; Schumann and Owen, 1988).

It is not known if soil-gas radon traverses are repeatable. If apparent soil-gas radon relationships that are observed at one point in time can be repeated, it may be possible to extrapolate the data and relationships regionally. The primary purpose of this report was to determine the repeatability of soil-gas relationships observed at twelve sites in the Laramie Basin, Wyoming.

A secondary purpose of this study was to investigate the relationships between soil-gas radon and environmental (meteorologic and soil) factors. Specifically, the relationships between soil-gas radon and air pressure, air temperature, relative humidity, wind speed, precipitation, soil temperature, and soil moisture were investigated for individual sites, from site-to-site, and for all sites together. Previous research indicates that there may be a relationship between soil-gas radon and precipitation, barometric pressure, wind speed, relative humidity, soil temperature, and air temperature (Asher-Bolinder, Owen, and Schumann, 1991).

In addition to the two primary purposes for this research, soil-gas radon data for all sites were to be compared to the geomorphic features, surficial deposits, and bedrock the sites were located on in order to determine if any regional assessments could be made from only twelve sites.

SITE SELECTION AND DESCRIPTION

In Wyoming, soil composition is in large part related to the type of bedrock present in the vicinity of the soil. If bedrock is enriched in uranium or radium, the soils derived from it may also be enriched (Reimer, 1990). The bedrock sources for windblown and alluvial deposits can also have a significant effect on the soils associated with those transported materials. Geomorphic features in an area, such as hillcrests, valleys, terraces, and landslides, can also effect the soil type and composition present in an area.

Twelve sites were selected for soil-gas radon sampling in the Laramie Basin study area. Each site had a distinct geological-pedological-geomorphic character. Where feasible, sites were located on native soils in remote areas. A few sites, however, were located on relatively undisturbed soils in residential areas.

All twelve sites are located in a "steppe" climate zone typical of semi-arid grassland prairies. The study area encompassing the sites has a mean January temperature of 20.4°F and a mean July temperature of 64.4°F (Martner, 1986). The study area has a mean annual precipitation of 10 to 12 inches, an annual mean temperature of 40° to 42°F, and an average of 93 frost free days extending from June 10 - September 10 (Martner, 1986).

A description of the twelve sample sites are below. All soil, soil permeability, and vegetation data are from unpublished U.S.D.A. Soil Conservation Service reports available at the Laramie, Wyoming field office. All geologic descriptions are from Love and Weitz (1953), Love and Christiansen (1985), and Lundy (1978).

Site 1

Location: NE NE NW section 9, T15N, R73W

Elevation: 7192 feet

Geomorphology: Quaternary-age flat-lying gravel-capped bench.

Underlying Geology: Triassic-age Chugwater Formation. The Chugwater Formation consists of red shale, siltstone, and sandstone with zones of gypsum and anhydrite.

Soil: Wycolo-Alcova complex. This complex is on strath terraces overlain with granitic alluvium and colluvium. The complex is developed primarily from weathered Chugwater Formation and gravelly alluvium/colluvium. The Wycolo soil consists of sandy loam with a clay loam substratum. The Alcova soil consists of gravelly sandy loam with a gravelly sandy clay loam substratum.

Soil Permeability: Moderate

Vegetation: Sparse grass

Site 2

Location: SE NW SE section 1, T15N, R73W

Elevation: 7450 feet

Geomorphology: Tributary valley alluvial fan and eolian deposits.

Underlying Geology: Permian/Pennsylvanian Casper Formation. Casper Formation consists of thick sandstone and interbedded limestones and sandstones, with some siltstones and shales.

Soil: Ryark loamy sand. This soil is commonly found on alluvial fans, and is formed from various alluvial sources reworked by the wind. It consists of loamy sand with a sandy loam substratum.

Soil Permeability: Moderately rapid

Vegetation: Sparse grass

Site 3

Location: NW NW NW section 32, T15N, R74W

Elevation: 7200 feet

Geomorphology: Quaternary-age Pahlow surface, age estimate approximately 300,000 years B.P. (Mears, 1991).

Underlying Geology: Cretaceous-age Niobrara Formation. The Niobrara Formation consists of light colored limestone and grey to yellow speckled limy shale.

Soil: Bosler fine sandy loam. This soil is found on alluvial fans and terraces, and formed in alluvium from mixed sources. This soil has a high salt content. It consists of fine sandy loam, with a sandy clay loam subsoil, and a gravelly sand substratum.

Soil Permeability: Moderate

Vegetation: Sparse grass

Site 4

Location: NW SW NW section 7, T15N, R73W

Elevation: 7200 feet

Geomorphology: Quaternary-age Stock Farm terrace, age estimate approximately 20,000 years B.P. (Mears, 1991).

Underlying Geology: Jurassic-age Morrison Formation and Cretaceous-age Cloverly Formation. The Cloverly Formation consists of sandstone with black shale partings. The Morrison Formation consists of siliceous claystone with silty sandstone lenses.

Soil: Alcova-Borollic Camborthids complex. This complex forms on alluvial fans and terraces. The Alcova soil consists of a sandy loam with a sandy clay loam and gravelly sandy clay loam substratum. The Borollic Camborthids soil consists of fine gravel and gravelly sandy loam with a gravelly sandy clay loam substratum.

Soil Permeability: Moderate to moderately rapid
Vegetation: Sparse grass

Site 5

Location: NE SW NE section 35, T16N, R74W
Elevation: 7265 feet
Geomorphology: Quaternary-age Airport bench. This surface is capped by gravels and cobbles originating to the west in the Snowy Range where metaquartzites and other crystalline rocks dominate. Intermingled on the surface may be remnants of Oligocene rhyolites and andesites from along the Laramie River to the south and west. Eolian sands and silts cover much of the bench (Mears, 1991).
Underlying Geology: Cretaceous-age Niobrara Formation. The Niobrara Formation consists of light colored limestone and grey to yellow speckled limy shale.
Soil: Stunner-Borollic Camborthids complex. This complex forms on strath terraces and alluvium from mixed sources. The Stunner soil consists of sandy loam. The Borollic Camborthids soil consists of a gravelly sandy loam with a sandy loam and gravelly sand substratum.
Soil Permeability: Moderate to moderately rapid
Vegetation: Sparse grass

Site 6

Location: SW NW SE section 34, T16N, R73W
Elevation: 7220 feet
Geomorphology: Tributary valley alluvium in urbanized area.
Underlying Geology: Triassic-age Chugwater Formation. The Chugwater Formation consists of red shale, siltstone, and sandstone with zones of gypsum and anhydrite.

Soil: Fiveoh, cobbly substratum-Joemre fine sandy loam. This complex is found on strath terraces and benches. Both portions are formed from alluvium derived from mixed sources. This complex consists primarily of fine sandy loam.

Soil Permeability: Moderate to moderately rapid

Vegetation: Grasses

Site 7

Location: SW SE SW section 31, T16N, R73W

Elevation: 7170 feet

Geomorphology: Quaternary-age Pahlow surface, age estimate approximately 300,000 years B.P. (Mears, 1991).

Underlying Geology: Jurassic-age Morrison Formation and Cretaceous-age Cloverly Formation. The Cloverly Formation consists of sandstone with black shale partings. The Morrison Formation consists of siliceous claystone with silty sandstone lenses.

Soil: Stunner sandy loam. This soil is developed on strath terraces and dissected pediments, and is derived from mixed sources. The Stunner sandy loam is a sandy loam, with a clay loam and loam subsoil, and a sandy loam substratum. This soil is commonly carbonate rich.

Soil Permeability: Moderate

Vegetation: Grass

Site 8

Location: SE SW NW section 27, T16N, R73W

Elevation: 7225 feet

Geomorphology: Slope of eroded bedrock outcrop capped with thin cover of alluvium. Material consists of colluvium and slopewash deposits.

Underlying Geology: Triassic-age Chugwater Formation. The Chugwater Formation consists of red shale, siltstone, and sandstone with zones of gypsum and anhydrite.

Soil: Wycolo-Thermopolis-Rock Outcrop Complex. This soil is found on structural bench escarpments and cuesta backslopes. The soil consists of two main regimes, both formed in materials weathered from redbed shales and siltstones. The first Wycolo soil is a fine sandy loam with sandy clay loam substratum. The Thermopolis soil is shallow and is commonly covered with limestone and sandstone pebbles. It consists of fine sandy loam and silt loam over shale.

Soil Permeability: Moderate

Vegetation: Very sparse grass

Site 9

Location: NE SE NE section 28, T16N, R73W

Elevation: 7175 feet

Geomorphology: Slopewash and alluvial deposits in a deflation hollow. This site is in an urbanized area. According to residents, it is subject to occasional flooding during heavy rains. Flooding was not observed during the course of the study.

Underlying Geology: Triassic-age Chugwater Formation. The Chugwater Formation consists of red shale, siltstone, and sandstone with zones of gypsum and anhydrite.

Soil: Almy loam. This soil occurs on alluvial flats and footslopes, and is formed in alluvium derived from mixed sources. The soil consists of loam with a sandy clay loam and sandy loam substratum.

Soil Permeability: Moderate

Vegetation: Lawn grass

Site 10

Location: NW SW SE section 35, T16N, R73W

Elevation: 7278 feet

Geomorphology: Tributary valley alluvium over a normal fault trace.

Underlying Geology: Permian-age Satanka Shale. The Satanka Shale is a red soft sandy shale.

Soil: Fiveoh-Fiveoh, cobbly substratum-Ryan Park complex. This complex is found on alluvial fans, terraces, and in areas of valley fill. The Fiveoh is formed in alluvium derived from limestone and sandstone, and consists of sandy loam and fine sandy loam. The Fiveoh, cobbly substratum portion formed in alluvium derived from mixed sources, and is a sandy loam with a cobbly sandy loam substratum. The Ryan Park soil formed in alluvium derived from mixed sources, and is a fine sandy loam with a gravelly sandy loam substratum.

Soil Permeability: Moderately rapid

Vegetation: Grasses and cottonwood trees

Site 11

Location: NE SW SW section 32, T16N, R73W

Elevation: 7145 feet

Geomorphology: Quaternary-age Stock Farm terrace, age estimate approximately 20,000 years B.P. (Mears, 1991).

Underlying Geology: Near contact of Triassic-age Chugwater Formation and Jurassic-age Sundance Formation. The Chugwater Formation consists of red shale, siltstone, and sandstone with zones of gypsum and anhydrite. The Sundance Formation consists of greenish-gray, glauconitic sandstone and shale underlain by red and gray non-glauconitic sandstone and shale.

Soil: Bosler fine sandy loam. This soil is found on alluvial fans and terraces, and formed in alluvium from mixed sources. This soil has a high salt content. It consists of fine sandy loam, with a sandy clay loam subsoil and gravelly sand substratum.

Soil Permeability: Moderate

Vegetation: Grasses

Site 12

Location: NE SW NE section 1, T15N, R74W

Elevation: 7179 feet

Geomorphology: Quaternary-age Pahlow surface, age estimate approximately 300,000 years B.P. (Mears, 1991). This site was subject to periodic flood irrigation.

Underlying Geology: Near contact of Cretaceous-age Mowry Shale and Frontier Formation. The Mowry Shale is a black and gray shale that weathers silvery gray, and contains thin bentonite beds. The Frontier Formation is a gray shale and sandstone, with a prominent sandstone at top.

Soil: Rock River sandy loam. This soil is found on alluvial and strath terraces, and formed in alluvium derived from mixed sources. This soil consists of sandy loam, with a sandy clay loam subsoil and a fine sandy loam substratum.

Soil Permeability: Moderate

Vegetation: Thick grasses

METHODS

SOIL-GAS RADON

Soil-gas radon samples were collected on a weekly basis at each of the twelve Laramie Basin sample sites, using techniques described by Reimer (1977), Reimer (1990), and Schumann and Owen (1988). All weekly samples were taken on the same day, usually between 9:00am and 2:00pm, and usually in the same order from one week to the next.

Gas Collection

Carbon steel and stainless steel probes were used to extract the soil-gas radon samples. The probes had an outside diameter of 0.32 inches and an inside diameter of 0.08 inches. The top end of the probe was open and the bottom end was blocked with a machine screw. Approximately 0.75 inches above the tip, opposite sides of the probe were ground flat for a length of 1.25 inches. Five sets of holes were drilled through the flattened portion of the tip. Soil-gas radon enters the probe through the drilled holes.

All probes were emplaced to a depth of 27 inches to collect soil-gas radon samples. Stainless steel probes were permanently installed at sites 1, 2, 4, 7, and 10. Carbon steel probes were emplaced and removed for each sample collection period at sites 3, 5, 6, 8, 9, 11, and 12. Soil-gas radon samples were collected until the upper portion of the sampled soils were frozen.

Other components of the soil-gas radon sampling system include an alpha-sensitive Lucas cell and a fixed-volume gas inlet system for the Lucas cells as described by Reimer (1977). The Lucas scintillation cell has a volume of 151 cc, and is supplied with two quick-release swagelock valves (female) for air intake and evacuation. The fixed-volume gas inlet system is supplied with a swagelock quick disconnect fitting (male) that connects into the Lucas cell. A "T" adapter is attached to the threaded end of the male quick disconnect fitting. The "T" adapter connects to both a gas injection system and a gas evacuation system. The gas injection system is composed of a 7 micron filter attached to a septum holder. Gas is injected into the system through the septum. The gas then passes through the 7 micron filter before entering the Lucas cell. The gas evacuation system consists of a shut-off valve and a hand-held vacuum pump. When the shut-off valve is open, the entire gas inlet system can be evacuated. The entire gas inlet system has a volume of approximately 12 cc. The volume of the gas inlet system connected to the Lucas cell is 163 cc.

To collect a soil-gas radon sample, an o-ring fitted brass needle guide cap with a septum is tightened onto the open end of the probe. The probe is purged of atmospheric air by inserting a 60 cc hypodermic syringe into the needle guide cap and extracting 30 cc of gas.

Before collecting a soil-gas radon sample for analysis, the fixed-volume gas inlet system is attached to a Lucas cell, and the apparatus is evacuated to 22 inches of mercury. 163 cc of soil gas is then extracted from the probe and injected into the Lucas cell and gas inlet system. This is done in order to allow the Lucas cell to be analyzed with the gas at a consistent pressure that approximates atmospheric pressure. This process reduces the need for pressure corrections as described by Holub and Stroud (1990).

Gas Analysis

Lucas cells filled with soil-gas were analyzed after a minimum of three and a half hours had elapsed from the time of gas injection in order to allow radon and its daughter products to reach equilibrium. This approach differs from that of Schumann and Owen (1988) and Reimer (1990). Radon levels in the Lucas cells were measured with a Pylon AB-5 radiation monitor, with counting taking place for three five-minute intervals. The three raw counts were each divided by five minutes to obtain counts per minute. An average count per minute was determined, from which the background count (acquired before sampling) was subtracted. The resulting number, net counts per minute, was entered into the following equation to determine radon concentration in piccocuries per liter (pCi/L) at each site:

$$RC = \frac{(NCPM)(1.00094)}{(0.1511)(2.22)(3)(E)(A)}$$

RC = radon concentration
NCPM = net counts per minute
1.00094 = decay factor during counting time of 15 minutes
0.1511 = volume of cell/volume of gas in liters
2.22 = conversion factor for decays per minute to pCi
3 = total number of alpha emitters
E = efficiency of Lucas cell determined during calibration
A = decay factor for time elapsed between collection and counting [$\ln e^{(-0.0001258)(\text{elapsed time min.})}$]

After radon levels in the Lucas cells were determined, the cells were flushed with atmospheric air.

SOIL MOISTURE AND TEMPERATURE

A variety of techniques for determining soil moisture were examined to find the best method for the Laramie Basin. A few techniques require that a permanent borehole be installed at the site. Those techniques were not chosen due to concerns that the borehole, even with casing in it, may serve to slowly degas the site. Other techniques require that a soil sample be extracted and analyzed in a laboratory for each moisture determination. Those techniques were not chosen as the many boreholes would result in a rapid degassing of the site. Another technique, using buried gypsum blocks, was not used because the blocks have a tendency to dissolve over a long period of time. A Soiltest, Inc. fiberglass and metal resistivity-type soil moisture cell was selected for this project as the cells do not dissolve and can be buried for a long period of time (Colman and Hendrix, 1949).

Soil samples from a depth of 27 inches were collected from each of the twelve sites in January, 1992. Soil samples were used to calibrate a moisture cell to the soil in which it would be placed. 12 cubic inch samples of each soil were oven-dried at 212°F for 24 hours. Calibration boxes, box lids, and moisture cells were weighed to obtain empty box and moisture cell weight. The boxes were then filled with dried soil while the moisture cell was centered in the box. Boxes were then weighed to obtain the dry weight of soil.

Samples were saturated by placing the boxes in a beaker partially filled with distilled water mixed with 2 grams of the same soil that was in the sample box. This was done to minimize the amount of salt and carbonate that would be leached from the sample. Our research indicated that salts and carbonate could be leached from the sample by using distilled water alone. Sample boxes were submerged halfway in the water-soil mixture in order to achieve saturation. A sample was considered to be saturated when a film of water was observed on the soil surface.

After saturation, samples were placed in a humidity chamber to stabilize. The first resistivity reading taken roughly equilibrated to a saturated condition. When duplicate resistivity/moisture readings were obtained, samples were removed from the humidity chamber, dried so as to reduce soil moisture a few percent, then placed back in the humidity chamber. Once duplicate resistivity/moisture readings were obtained for the dried sample, the process was repeated until the moisture level would no longer decrease (Kelley, 1944).

In theory, a plot of resistivity versus soil moisture, as outlined by Kelley (1944) and Colman and Hendrix (1949), should have yielded smooth, uniform, double S-shaped calibration curves (Otto Baumer, U.S.D.A. Soil Conservation Service National Soil Survey Center, Lincoln, Nebraska, personal communication, 1992). Calibration curves for this study did not conform to those described by previous researchers. Most of the calibration curves for this project were not of uniform shape (Appendix A). In fact, many of the calibration curves for different soils intersected when plots were combined. Due to the extreme care that was taken in the calibration process, we feel that salts and carbonates present in the soils had a negative effect on the calibration process. Additional research is needed in order to confirm this hypothesis.

After the calibration process was completed, moisture cells were buried to a depth of 27 inches at the site that corresponded to the soils that the cells were calibrated in. Due to the problems encountered with calibration, the accuracy of the soil moisture readings obtained is not known.

The soil moisture cells described above also contained a small thermistor to measure soil temperature. Each moisture/temperature cell was calibrated over a variety of temperatures, and it was found that each cell had a unique temperature calibration curve when used with a Soiltest soil moisture-temperature meter.

METEOROLOGIC MEASUREMENTS

Air pressure, air temperature, relative humidity, and wind speed data were collected weekly at the time of soil-gas radon sampling. In addition, daily precipitation, average daily air pressure, average daily wind speed, and daily high and low air temperature data were obtained from the Federal Aviation Administration weather station at Brees Field in Laramie, Wyoming.

SOIL-GAS RADON RELATIONSHIPS

Soil-gas radon data have been used to generally characterize the radon occurrence potential of areas underlain by various types of soil or bedrock. Schumann and Owen (1988) conducted 15 distinct soil-gas radon traverses composed of 129 sample points in Fairfax County, Virginia, and attempted to rank geologic formations based upon the soil-gas radon levels present in soils developed or present on top of the formations. Reimer (1990) conducted a single twelve mile long soil-gas radon traverse composed of 28 sample points in Prince Georges County, Maryland, and attempted to generally rank geologic formations using that data. Both studies had soil-gas radon traverses that were composed of sites that were sampled one time.

If apparent soil-gas radon relationships that are observed at one point in time are repeatable over a period of time, the data and relationships observed may be extrapolated regionally. The primary purpose of this portion of the study was to determine if relative soil-gas radon relationships that were observed among twelve sites in the Laramie Basin, Wyoming, during one sample period were repeatable. Twelve sites were sampled weekly for 35 weeks in order to assess the variability in soil-gas radon relationships.

SITE SPECIFIC SOIL-GAS RADON DATA

Plots of weekly soil-gas radon concentrations for each of the twelve sample sites are shown in Appendix B. A plot of weekly mean radon levels for all sites is shown in Figure 1. A fourth degree polynomial curve was fit to the mean data using a statistical package present in Grapher™ (Golden Software, Inc., 1990). Use of the trade names does not imply endorsement.

Previous research (Asher-Bolinder, Owen, and Schumann, 1990,

1991) indicates that soil-gas radon at a single site on the Denver Federal Center was highest during the winter and spring and lowest during the summer and fall. Those observations were not consistent with those found in Pennsylvania. Rose, Hutter, and Washington (1990) found that for five sites in central Pennsylvania, soil-gas radon values were generally lower in winter than in summer. These apparent contradictions may be due to differences in soil type, soil moisture, and meteorologic conditions between Colorado and Pennsylvania.

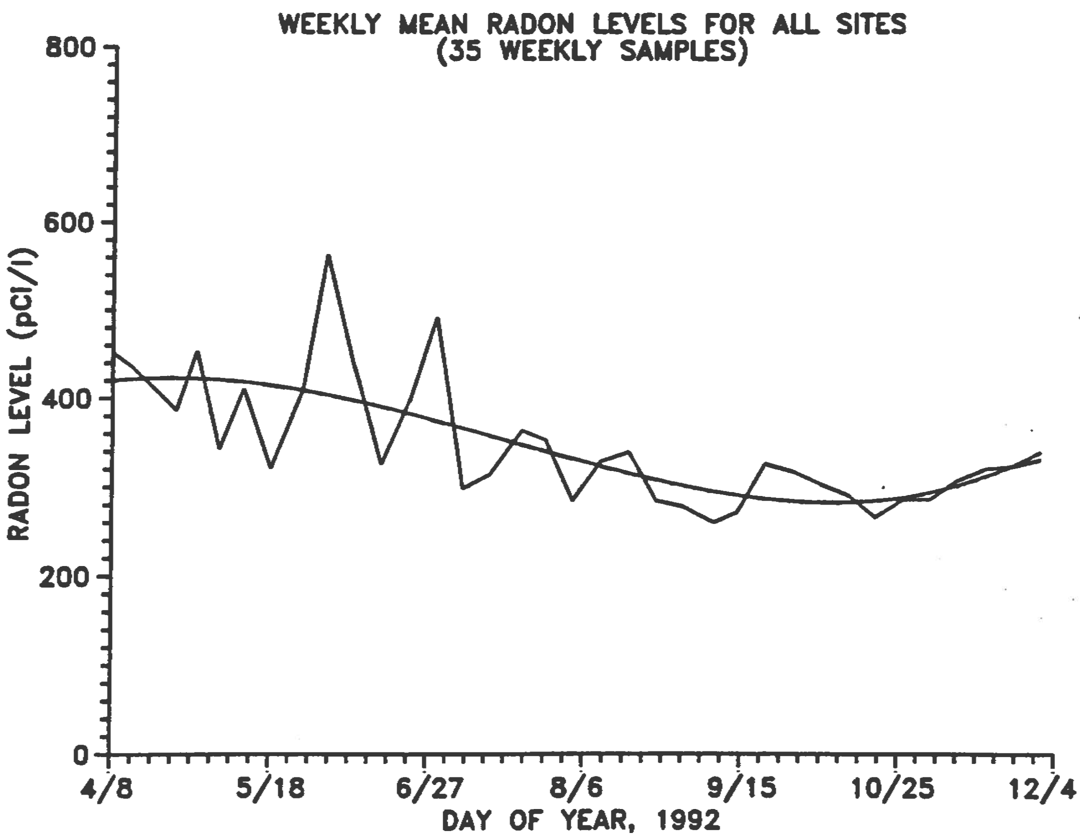

Figure 1. Weekly mean soil-gas radon levels for all sites. A fourth degree polynomial curve is fit to the mean data.

A plot of weekly mean radon levels for all sites (Figure 1) in the Laramie Basin Study indicates that soil-gas radon distributions as a whole are somewhat similar to the distribution model presented by Asher-Bolinder, Owen, and Schumann (1990, 1991) for the Denver Federal Center. Overall, soil-gas radon levels were highest in the spring and early summer, lowest from mid-summer to early fall, and higher in late fall. Soil-gas radon samples were not collected during the winter months due to difficulty in inserting soil-gas probes in frozen ground. It would be reasonable to assume that soil-gas radon samples would be elevated in the winter months as shown by Asher-Bolinder, Owen, and Schumann (1990, 1991). Specific sites within the Laramie Basin study area can differ significantly from the proposed model. A summary of the observed soil-gas radon distribution at all twelve sites is presented in Table 1.

Table 1. Summary of the observed soil-gas radon distribution.

Site	Observed soil-gas radon distribution trends
1	No significant trends; low variability in soil-gas radon levels.
2	Highest levels in spring and early summer, lowest levels in summer and early fall, with increasing levels mid- to late fall. Low variability in soil-gas radon levels.
3	Highest levels in spring, lowest levels in summer, with increasing levels through the fall. Moderate variability in soil-gas radon levels.
4	Highest level from spring through mid-summer, lowest levels from mid-summer through early fall, increasing levels through fall. Moderate variability in soil-gas radon levels.
5	Highest level from spring through mid summer, lowest levels from mid-summer through early fall, increasing levels through fall. High variability in soil-gas radon levels.
6	Highest levels in spring, otherwise no significant trend. Low variability in soil-gas radon levels.
7	Highest levels in early to mid-spring, otherwise no significant trend. Moderate variability in soil-gas radon levels.

Table 1. (Continued)

8	Highest levels from late spring to early summer, lowest levels from mid-summer to early fall, increasing levels through fall. Low variability in soil-gas radon levels.
9	Highest levels from spring through late summer, lowest levels (decreasing) in and through fall. Moderate variability in soil-gas radon levels.
10	Highest levels in late spring and from late summer through fall, lowest levels in mid-spring and early to mid-summer. Low variability in soil-gas radon levels.
11	Highest levels in late spring and early summer, lowest levels in mid-spring and mid-summer through early fall, increasing levels through mid- to late fall. Moderate variability in soil-gas radon levels.
12	Highest levels in spring and early summer, variable levels through spring and early fall, lowest levels in mid- to late fall. Moderate variability in soil-gas radon levels.

STATISTICAL DESCRIPTION OF SOIL-GAS RADON DATA

All soil-gas radon data for the Laramie Basin study has been statistically analyzed and summarized with MINITAB™ software (Minitab, Inc., 1992, Use of trade names does not imply endorsement). Presented below (Tables 2a and 2b) are a summary of the data, with N the number of samples, MEAN the mean of soil-gas radon data, MEDIAN the median of soil-gas radon data, TRMEAN the trimmed mean (mean of data excluding top and bottom 5%), STDEV the standard deviation, MIN the minimum soil-gas radon value, and MAX the maximum soil-gas radon value. Standard deviation data (Table 2b) were used to assess the levels of variability in soil-gas radon for all sites (Table 1).

Table 2a. Summary of soil-gas radon data for all sites by date.

DATE (1992)	N	MEAN (pCi/L)	MEDIAN (pCi/L)	TRMEAN (pCi/L)	STDEV (pCi/L)	MIN (pCi/L)	MAX (pCi/L)
4/8	12	451.7	306.3	419.3	336.5	122.2	1105.0
4/13	12	435.0	298.0	359.0	365.0	179.0	1453.0
4/24	12	386.1	226.1	318.0	338.9	104.2	1348.8
4/29	12	453.0	263.0	378.0	412.0	138.0	1520.0
5/5	12	343.0	230.0	250.0	384.0	111.0	1506.0
5/11	12	410.0	249.0	353.0	391.0	116.0	1276.0
5/18	12	321.2	210.9	249.9	316.2	110.7	1245.2
5/26	12	408.0	264.0	297.0	449.0	146.0	1780.0
6/1	12	562.0	374.0	427.0	552.0	238.0	2231.0
6/8	12	435.0	284.0	350.0	381.0	189.0	1527.0
6/15	12	325.8	236.0	267.4	250.4	173.9	1061.9
6/22	12	396.0	258.0	313.0	372.0	147.0	1480.0
6/29	12	491.0	319.0	377.0	477.0	204.0	1909.0
7/6	12	298.5	215.9	249.1	232.6	133.7	957.1
7/13	12	314.4	192.9	239.4	314.9	121.2	1258.1
7/21	12	363.0	255.0	264.0	396.0	141.0	1583.0
7/27	12	352.0	200.0	265.0	377.0	97.0	1474.0
8/3	12	284.0	189.5	237.6	226.7	112.9	919.3
8/10	12	328.3	224.6	264.0	293.5	124.3	1174.6
8/17	12	338.7	259.5	285.8	288.7	82.0	1123.8
8/24	12	284.5	178.4	234.6	231.2	127.6	940.1
8/31	12	277.8	211.6	229.4	219.0	131.3	908.1
9/8	12	259.9	175.7	208.4	218.3	128.1	906.8
9/14	12	271.2	191.3	215.9	236.3	125.1	970.0
9/21	12	325.6	264.2	257.8	301.2	112.4	1216.7
9/28	12	316.4	259.1	273.8	228.1	121.0	937.9
10/5	12	302.2	220.2	239.7	271.2	119.2	1109.3
10/12	12	290.4	228.9	252.4	213.2	114.3	846.3
10/19	12	265.8	195.4	219.3	209.8	121.8	874.8
10/26	12	285.3	205.5	235.8	225.9	119.6	945.6
11/2	12	285.5	193.4	230.8	236.7	128.8	989.6
11/9	12	307.0	229.3	243.2	267.7	138.4	1113.7
11/16	12	319.6	224.5	251.3	281.1	151.0	1170.5
11/23	12	322.7	234.1	250.4	288.1	164.0	1204.5
11/30	12	330.2	230.8	257.1	290.1	175.0	1215.7

Table 2b. Summary of soil-gas radon data by site.

SITE	N	MEAN (pCi/L)	MEDIAN (pCi/L)	TRMEAN (pCi/L)	STDEV (pCi/L)	MIN (pCi/L)	MAX (pCi/L)
1	35	192.0	189.2	191.1	20.7	152.2	257.6
2	35	160.0	149.5	158.0	36.1	119.2	238.2
3	35	303.9	297.8	297.1	112.8	142.0	574.4
4	35	416.1	420.7	413.8	98.3	161.9	661.1
5	35	1236.7	1174.6	1207.2	318.3	846.3	2230.7
6	35	163.7	150.1	162.0	40.1	97.0	259.9
7	35	339.8	317.8	322.4	120.0	232.9	961.4
8	35	171.4	163.0	167.5	44.0	111.0	313.8
9	35	382.7	331.2	371.1	176.6	149.8	862.0
10	35	171.7	171.2	171.8	41.6	82.0	252.3
11	35	228.8	179.3	198.6	177.4	110.9	1124.9
12	35	395.5	383.2	380.7	159.8	168.7	933.1

REPEATABILITY OF SOIL-GAS RADON RELATIONSHIPS

As stated earlier, one of the primary purposes of this research was to determine the repeatability of observed soil-gas radon relationships. Twelve sites were sampled on a weekly basis for 35 weeks. Two techniques were utilized in examining and interpreting the soil-gas radon data. First, relationships between individual sites were compared on a week to week basis. Second, sites were grouped into categories that represent ranges of soil-gas radon levels. The repeatability of relationships observed between the grouped data was examined.

Relationships between individual sites over the project period

As mentioned previously, twelve sites have been sampled for soil-gas radon on a weekly basis for 35 weeks. After each weekly sample period, soil-gas radon levels for the twelve sites were

Table 3. Frequency (%) that each site occurs in a specific rank.

SITE	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
1	-	2.9	11.4	20.0	28.6	20.0	17.1	-	-	-	-	-
2	34.3	14.3	22.9	11.4	11.4	5.7	-	-	-	-	-	-
3	-	-	2.9	5.7	2.9	11.4	22.9	11.4	22.9	17.1	2.9	-
4	-	-	-	-	2.9	-	-	17.1	14.3	31.4	34.3	-
5	-	-	-	-	-	-	-	-	-	-	-	100.0
6	17.1	25.7	20.0	20.0	2.9	8.6	5.7	-	-	-	-	-
7	-	-	-	-	-	2.9	20.0	31.4	22.9	20.0	2.9	-
8	11.4	11.4	20.0	22.9	25.7	8.6	-	-	-	-	-	-
9	-	5.7	5.7	2.9	2.9	5.7	11.4	5.7	14.3	17.1	28.6	-
10	28.6	20.0	5.7	5.7	8.6	22.9	2.9	5.7	-	-	-	-
11	8.6	20.0	11.4	11.4	11.4	14.3	17.1	2.9	-	-	2.9	-
12	-	-	-	-	2.9	-	2.9	25.7	25.7	14.3	28.6	-

The above data is presented graphically in Appendix D.

ranked from lowest to highest (Appendix C). The data (Appendix C) indicate that from one weekly sample period to another, most sites vary in their relative rank. In fact, no two sample periods have the same site rankings. The frequency (expressed as %) that each site occurs in a specific rank (R1 - lowest, R12 - highest) for the entire project period is shown in Table 3.

The data (Table 3) and graphs (Appendix D) indicate that while many sites occur at a specific rank a significant portion of the time, there is still considerable variability overall. The data in Table 3 can be analyzed by comparing the preferred site for each rank with the preferred ranking for each site. If each site consistently ranks in the same position from one sample period to another, the preferred site for each rank would be the same as the preferred ranking for each site.

Within Rank 1 (R1, Table 3), site 2 occurs 34.3 % of the time, followed by site 10 (28.6%), site 6 (17.1%), site 8(11.4%), and site 11 (8.6%), making site 2 the preferred site for Rank 1 (R1). Rank 1 (R1) is also the preferred rank for site 2, as site 2 occurs in that rank position more often than any other rank position. Within Rank 6 (R6, Table 3), Site 10 occurs more often than any other site, making site 10 the preferred site for Rank 6. However, site 10 also occurs at a Rank 1 (R1) position more frequently (28.6%) than any other rank position associated with site 10, making Rank 1 (R1) the preferred ranking for site 10.

The preferred site for each rank is compared to the preferred ranking for each site in Table 4. Utilizing the data from all sample periods, only seven sites or 58.3% of the sites tend to occur in the same position when comparing both of the above methods of analysis. Only ranks R1, R2, R5, R7, R8, R11, and R12 have consistent sites (sites 2, 6, 1, 3, 7, 4, and 5 respectively) associated with them for the complete data set. When comparing individual sample period site relationships (Appendix C) to the R1, R2, R5, R7, R8, R11, and R12 associations observed above, no single sample period has a direct correlation. The July 21, 1992 sample period has six of seven sites that have ranks that are equivalent to the total sample period ranking in Table 4. All of the other sample period associations are of less significance.

Table 4. Comparison of preferred site for each rank and preferred ranking for each site.

Rank	Preferred Site for Each Rank	Preferred Ranking for Each Site
R1	**2**	**2**, 10
R2	**6**	**6**
R3	2	-
R4	8	-
R5	**1**	**1**, 8
R6	10	-
R7	**3**	**3**, 11
R8	**7**	**7**
R9	12	3
R10	4	-
R11	**4**	**4**, 9, 12
R12	**5**	**5**

Sites in **bold** have consistent ranking.

Relationships between groups of sites over the sample period

Due to the fact that no two sample periods had the same site ranking, another method of analysis was devised. Data was categorized into high, moderate, and low ranges or groups based upon both visual observation and by grouping site means and standard deviations (Table 2b). The high, moderate, and low ranges that have been defined are only of significance to the existing set of data in this study. If additional sites were sampled, it is possible that the observed distinctions between sites would not exist. Visual observation of plots of weekly soil-gas radon levels for each site (Appendix B), indicates that six sites (1, 2, 6, 8, 10, and 11) are generally present in a 0-250 pCi/L range, five sites (3, 4, 7, 9, and 12) are generally present in a 250-750 pCi/L range, and one site (5) is generally in a range above 750 pCi/L. Statistically, sites 1, 2, 6, 8, 10, and 11 all have mean radon levels below 250 pCi/L (192, 160, 164, 171, 172, and 229 pCi/L respectively); sites 3, 4, 7, 9, and 12 all have mean radon levels between 250 pCi/L and 750 pCi/L (304, 416, 340, 383, and 396 pCi/L respectively); site 5 has a mean radon level of 1237 pCi/L. Sites 1, 2, 6, 8, 10, and 11 have radon level standard deviations (Table 2b) of 20.7, 36.1, 40.1, 44.0, 41.6, and 177.4 pCi/L respectively. Sites 3, 4, 7, 9, and 12 have radon level standard deviations (Table 2b) of 112.8, 98.3, 120.0, 176.6, and 159.8 pCi/L respectively. Site 5 has a radon level standard deviation of 318.3 pCi/L (Table 2b). With the exception of site 11, all of the low range sites have low variability, all of the moderate range sites have moderate variability, and the high range site has the highest variability.

The high, moderate, and low ranges used in this study are useful only for comparing data. The ranges do not equate to hazard levels. The average soil-gas radon levels for the entire United States range from 500 pCi/L to 1500 pCi/L (Mike Reimer, U.S. Geological Survey, personal communication, 1992). The mean soil-gas radon levels for the low and moderate range sites were below the average U.S. ranges. The mean soil-gas radon level for the high range site was within the average U.S. range.

Not all sites fall within the same ranges at all times. Table 5 shows the frequency distribution of site occurrences in each range for the entire 35 week sample period. If a site occurs within a range more than 50% of the time (18 times), it seems reasonable to assign that site to that range. Table 6 shows the distribution of sites by range using this technique.

The site distributions within the three ranges appear to be statistically significant. However, when analyzing the actual distribution present within each specific sample period, the significance is not as strong. For example, only eight out of 35 (23%) of the sample periods have site distributions that correspond with the model presented in Table 6. 94% of the sites that occur in the high range (>750 pCi/L) for each sample period, 23% of the sites that occur in the moderate range (250-750 pCi/L) for each sample period, and 28.5% of the sites that occur in the low range (0-250 pCi/L) for each sample period (Appendix C) correspond exactly to the model presented in Table 6.

Table 5. Site frequency distribution within ranges.

	Ranges of Soil-Gas Radon		
Site	Low (0-250 pCi/L)	Moderate (250-750 pCi/L)	High (>750 pCi/L)
1	34	1	0
2	35	0	0
3	11	24	0
4	1	34	0
5	0	0	35
6	34	1	0
7	5	29	1
8	32	3	0
9	8	26	1
10	34	1	0
11	29	6	0
12	6	28	1

Table 6. Site distribution within ranges.

	Ranges of Soil-Gas Radon		
	Low (0-250 pCi/L)	Moderate (250-750 pCi/L)	High (>750 pCi/L)
Sites that occur within range more than 50% of the time.	1	3	5
	2	4	
	6	7	
	8	9	
	10	12	
	11		

The technique of grouping sites into soil-gas radon ranges and then comparing the grouped sites from one sample period to another results in a statistically more significant method of analysis than does comparing specific sites within one sample period to those in another. No individual sample period has a site distribution or order that exactly corresponds to the order of sites shown in Table 4. 23% of the sample periods in which sites have been grouped correspond to the grouping of sites shown in Table 6.

DATA VARIABILITY AND ADEQUATE SAMPLE SIZE

Patterns of variability between sample periods (measures of all sites of interest on a single day) are discussed above. If this type of variability will be present in other studies, as would be expected, the practicing geologist has the task of determining what can be done to make field measurements of radon more trustworthy.

The most readily apparent solution is to observe more than one sample period and to compare soil-gas radon levels averaged across the different measures of each site. In a real setting, one would observe k sites without knowing if any of the sites actually differed from the others in terms of mean soil-gas radon levels, and one would ideally wish to be reasonably certain they can distinguish sites that differ greatly. A formal technique for determining precisely which differences in means may be considered to be small and which differences are large is provided by Tukey's method of multiple comparisons, also called the method of *honestly significant differences*. (See, for example, Neter, et al., 1990, Montgomery, 1991 or Hochberg and Tamhane, 1987.)

Based on this procedure, if the focus of interest is on separating sites when the difference in their mean levels actually exceeds an amount Δ and the variability of measures taken within a site is specified by a standard deviation σ, one can determine the number of sample periods needed to separate *all* pairs of sites that differ by at least Δ with a chosen probability. Because observational variability increases with the true mean soil-gas radon level of a site and because percentage-based comparisons may actually be of more interest than absolute differences in mean soil-gas radon, using logarithms of soil-gas radon concentrations instead of raw concentrations is suggested for these analyses.

As an example, suppose that k sites were observed and that one wished to distinguish sites whenever one site had a mean level more than about 50% above that of the other. $\mu_1/\mu_2 = 1.5$ implies that ~~log~~ ln(μ_1) - ~~log~~ ln(μ_2) = 0.4, and we can roughly treat a difference in log soil-gas radon concentrations of $\Delta = 0.4$ as a threshold which should be detectable. Using our data, gathered over the entire sampling period, we found a mean squared error (MSE) of 0.086291, so we use an estimated standard deviation of $\sqrt{0.086291} = 0.294$. With n sample periods, the estimated standard deviation of the difference in means is $\sigma_n = 0.294\sqrt{2/n}$, and the normalized difference between sample means may be written as $\sqrt{n/2}\Delta/\sigma = 0.976\sqrt{n}$. This value can then be compared against charts of the Studentized Range Distribution, with degrees of freedom k and $(n-1)k$, to determine requisite sample sizes. To detect all differences of Δ or more with *combined* probability 0.90, the following sample sizes are adequate (Table 7).

Table 7. Adequate sample size, one-way anova design.

ONE-WAY ANOVA DESIGN	
k = number of sites	n = number of sample periods needed for P = 0.90
3	7
4	9
5	11
6	12
7	13
8	14
9-10	15
11	16
12	17

A weakness of the above procedure is that it fails to account for the fact that soil-gas radon levels observed at the same time at sites in the same region are correlated. An improvement on the above method is to use randomized block design, with days used as a blocking variable. With this approach, the degrees of freedom in the above procedure change to k and $(k-1)(n-1)$ and the within site standard deviation should decrease. In the current study, the observed MSE for the randomized block analysis is 0.063492. The resultant requisite sample sizes are shown in Table 8.

Table 8. Adequate sample size, randomized block analysis.

k = number of sites	n = number of sample periods needed for P = 0.90
3	6
4	7
5	8
6	9
7	10
8-9	11
10-11	12
12	13

An ordering based on average log soil-gas radon concentrations using sample sizes as above will, assuming data are gathered on the same days, be 90% sure to correctly order all sites that differ by 50% or more soil-gas radon concentration. If data are gathered over a brief time period when weather is stable, then observed variations could decrease, and smaller samples may be acceptable. The larger samples indicated in the first chart should be usable even if data are gathered on different days. Also, the listed sample sizes merely insure that the *ordering* is 90% sure to be correct; larger samples would be needed to ensure that observed differences would be considered *significant* using Tukey's criterion for honestly significant differences.

Classifications or categories of data may sometimes be derived from ordered data. When data in this study were ordered using the criteria specified above, the data categories or ranges that had been developed were confirmed. In the current study, all low range (0-250 pCi/L) sites had mean soil-gas radon levels that were within 50% of one another, as did all moderate range (250-750 pCi/L) sites. Most moderate range sites (sites 3, 4, 7, 9, and 12) had mean soil-gas radon levels that were 50% greater than mean soil-gas radon levels for the low range sites (sites 1, 2, 6, 8, 10, and

11). The high range (>750 pCi/L) site (site 5) had a mean soil-gas radon level that was over 50% higher than any of the low or moderate range sites. Using the data presented in Table 8, thirteen sample periods would ensure (probability = 90%) that sites are correctly ordered from highest group to lowest group. Sites in the ordered groupings correspond to sites in the high, moderate, and low ranges. If the data set were more extensive, with more sites sampled, it is possible that there would be a poorer correlation between ordered sites and site categories or ranges. In fact, if the data set were larger, meaningful data classifications or categories may not compare at all with the categories or ranges suggested for the existing data set.

HOURLY SAMPLING RELATIONSHIPS

Diurnal variation in soil-gas radon levels have been described most recently by Asher-Bolinder, Owen, and Schumann (1991). Diurnal variations are thought to be due to regular changes in air temperature, air pressure, soil temperature, and relative humidity. Some of the weekly variations in soil-gas radon (Appendix B) observed in this study may be due to differences in the time of day that samples were collected. In order to determine what effect diurnal variation may be having on this study, hourly soil-gas radon, meteorologic, and soil moisture/temperature data were collected for site 5 (high soil-gas radon range), site 4 (moderate soil-gas radon range), and site 1 (low soil-gas radon range). Four 13 hourly samples were obtained for site 5, two 10 hourly samples were obtained for site 4, and two 9 hourly samples were obtained for site 1. Duplicate samples were also obtained for portions of the site 5 sampling. Plots of hourly soil-gas radon levels for sites 5, 4, and 1 are shown below as Figures 2a, 2b, and 2c. Basic statistical data for each sample period for each site are shown below in Tables 9a, 9b, and 9c.

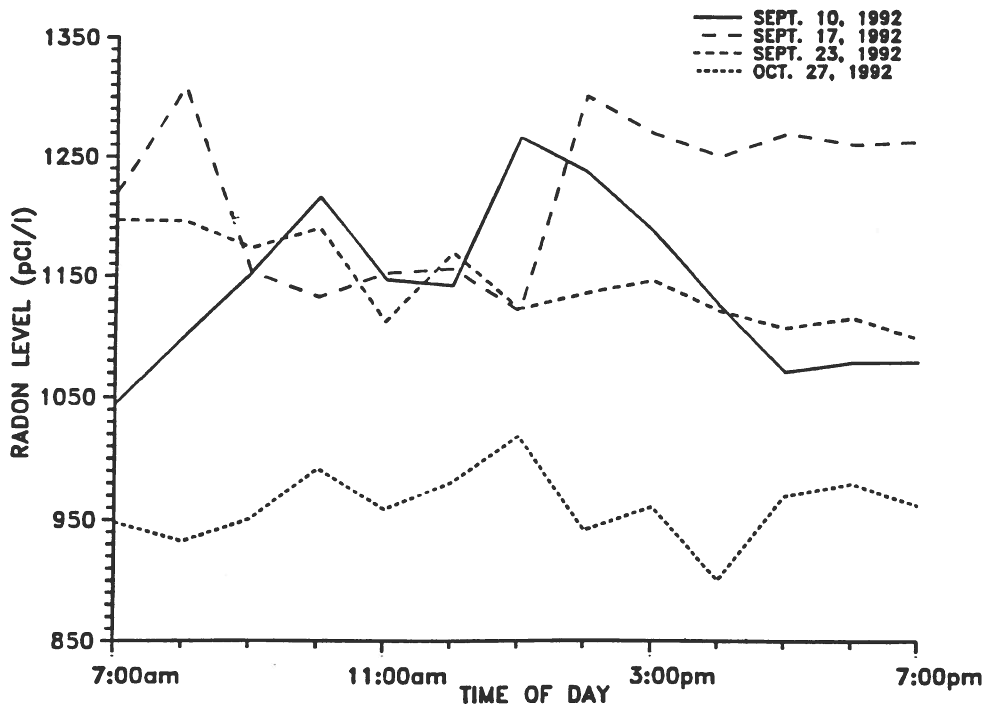

Figure 2a. Hourly soil-gas radon levels, site 5.

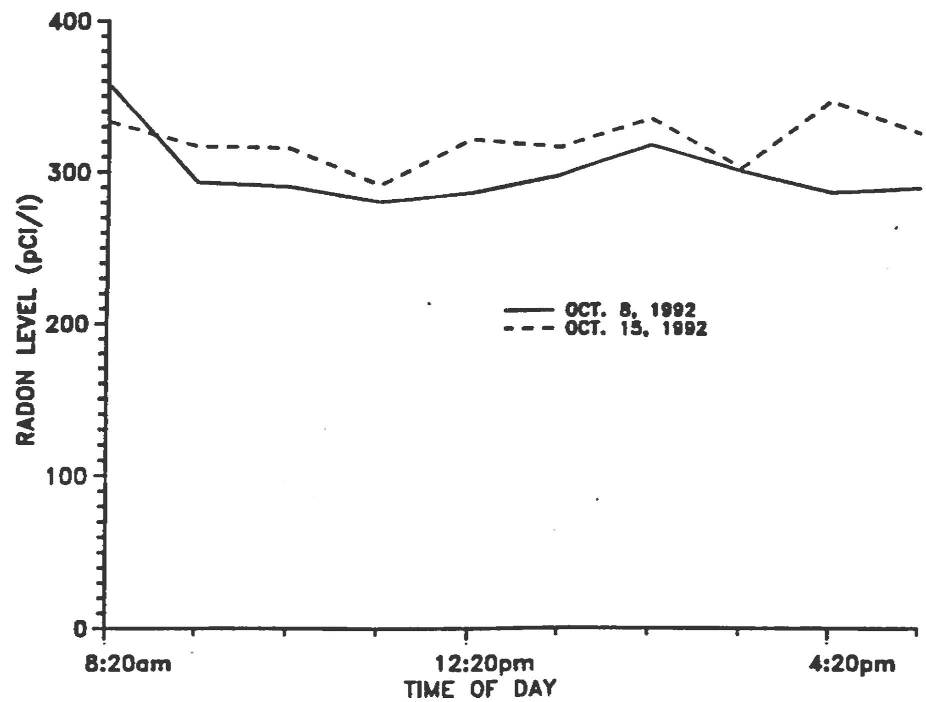

Figure 2b. Hourly soil-gas radon levels, site 4.

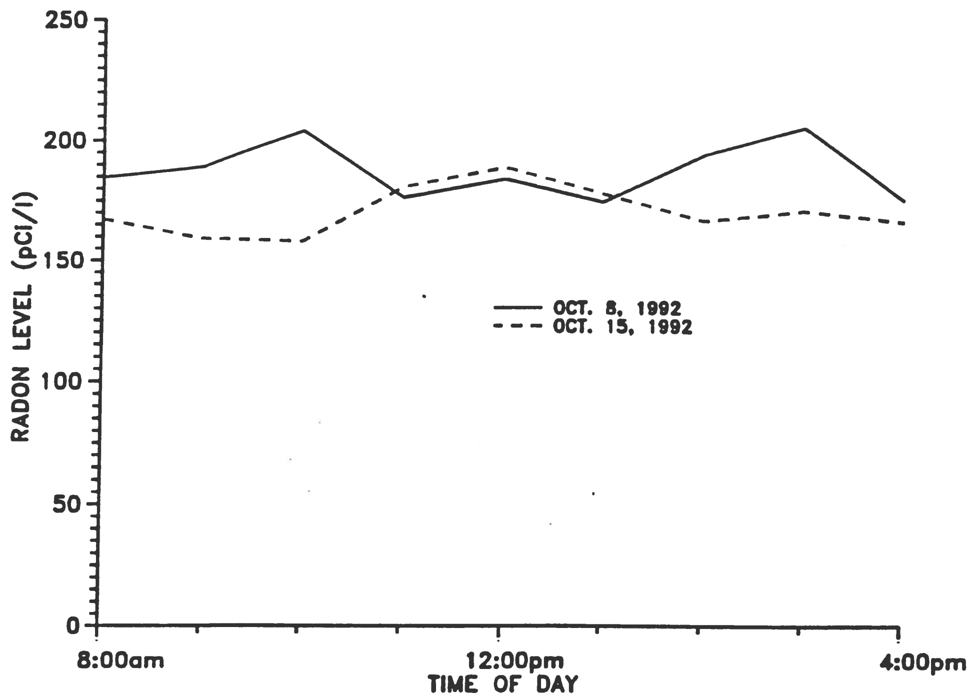

Figure 2c. Hourly soil-gas radon levels, site 1.

Diurnal variations for soil-gas radon are not consistent from one sample period to another for site 5 (Table 9a, Figure 2a). Duplicate samples taken for a portion of the site 5 sampling indicate that the variability observed is not due to error in sampling or analysis of the soil-gas radon. Duplicate samples were taken at 11:00am and 12:00pm on September 17, 1992 and September 23, 1992. On September 17, 1992, duplicate samples taken at 11:00am showed soil-gas radon levels of 1151.1 pCi/L and 1171.2 pCi/L, and duplicate samples taken at 12:00pm showed soil-gas radon levels of 1155.4 pCi/L and 1150.1 pCi/L. On September 23, 1992, duplicate samples taken at 11:00am showed soil-gas radon levels of 1111.7 pCi/L and 1109.8 pCi/L, and duplicate samples taken at 12:00pm showed soil-gas radon levels of 1169.0 pCi/L and 1149.8 pCi/L. All of the duplicate samples are within 2% of one another.

Table 9a. Statistical soil-gas radon data, site 5 hourly samplings.

Sample Date	Sample Size	Mean (pCi/L)	Std. Dev. (pCi/L)	Coefficient of Variation	Min (pCi/L)	Max (pCi/L)
9/10/92	13	1141.4	68.7	0.0602	1043.8	1265.4
9/17/92	13	1218.8	67.0	0.0550	1120.1	1308.2
9/23/92	13	1144.3	36.0	0.0315	1097.4	1196.6
10/27/92	13	960.8	29.1	0.0303	900.1	1017.8

Table 9b. Statistical soil-gas radon data, site 4 hourly samplings.

Sample Date	Sample Size	Mean (pCi/L)	Std. Dev. (pCi/L)	Coefficient of Variation	Min (pCi/L)	Max (pCi/L)
10/8/92	10	299.70	22.99	0.0767	280.20	358.30
10/15/92	10	320.24	16.02	0.0500	291.30	346.40

Table 9c. Statistical soil-gas radon data, site 1 hourly samplings.

Sample Date	Sample Size	Mean (pCi/L)	Std. Dev. (pCi/L)	Coefficient of Variation	Min (pCi/L)	Max (pCi/L)
10/8/92	9	187.46	11.75	0.0627	174.50	205.50
10/15/92	9	170.62	10.18	0.0597	158.00	188.80

Factors other than those usually associated with normal diurnal variation may have been effecting radon levels for the site 5 hourly samples, but diurnal variation was observed. The additional factors may have served to enhance the variability of the data. The same additional influences may have existed for the other sites sampled hourly, but to a lesser degree. Due to the variability observed in the hourly sampling data from one sample period to another,as described above, the term "apparent diurnal variation" will be used to describe the hourly variations observed.

In order to determine if factors other than apparent diurnal variations were significantly effecting soil-gas radon levels observed over the entire project, data from the hourly sampling was compared to the total project data. The hourly samples with the greatest amount of variability for sites 5, 4, and 1 were compared to the total project data for those sites. The standard deviation and coefficient of variation for any data set are a measure of the data variability. With four hourly sample periods, site 5 had the largest standard deviation (68.7 pCi/L) and coefficient of variation (0.0602) associated with the September 10, 1992 sample (Table 9a). With two sample periods each, both sites 4 and 1 had the largest standard deviations and coefficients of variation associated with the October 8, 1992 sample period. The largest standard deviation and coefficient of variation for site 4 was 22.99 pCi/L and 0.0767 respectively (Table 9b), and the largest standard deviation and coefficient of variation for site 1 was 11.75 pCi/L and 0.0627 respectively (Table 9c). Data for apparent diurnal variations are compared to project summary data for each of the hourly sample sites in Table 10 below.

Table 10. Statistical comparisons of soil-gas radon hourly sample data with the greatest variability and total project data for sites 5, 4, and 1.

Soil-Gas Radon	Site 5	Site 4	Site 1
Project Mean	1236.7	416.1	192.0
Hourly Mean for Sample Period with Greatest Variability	1141.4	299.7	187.46
Project Standard Deviation	318.3	98.3	20.69
Hourly Standard Deviation for Sample Period with Greatest Variability	68.7	22.99	11.75
Project Coefficient of Variation	0.2573	0.2362	0.1077
Hourly Coef. of Variation for Sample Period with Greatest Variability	0.0602	0.0767	0.0627

Sample sizes for the diurnal variation study were small, with only three of the twelve sites in the project examined for hourly soil-gas radon variation. Nevertheless, coefficients of variation associated with soil-gas radon data for sites 5, 4, and 1 for the entire project were considerably larger than the coefficients of variation observed for the hourly samples for sites 5, 4, and 1 (Table 10). Site 5 had a coefficient of variation for the entire project that was approximately 4.3 times larger than the coefficient of variation for the hourly samples represented in Table 10. Site 4 had a coefficient of variation for the entire project that was approximately 3.1 times larger than the coefficient of variation for the hourly samples represented in Table 10. Site 1 had a coefficient of variation for the entire project that was over 1.7 times larger than the coefficient of variation for the hourly samples represented in Table 10. If apparent diurnal variations were the only factors effecting soil-gas radon variability, coefficients of variation for soil-gas radon should have been similar for the hourly samples and the total project data for each site. Factors other than regular apparent diurnal variation appear to be strongly influencing the weekly samples over the entire project period. With the limited data, it is not known how apparent diurnal variations compare from day-to-day and week-to-week over the entire project. If such data were available, the differences in the coefficients of variation may not be the same as those observed.

ENVIRONMENTAL CONTROLS ON SOIL-GAS RADON LEVELS

A secondary purpose of this study was to investigate the relationships between soil-gas radon and soil temperature, soil moisture, air pressure, air temperature, relative humidity, wind speed, and precipitation. Meteorologic and soil factors were monitored on a weekly basis at the time of soil-gas radon collection at each of the twelve sample sites. In addition, regional weather data was obtained at the Federal Aviation Administration weather station at Brees Field in Laramie, Wyoming.

PREVIOUS RESEARCH

Previous researchers have summarized the environmental factors that may effect soil-gas radon concentrations (Asher-Bolinder, Owen, and Schumann, 1991). Factors that have been previously investigated are soil moisture, soil temperature, precipitation, barometric pressure, relative humidity, air temperature, and wind. A summary of previous research is presented below.

Soil Moisture

Previous research has indicated that radon emanation rates increase from dry conditions up to 15-17% soil moisture, and decrease beyond that point (Asher-Bolinder, Owen, and Schumann, 1991; Lindmark and Rosen, 1985). When a radium atom in a soil or rock particle decays, an alpha particle and radon are formed. The alpha particle (two protons and two neutrons) is ejected from the nucleus of the radium atom, and the newly formed radon atom is recoiled in the opposite direction of travel of the alpha particle. The recoiling radon atom may remain embedded in the soil or rock particle, or it may escape into a pore space between the particles. If there is nothing but air in the pore space, the recoiling atom may travel through the void and embed in an adjacent particle. If the pore space is large enough, the radon atom may stop in the void and move towards the surface. Water surrounding soil particles may prevent a recoiling radon atom from embedding in an adjacent soil grain (Asher-Bolinder, Owen, and Schumann, 1991; Tanner, 1980;

Otton, 1992). If there is a significant amount of water in the pore space, however, the rate of radon emanation may be much lower than with a smaller amount of water. Soil moisture levels at and below 15-17% do not significantly impede the distance a radon atom can move in the soil. Moisture levels above 15-17% can significantly decrease the distance the atoms can move (Asher-Bolinder, Owen, and Schumann, 1991; Lindmark and Rosen, 1985). Soil moisture should have a significant effect on radon emanation rates and soil-gas radon concentrations.

Soil Temperature/Air Temperature

Asher-Bolinder, Owen, and Schumann (1991) summarized from previous research that the "effects of temperature may be difficult to separate from the effects of other factors that exert a greater influence on the soil-gas radon concentration." Existing literature reviewed by those authors demonstrated conflicting observations. Asher-Bolinder, Owen, and Schumann (1991) found a <u>seasonal</u> negative correlation of air and soil temperature data with soil-gas radon during a study at a Denver, Colorado area site. They also found a weak negative correlation between day-to-day fluctuations in air temperature and soil-gas radon, probably due to a correlation between low temperature and low pressure/precipitation. Those researchers also found no consistent correlation between soil temperature and soil-gas radon.

Precipitation

Precipitation effects soil moisture which effects radon emanation rates as previously described. In addition, precipitation can produce a cap that slows the release of radon to the atmosphere (Asher-Bolinder, Owen, and Schumann, 1991). When the cap is frozen, soil-gas radon concentrations may be at their highest levels. Asher-Bolinder, Owen, and Schumann (1991) found precipitation to have a significant positive correlation with soil-gas radon levels during Denver, Colorado study of a single site.

Barometric Pressure

Asher-Bolinder, Owen, and Schumann (1991) summarized from previous research that "low barometric pressure causes an increase in soil-gas radon concentration in the upper few meters of soil. Low pressure causes soil gas to rise toward the surface from greater depths, where the soil-gas radon concentrations are generally higher because of less dilution by atmospheric air. High pressure has the opposite effect and pushes the atmospheric air into the ground, diluting the soil gas." A Denver, Colorado area study by Asher-Bolinder, Owen, and Schumann (1991) found that barometric pressure changes were more significant than actual barometric pressure levels in bringing about a change in soil-gas radon levels. They also noticed a lag of from several hours to over a day between barometric pressure changes and changes in soil-gas radon.

Wind

Asher-Bolinder, Owen, and Schumann (1991) summarized from previous research that "gusting winds cause a decrease in soil-gas radon concentrations, because soil gas is being diluted or removed at the surface." Previous studies indicated to them that the depth to which wind will effect radon concentration will vary depending on soil type, soil moisture, and other factors. Asher-Bolinder, Owen, and Schumann (1991) could not find a correlation between wind and soil-gas radon during a study at a Denver, Colorado area site. The reason for the lack of correlation is uncertain.

Relative Humidity

Asher-Bolinder, Owen, and Schumann (1991) found a positive correlation between relative humidity and soil-gas radon at a single site in Denver, Colorado. Relative humidity correlated well with precipitation in their study.

ENVIRONMENTAL DATA

Site specific soil data, including soil temperature, soil resistivity, and soil moisture for all sample sites are presented in Appendix E. Site specific weekly weather data are presented in Appendix F. Air temperature, air pressure, wind velocity, and relative humidity data at the time of soil-gas radon sample collection are included with the site specific weekly weather data. Regional weather data are presented in Appendix G. Daily air temperature high and low, daily average barometric pressure, daily average wind velocity, daily precipitation, and weekly accumulated precipitation are included with the regional weather data.

CORRELATIONS BETWEEN ENVIRONMENTAL FACTORS AND SOIL-GAS RADON

All weather data and soil data were compared to soil-gas radon data for each site for the entire project period by using MINITAB™ Software (Minitab, Inc., 1992. Use of trade names does not imply endorsement).

Linear correlation coefficients for environmental (soil and meteorologic) factors versus soil-gas radon for each of the sites (total project period) are shown in Table 11. Coefficients shown in bold type are those that are significantly different than 0 at an $\alpha = 0.05$. Correlations between all factors for each site are shown in Appendix H.

When comparing correlation coefficients from one site to another, it appears that accumulated precipitation, soil temperature, soil moisture, and air pressure may be the most significant factors, based upon the number of significant correlations present in each. Of those four factors, accumulated precipitation appears to be the most significant for a number of reasons. First, it has more significant correlations for all sites than any other factor. Second, the significant correlations are all positive. When looking at all of the soil-gas radon versus

Table 11. Linear correlation coefficients for soil-gas radon versus environmental factors for all sites. Coefficients in **bold type** are significantly different than 0 at an $\alpha = 0.05$.

Site	Airtemp	Airpres	Windvel	Humidity	Soiltemp	Resistiv	Soilmois	Accumpp
1	-0.073	-0.118	0.108	0.298	**-0.559**$_2$	0.268$_2$	-0.246$_2$	**0.349**
2	0.047	-0.228	0.279	-0.083	**-0.713**$_2$	0.062$_2$	-0.062$_2$	**0.431**
3	-0.249	-0.070	-0.036	0.098	-0.815$_1$	0.821$_1$	-0.821$_1$	0.215
4	0.029	-0.113	0.001	0.145	**-0.722**$_2$	**0.581**$_2$	**-0.634**$_2$	**0.475**
5	0.120	-0.042	-0.302	0.026	**-0.667**$_2$	0.190$_2$	-0.190$_2$	**0.682**
6	-0.254	-0.258	0.269	0.083	*	*	*	0.209
7	0.010	-0.003	-0.174	0.008	0.078$_3$	-0.132$_3$	0.215$_3$	-0.033
8	-0.174	-0.297	0.117	0.215	-0.265$_3$	-0.055$_3$	0.368$_3$	**0.443**
9	**0.590**	**0.477**	**-0.363**	-0.119	**0.558**$_3$	**-0.610**$_3$	**0.568**$_3$	-0.016
10	-0.031	-0.185	-0.093	-0.178	-0.015$_3$	**0.413**$_3$	-0.133$_3$	0.281
11	-0.224	**-0.345**	0.129	0.169	-0.235$_3$	**-0.574**$_3$	**0.824**$_3$	**0.513**
12	0.157	**0.384**	**-0.455**	0.086	0.223$_3$	-0.159$_3$	0.115$_3$	0.195

* Indicates missing data

$_1$ Four readings were obtained for this factor due to equipment failure
$_2$ Thirteen readings obtained for this factor
$_3$ Twenty-six readings obtained for this factor

Explanation

Airtemp = Air temperature at time of sample collection
Airpres = Air pressure at time of sample collection
Windvel = Wind speed at time of sample collection
Humidity = Relative humidity at time of sample collection
Soiltemp = Soil temperature at time of sample collection
Resistiv = Resistivity of soil moisture cell at time of sample collection
Soilmois = % soil moisture at time of sample collection
Accumpp = Weekly accumulated precipitation (totalled for 7 days previous to sample day)

precipitation correlations for all sites, only two correlations are negative, and those correlations are close to 0 (-0.033 and -0.016). Sample size is consistent for accumulated precipitation, with all sites having 35 samples.

Soil temperature also appears to be a significant factor. However, the number of samples used for analysis are significantly smaller than for other factors. Thirteen weekly samples were obtained for sites 1, 2, 4, and 5, four weekly samples were obtained for site 3, twenty-six weekly samples were obtained for sites 7, 8, 9, 10, 11, and 12, and no samples were obtained for site 6 due to equipment failures and problems with equipment calibration. All of the sites that had thirteen or less samples had negative correlations, including four significant correlations (-0.559, -0.713, -0.722, and -0.667). The sites that had twenty-six samples had three negative correlations and three positive correlations. The one significant correlation in this group of sites was positive (0.558). Sample size may be effecting correlation coefficients for soil-gas radon versus soil temperature. Exact relationships are unknown.

Soil moisture also appears to be a significant factor. However, the sample sizes for soil moisture were the same as for soil temperature. As with soil temperature, when sample sizes were thirteen or less (sites 1-5), all correlations with soil-gas radon were negative, including one significant correlation (-0.634, site 4). When sample sizes were larger (sites 7-12), correlations with soil-gas radon were generally positive, with two significant positive correlations (0.568 and 0.824). As with soil temperature, sample size may be effecting correlation coefficients for soil moisture. Exact relationships are unknown.

Sample size is consistent for air pressure, with all sites having 33 samples. Correlations shown on Table 11 are for air pressure at time of sample collection. Daily average air pressure data were also available (Appendix G), but correlations with soil-gas radon are not shown on Table 11 as correlations were more significant for air pressure at the time of sample collection. Ten of twelve correlations for air pressure versus soil-gas radon were negative. Three of twelve correlations were significant, but two of those were positive (0.477 for site 9 and 0.384 for site 12). The other significant correlation was negative (-0.345 for site 11). Sites 9 and 12 were moderate range (250-750 pCi/L) soil-gas radon sites, and site 11 was a low range (0-250 pCi/L) soil-gas radon site. At the present time, the reasons for the differences in the significant correlations are unknown.

While sample sizes are generally consistent for the remaining three factors (wind velocity, air temperature, and relative humidity) there are fewer significant strong correlations than for the other factors. Correlation coefficients for wind velocity are split between negative correlations and positive correlations, with six positive correlations and six negative correlations. There does not appear to a significant pattern of distribution for either negative correlations or positive correlations, although the two correlations of significance were both negative (-0.363 and -0.455). Of interest is the relationship between significant correlation coefficients for air pressure and wind velocity. Sites 9 and 12 had significant correlation coefficients for both air pressure and wind velocity, with positive correlation coefficients for air pressure (0.477 and 0.384) and negative correlation coefficients for wind velocity (-0.363 and -0.455). Site 11 had a significant correlation for air pressure but not for wind velocity. The significant correlation for air pressure for site 11 was negative (-0.345). The less significant correlation for wind velocity for site 11 was positive (0.129). The fact that significant correlations have the opposite signs for air pressure versus wind velocity indicates that wind and barometric pressure effects may be inter-related.

The correlations between air temperature and soil-gas radon are poorly defined. For all twelve sites, half of the correlations were negative, and half were positive. Only one correlation coefficient was of significance (0.590, site 5). There appeared to be no correlation between relative humidity and soil-gas radon.

Nine of the correlation coefficients were weakly positive, while three were weakly negative. No significant correlation coefficients exist for relative humidity versus soil-gas radon.

OVERALL ENVIRONMENTAL CORRELATIONS

The discussion above summarizes relationships observed between soil-gas radon and environmental (soil and meteorologic) factors for each site. Analyses were also conducted for all sites taken together. To account for differences in average site levels of soil-gas radon, correlations for all sites taken together were calculated as partial correlation coefficients (all variables adjusted for different levels at different sites) versus the simple Pearson's coefficients of correlation used for site to site analyses. Log soil-gas radon concentrations were used for the analyses for all sites taken together, as log concentrations were distributed more nearly like normal data than were the raw concentrations. Correlation coefficients for all the sites taken together are presented in Table 12.

Table 12. Significant correlations for all sites taken together (radon versus factor), $\alpha = 0.05$.

Factor	Significant Correlations
Precipitation	0.370
Day of Year	
Sine(day)	0.319
Cosine(day)	-0.179
Pressure	--
Wind	--
Temperature	--
Time of day	--
Relative Humidity	--
Soil temperature	--
Soil moisture	0.205

This method of analysis indicates that for all sites taken together, correlation coefficients were most significant for accumulated precipitation and time of year. Soil moisture may also be of significance overall, when using correlation coefficients as a method of comparison.

Multiple Regression Model

To further explore the relationships between soil-gas radon and the environmental factors (soil and air), the empirical fit of the data with a variety of multiple regression models was examined. Attempts to fit all possible regressions revealed that the model most worth considering is:

$$\log(\text{radon}) = \text{site} + \text{sine(day)} + \text{cosine(day)} + \text{precip} + \text{press} + \text{wind} + \text{error}$$

Parameter estimates for coefficients of covariates are presented in Table 13.

Table 13. Parameter estimates for coefficients of covariates.

Factor	estimate	std error
sine(day)	0.1344	0.0236
cosine(day)	0.2296	0.0438
precipitation	5.094	0.6953
air pressure	0.1997	0.0777
wind speed	-0.00469	0.00207

The most important factor is "site", which is to say that variation between different sites overshadowed the effects of meteorologic and soil characteristics that were measured. One site, in particular (site 5) was substantially different from the other sites, and this difference accounted for a large portion of the observed variability in soil-gas radon levels.

The factor "day of year" was modelled as the equivalent of

"$\beta\cos(2\pi t/366+\Phi)$". A shifted cosine curve over the year was not, nor was expected to be, a perfect fit, but it indicates the basic pattern of soil-gas radon levels anticipated over a year's time. Various polynomial fits (up to order 4) were considered as alternatives, but none improved on the conceptually more satisfying cosine curve modelling of time. We conclude that a rough cycling over the year is expected and fits the present data. An alternative is to simply use individual days as blocks, and this approach does improve the model fit, but such an approach also fails to reveal the overall shape of movement in soil-gas radon levels throughout the year.

Translating the two time factors into their more interpretable equivalent, we find the estimated term "$0.266 \cos\{(2\pi t-30.8)/366\}$", that is the cycle peaks about the end of January or the beginning of February and reaches a low soil-gas radon level about the end of July or the beginning of August.

Accumulated precipitation is the most important of the observed covariates. The precipitation measure used is actually an exponentially weighted moving average of past precipitation of the form:

$$.06\ \text{Precip}_{t-1}+.06(.94)\ \text{Precip}_{t-2}+.06(.94)^2\ \text{Precip}_{t-3}+\ldots.$$

In this formula, the time increment t is in days and the weight 0.06 was chosen empirically from the data, although similar results could have been obtained using any weights between 0.05 and 0.15. Unfortunately only regional rainfall measures were available, and site-to-site variation in true precipitation could account for further errors. Note that increased accumulated precipitation is related to increased soil-gas radon levels. The hypothesis that surficial soil moisture forms a partial cap that inhibits soil-gas radon diffusion from the soil may account for the modest but clear relation with moisture.

Air pressure was measured in a variety of ways, including lagged pressure and change in pressure, but simple measures of air pressure on the day of measurement proved to be most closely related to soil-gas radon. The relationship is not strong, but indicates that for this study, lower air pressure correlated with lower soil-gas radon levels. Other studies (Asher-Bolinder, Owen, and Schumann, 1991) indicate an opposite relationship, with lower air pressure correlating with increased soil-gas radon. It must be noted that the majority of the site by site correlations indicate that lower air pressure correlates with higher soil-gas radon, but the correlations of significance generally indicate that lower pressure correlates with lower soil-gas radon. The reasons for these contradictions are not understood.

Wind is moderately correlated to soil-gas radon with the overall site data. The direction of association (negative) is somewhat consistent with previous studies (Asher-Bolinder, Owen, and Schumann, 1991) that indicate that gusting winds can cause a decrease in soil-gas radon concentrations.

Other factors measured but not included did not significantly improve the explanatory power of the model in the presence of the selected factors. These include soil moisture and time of day. It appears likely that factors other than those measured also play a role, and these unknown extraneous factors could also affect the inferred value of variables that were measured. The reasons for soil-gas radon variability do not appear to be fully understood.

Errors in the selected model are modestly autocorrelated over time, but fitting a more complicated model of this type changes parameter estimates only slightly. Autocorrelations may be in part an artifact of the imperfection of the cosine fit for day-of-year. Autocorrelations were also expected for hourly observations, but these data failed to disclose such a pattern. In fact, no consistent pattern of diurnal variation was found for sites taken together, and previously reported patterns of diurnal variation were not clear in the current study.

RELATIONSHIPS BETWEEN SOIL-GAS RADON, SURFICIAL MATERIALS, AND BEDROCK

Each of the twelve sample sites in this study area were located on a distinct soil type, geomorphic feature, or surficial deposit, and were underlain by a variety of geologic formations. Geomorphic features or surficial deposits represented in the study include gravel-capped benches, alluvial fans, surfaces, terraces, alluvium, colluvium, and slope wash. Geologic formations represented in the study include the Niobrara Formation, Frontier Formation/Mowry Shale, Cloverly Formation/Morrison Formation, Sundance Formation, Chugwater Formation, Satanka Shale, and the Casper Formation.

Source areas for surficial materials should be of significance if surficial materials contribute significantly to soil-gas radon levels. Source areas for surficial materials in the study area are generally existing or ancestral streams, intermittent streams, or floods that drained the Laramie Mountains; existing or ancestral rivers that drained the Medicine Bow Mountains; and weathered bedrock exposures. The geologic formations that underlie the surficial materials may also contribute significantly to the presence or absence of soil-gas radon in the surficial materials. In order to determine if either surficial materials or the underlying bedrock were having the most significant influence on soil-gas radon levels in the surficial materials and soils, a variety of sites on similar surficial features that are underlain by different geologic formations would need to be sampled.

Four sample sites (sites 1, 2, 6, and 10) were located on soils, features or deposits associated with existing or ancestral streams, intermittent streams, or floods that drained the Laramie Mountains. Those four sites, which all had mean soil-gas radon levels in the low soil-gas radon range (0-250 pCi/L), were underlain by the Chugwater Formation, Satanka Shale, or the Casper Formation.

Six sample sites (sites 3, 4, 5, 7, 11, and 12) were located on soils, features, or deposits associated with existing or ancestral rivers that drained the Medicine Bow Mountains. Sites 3, 4, 7, and 12 had mean soil-gas radon levels in the moderate soil-gas radon range (250-750 pCi/L), and were underlain by the Niobrara Formation, Frontier Formation/Mowry Shale, or the Cloverly/Morrison formations. Site 5 had a mean soil-gas radon level in the high soil-gas radon range (>750 pCi/L), and was underlain by the Niobrara Formation. Site 11, the last of the six sites associated with existing or ancestral rivers that drained the Medicine Bow Mountains, had a mean soil-gas radon level in the low soil-gas radon range (0-250 pCi/L), and was underlain by the Sundance/Chugwater formations.

The last two sites (sites 8 and 9) in the study area were located on soils, features, or deposits derived from the weathering of Chugwater Formation exposures in the Laramie area. Those two sites were split in their classifications, with site 8 in the low soil-gas radon range (0-250 pCi/L) and site 9 in the moderate soil-gas radon range (250-750 pCi/L).

There are not enough data to determine if either surficial features/deposits or bedrock are controlling soil-gas radon levels. Most sites with soil-gas radon levels in the low range were located along the far eastern margin of the Laramie Basin. Those sites were generally covered by surficial deposits associated with existing or ancestral streams draining the Laramie Mountains, and were underlain by the Chugwater Formation, the Satanka Shale, and the Casper Formation. Most sites with soil-gas radon levels in the moderate to high ranges were located in the eastern to central portions of the Laramie Basin. The moderate to high range sites were usually covered by surficial deposits associated with existing or ancestral rivers draining the Medicine Bow Mountains, and were generally underlain by the Niobrara Formation, Frontier Formation/Mowry Shale, or the Cloverly and Morrison formations. There was little overlap in the geologic formations that underlie surficial deposits associated with the low soil-gas radon range sites and those that underlie surficial deposits associated with the moderate to high soil-gas radon range sites. Future studies with additional sample localities will address this problem in more detail.

SUMMARY

The primary purpose of this study was to determine if relative soil-gas radon relationships that were observed among twelve sites during one sample period (traverse) were repeatable. A secondary purpose of this study was to investigate the relationships between soil-gas radon and various meteorologic and soil (moisture and temperature) factors. In addition to the two primary purposes of the research, soil-gas radon data for all sites were to be compared to the geomorphic features, surficial deposits, and bedrock that the sites were located on in order to determine if any regional assessments could be made from only twelve sites.

Each sample period (traverse) was conducted in one day, and was composed of twelve sites. The same twelve sites were sampled for thirty-five weeks, and sites within each sample period were ranked from highest soil-gas radon level to lowest soil-gas radon level. No two sample periods had the same site rankings. This indicated that when comparing site rankings from sample period to sample period, repeatability was low.

Results were somewhat better when sites were grouped into soil-gas radon ranges, and the relationships between the grouped sites were compared. A low range (0-250 pCi/L), a moderate range (250-750 pCi/L), and a high range (>750 pCi/L) for soil-gas radon were observed in the study. Six sites with a mean soil-gas radon level of 181.3 pCi/L were located in the low range, five sites with a mean soil-gas radon level of 367.6 pCi/L were located in the moderate range, and one site with a mean soil-gas radon level of

1236.7 pCi/L was located in the high range. Using the grouping technique, 23% of the sample periods (traverses) had identical groupings of sites, without regard to the order of sites within any group.

Obviously, a single sample period (traverse) may not accurately represent soil-gas radon relationships between sites sampled in an area. The Statistics Department at the University of Wyoming determined how many sample periods were needed to statistically differentiate the twelve sites in this study. In order to distinguish sites with mean radon levels that differ by more than 50% apart, thirteen sample periods would be needed for the twelve sample sites. If it was necessary to distinguish sites with mean radon levels less than 50% apart, more sample periods would be needed.

There is a complex relationship between soil-gas radon and meteorologic and soil (moisture and temperature) factors. Relationships were not consistent from site to site, and at a few sites relationships varied over time. A few statistically valid correlations can be made when examining the complete data set, however.

A significant positive correlation was found between soil-gas radon and precipitation. As precipitation increased, so did soil-gas radon levels. The precipitation may have wetted the surficial layer of the soils to the point where a "cap" was formed. The "cap" would slow the movement of radon to the atmosphere, allowing radon levels to increase.

There also appeared to be a correlation between soil-gas radon and air pressure, although the correlation appears to be weakly positive. Previous research indicates that there should be a negative correlation between soil-gas radon and air pressure (Asher-Bolinder, Owen, and Schumann, 1991). The reasons for this apparent conflict are unknown. There also appears to be a weak negative correlation between wind speed and soil-gas radon, which is consistent with most previous research (Asher-Bolinder, Owen, and Schumann, 1991).

Conflicting correlations were found between soil-gas radon and soil temperature or soil moisture. When sample sizes were small (13), as they were for half of the sites, significant correlations between soil-gas radon and both soil factors were negative. When sample sizes were larger (26), as they were for the other half of the sites, significant correlations between soil-gas radon and both soil factors were positive. While it was not determined what sample size would be statistically significant for both meteorologic and soil factors, it appears that a sample size of 13 for each site may not be adequate. No correlations were found between soil-gas radon and air temperature or relative humidity.

There is not enough data to determine if either surficial features/deposits or bedrock are controlling soil-gas radon levels. Most sites with soil-gas radon levels in the low range (0-250 pCi/L) were located along the far eastern margin of the Laramie Basin. The low range sites were generally covered by surficial deposits associated with existing or ancestral streams draining the Laramie Mountains, and were underlain by the Chugwater Formation, the Satanka Shale, and the Casper Formation. Most sites with soil-gas radon levels in the moderate (250-750 pCi/L) to high (>750 pCi/L) ranges were located in the eastern to central portions of the Laramie Basin. The moderate to high range sites were usually covered by surficial deposits associated with existing or ancestral rivers draining the Medicine Bow Mountains, and were generally underlain by the Niobrara Formation, Frontier Formation/Mowry Shale, or the Cloverly and Morrison formations. There was little overlap in the geologic formations that underlie the surficial deposits associated with low soil-gas radon range sites and those that underlie the surficial deposits associated with moderate to high soil-gas radon range sites. Future studies will attempt to determine if surficial deposits or the underlying bedrock most strongly control the levels of soil-gas radon in the surficial deposits. This needs to be done before any regional assessments can be made with any degree of certainty.

Not all soils, features, or deposits in the Laramie area were sampled. Future sampling may find sites with higher soil-gas radon levels in Laramie. The average soil-gas radon levels for the entire United States range from 500 pCi/L to 1500 pCi/L (Mike Reimer, U.S. Geological Survey, personal communication, 1992). The mean soil-gas radon levels for the low and moderate range sites in the Laramie Basin study were below the average U.S. ranges. The mean soil-gas radon level for the high range site in the Laramie Basin study was within the average U.S. range. The higher soil-gas radon levels in some areas may not mean that all homes in those areas are elevated in radon.

In summary, caution should be exercised in applying soil-gas radon data. Soil-gas radon relationships between sites and relationships between soil-gas radon and environmental factors may not be entirely repeatable from one sample period to another.

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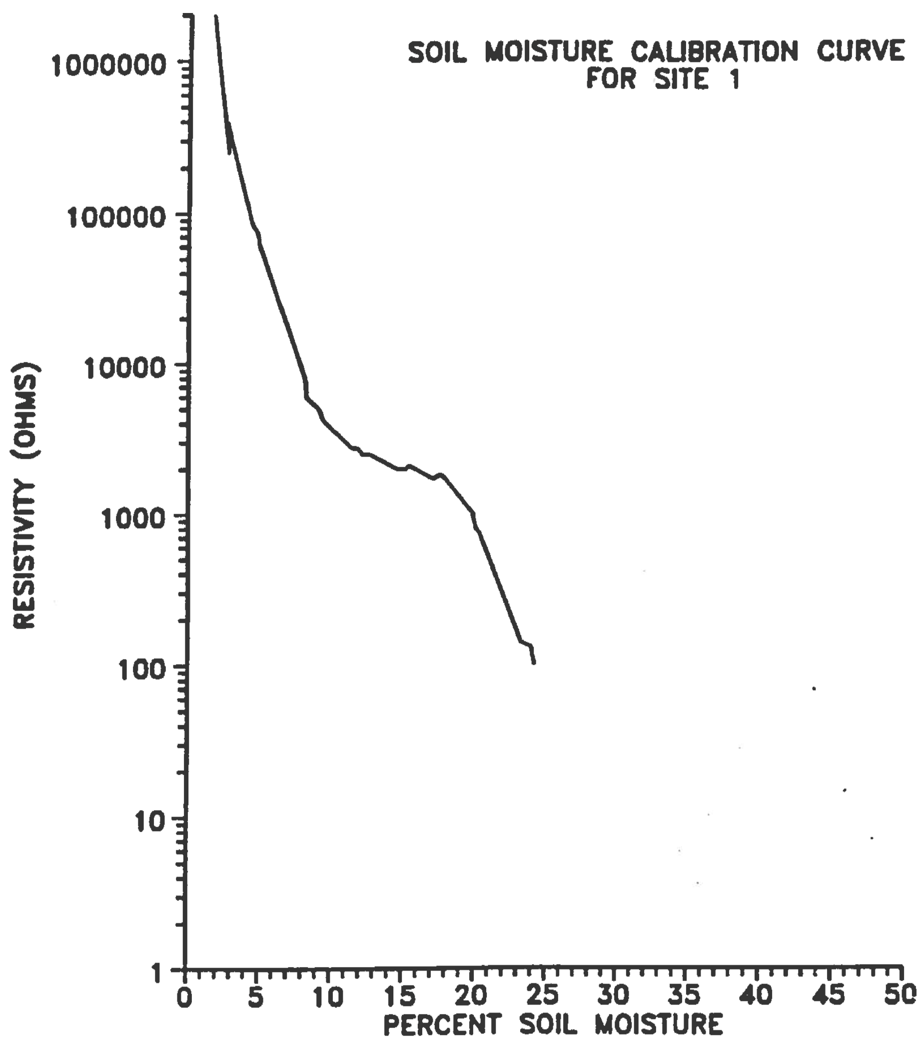
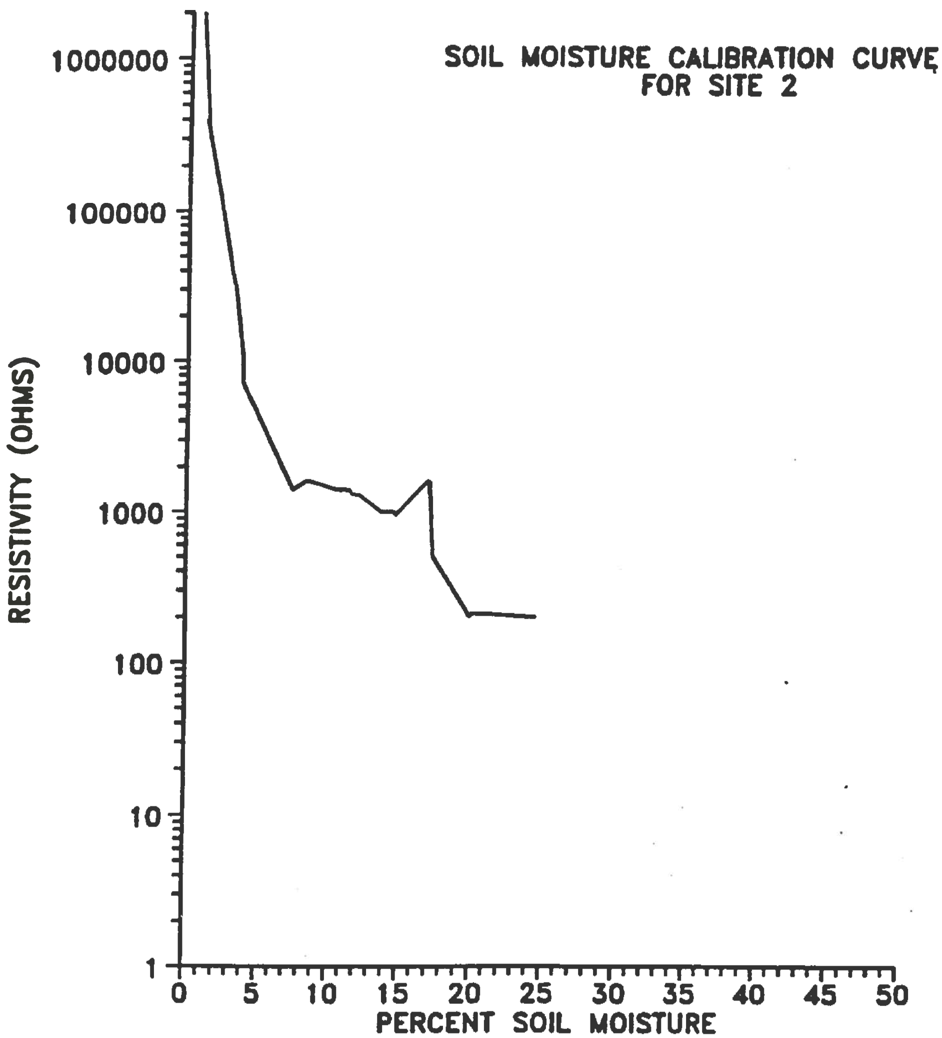
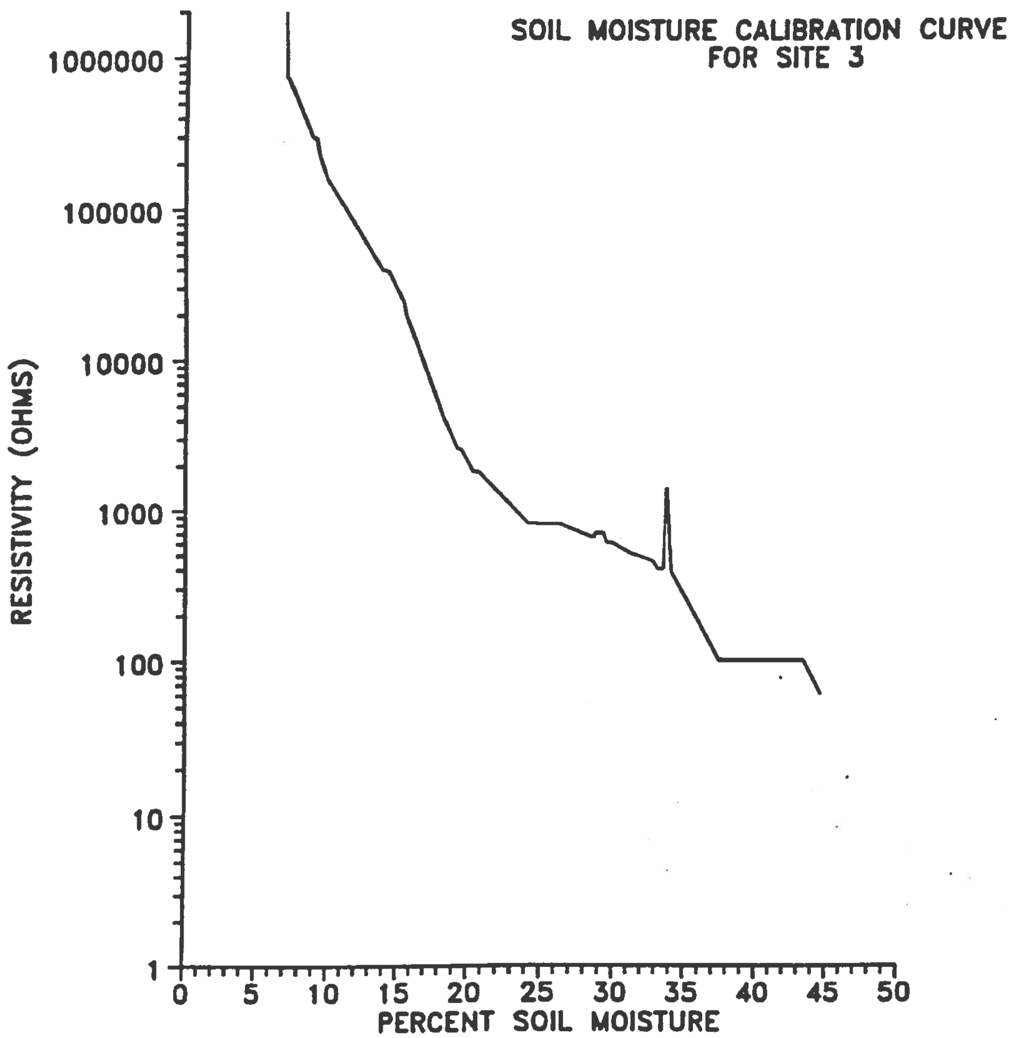
APPENDIX A

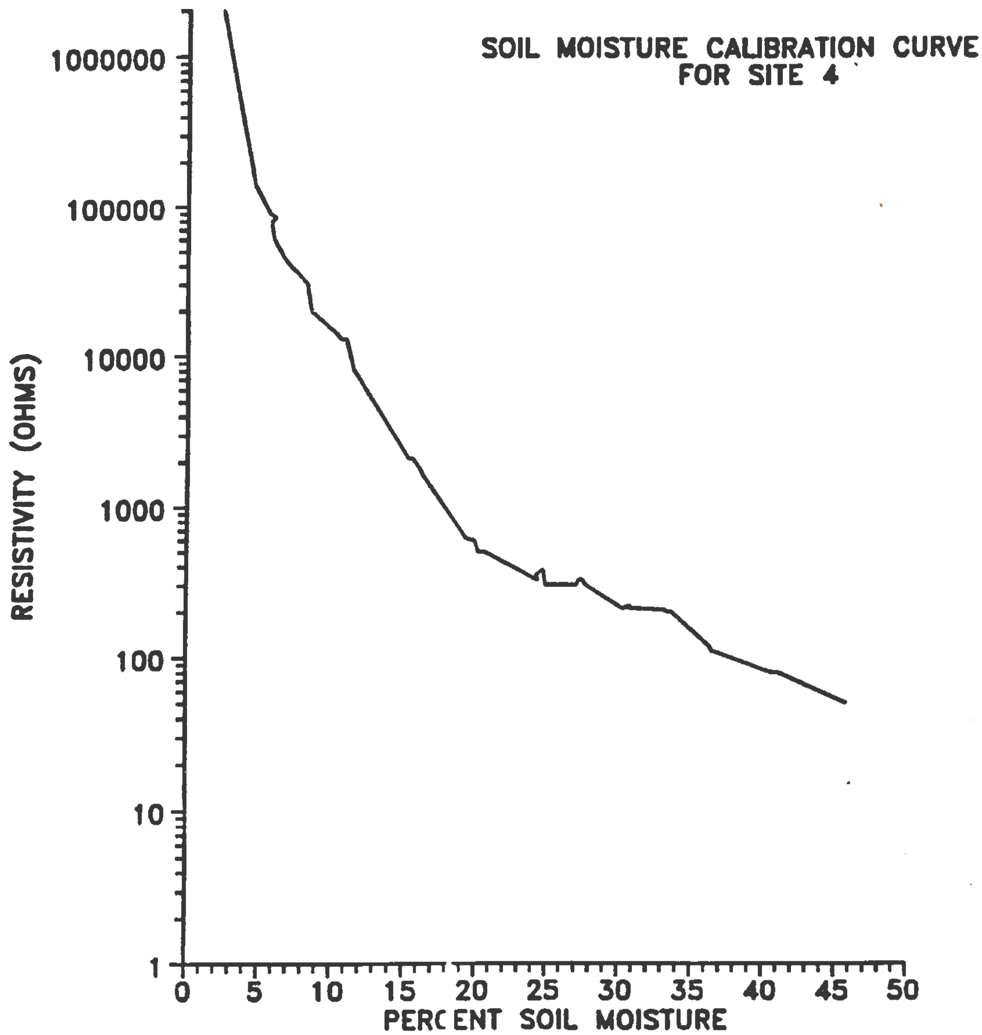
Soil Moisture Calibration Curves

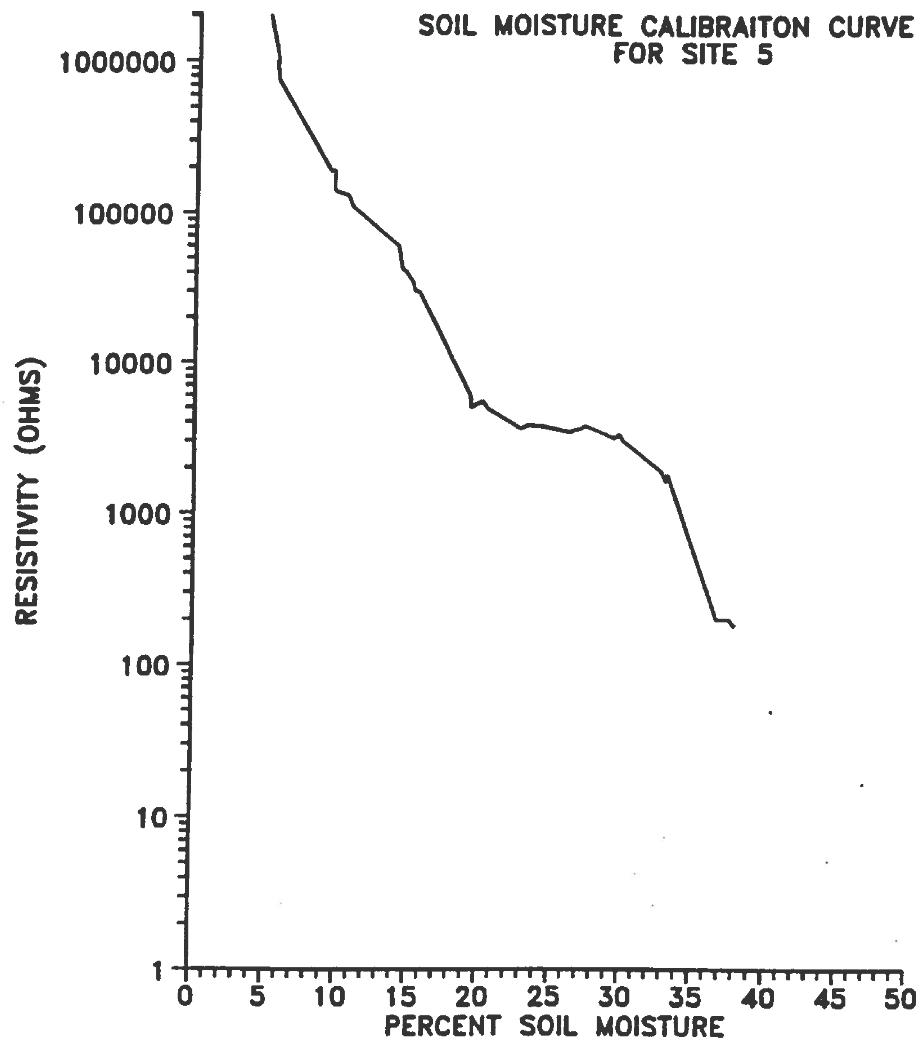


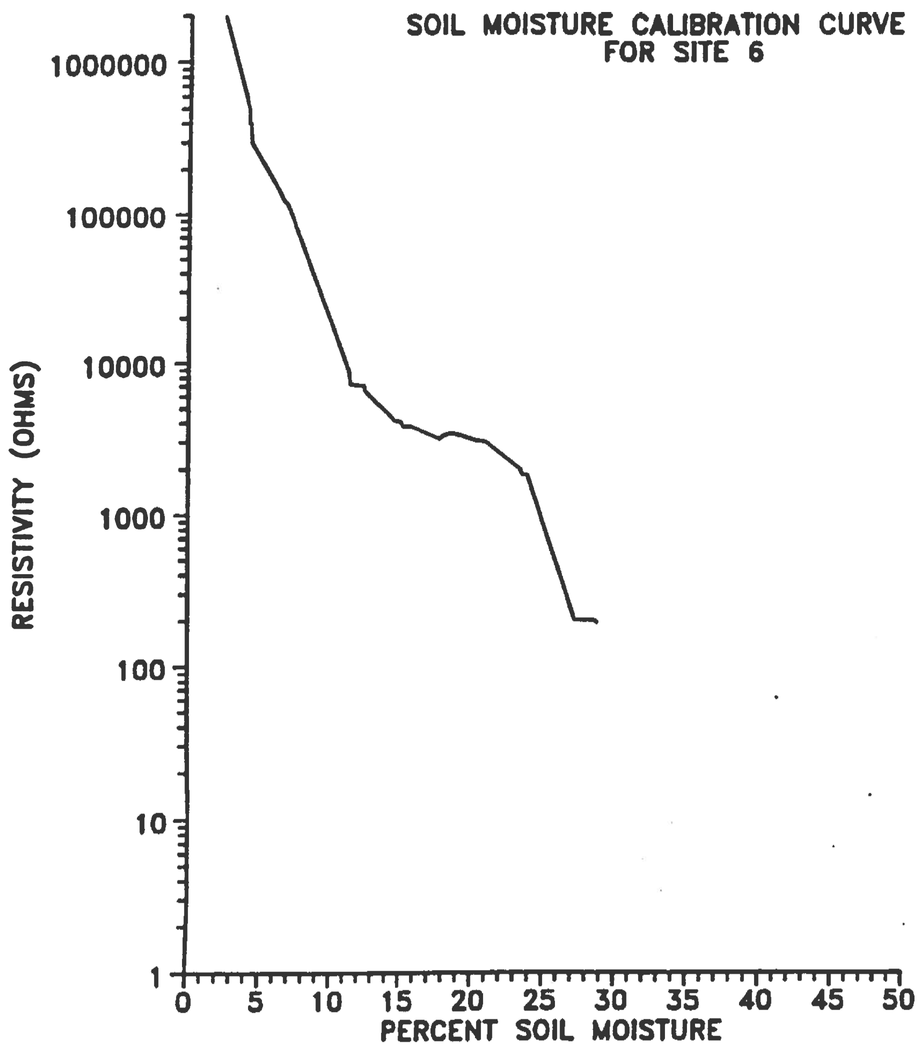
SOIL MOISTURE CALIBRATION CURVE
FOR SITE 1
1000000
100000
10000
1000
100
10
1
RESISTIVITY (OHMS)
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE

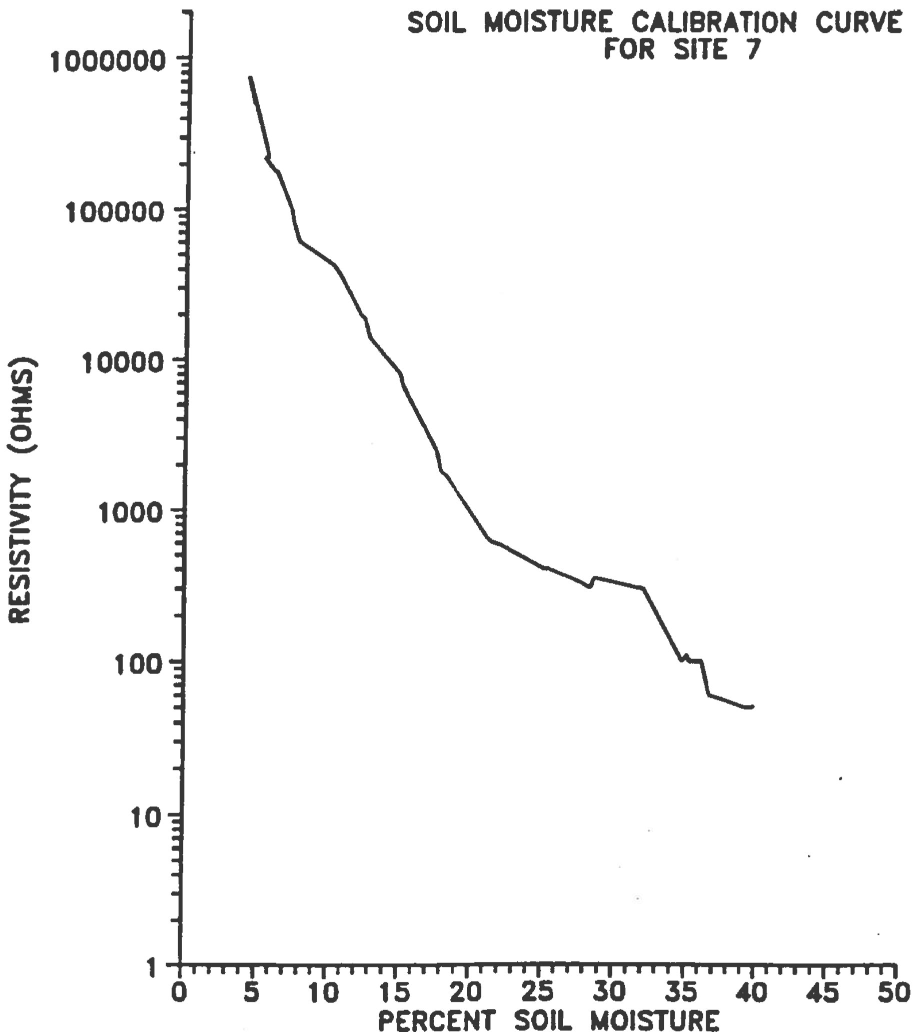

SOIL MOISTURE CALIBRATION CURVE
FOR SITE 2
RESISTIVITY (OHMS)
1000000
100000
10000
1000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE

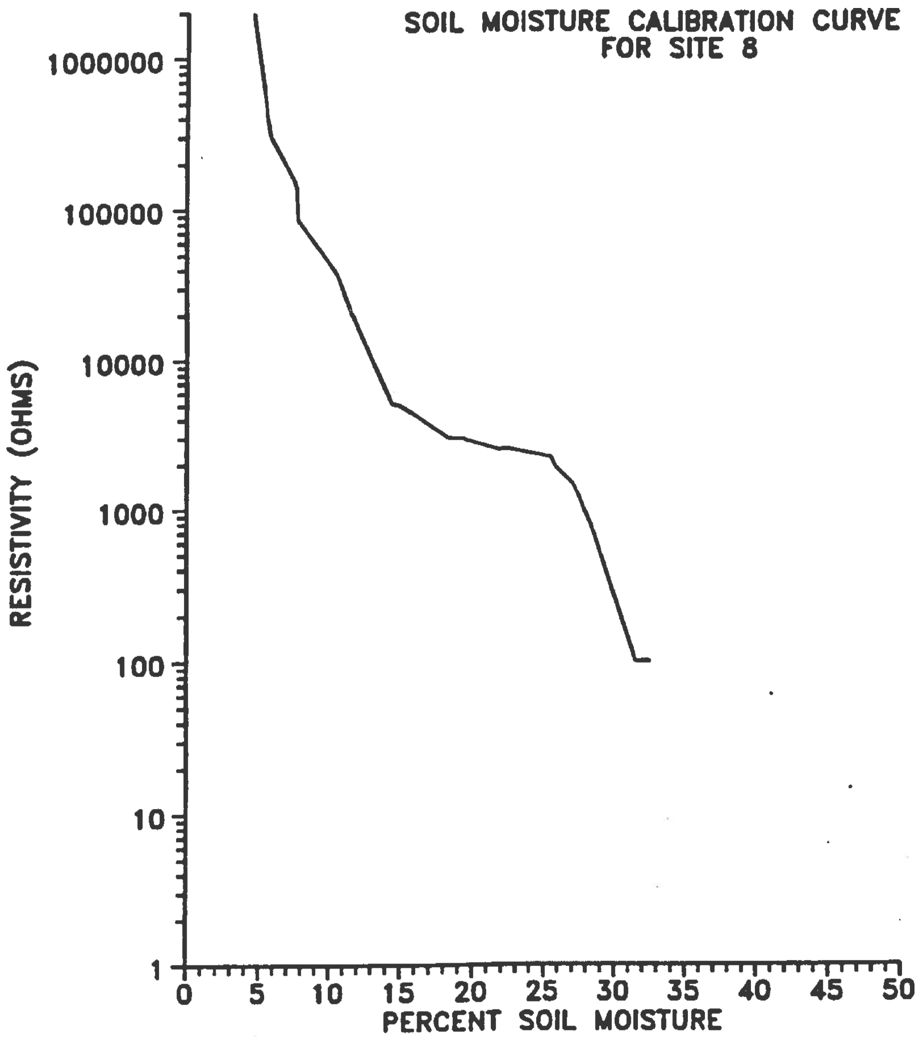

SOIL MOISTURE CALIBRATION CURVE
FOR SITE 3
RESISTIVITY (OHMS)
1000000
100000
10000
1000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE

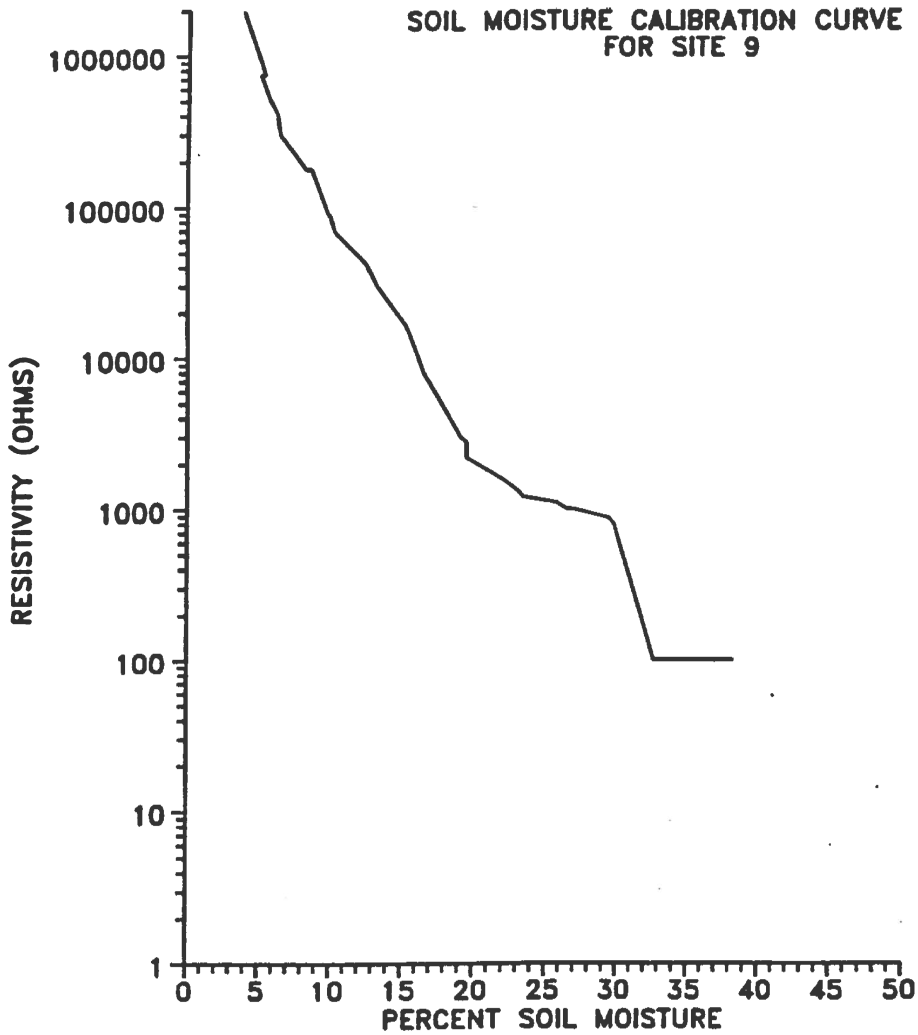

SOIL MOISTURE CALIBRATION CURVE
FOR SITE 4
RESISTIVITY (OHMS)
1000000
100000
10000
1000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE

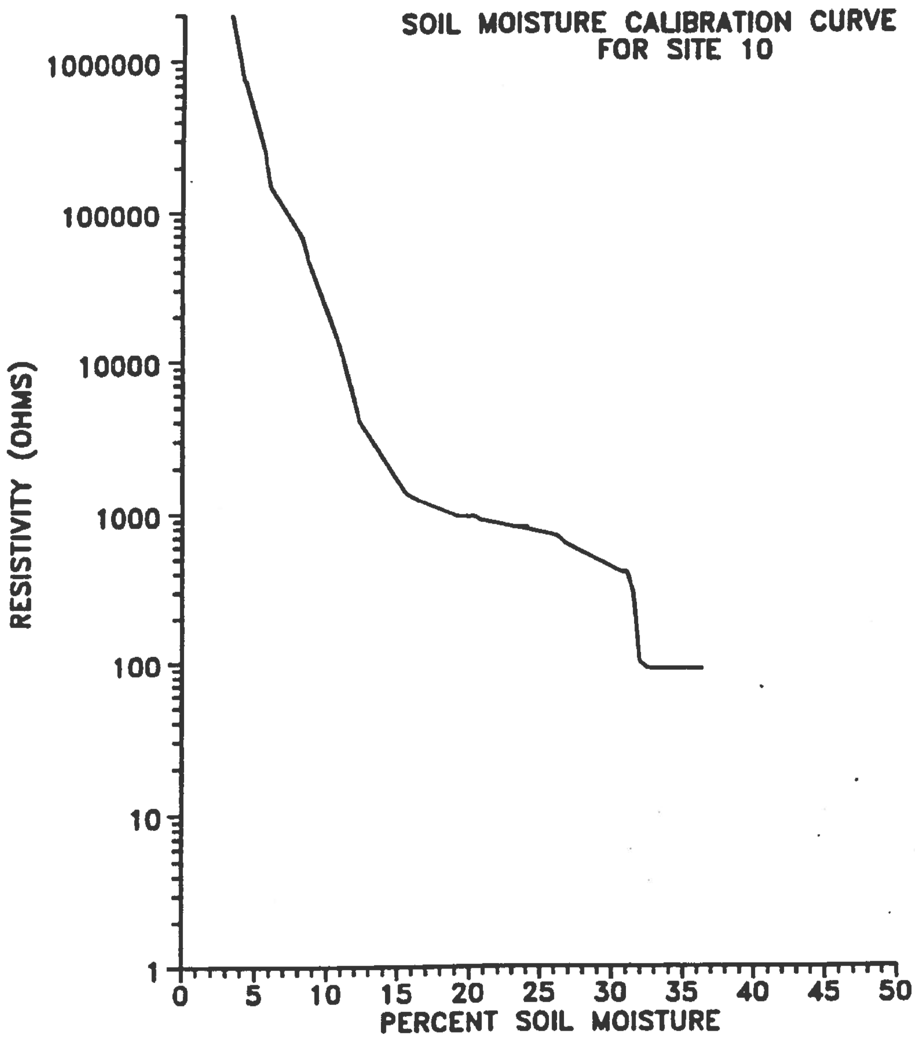

SOIL MOISTURE CALIBRAITON CURVE
FOR SITE 5
RESISTIVITY (OHMS)
1000000
100000
10000
1000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE

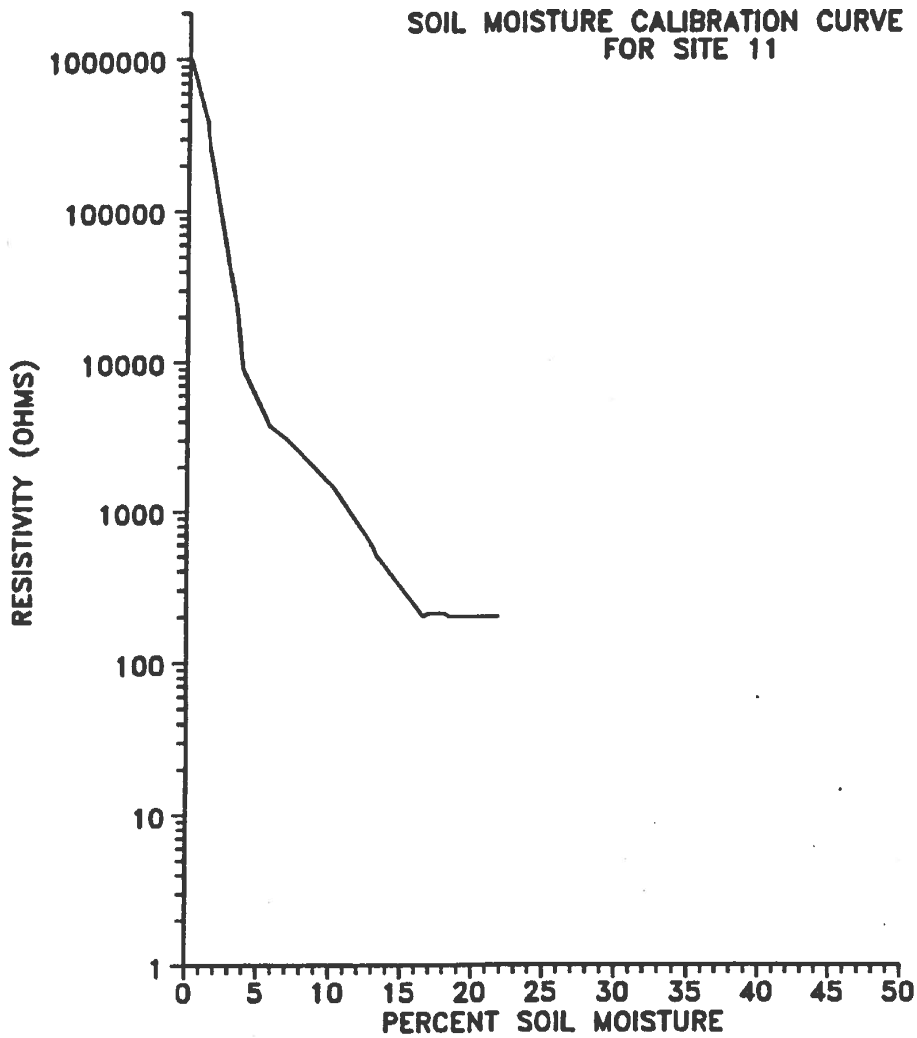

SOIL MOISTURE CALIBRATION CURVE
FOR SITE 6
RESISTIVITY (OHMS)
1000000
100000
10000
1000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE

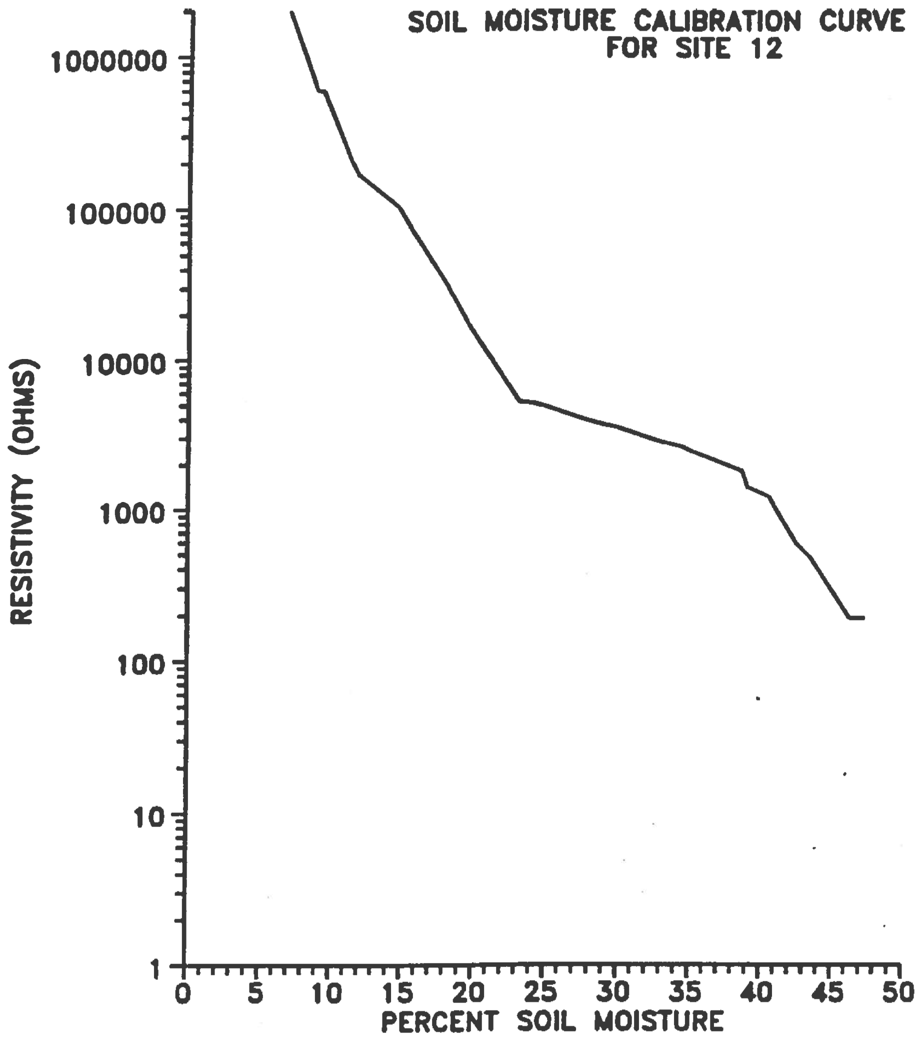

SOIL MOISTURE CALIBRATION CURVE
FOR SITE 7
RESISTIVITY (OHMS)
1000000
100000
10000
1000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE


SOIL MOISTURE CALIBRATION CURVE
FOR SITE 8
1000000
100000
10000
1000
100
10
1
RESISTIVITY (OHMS)
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE


SOIL MOISTURE CALIBRATION CURVE
FOR SITE 9
RESISTIVITY (OHMS)
1000000
100000
10000
1000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE

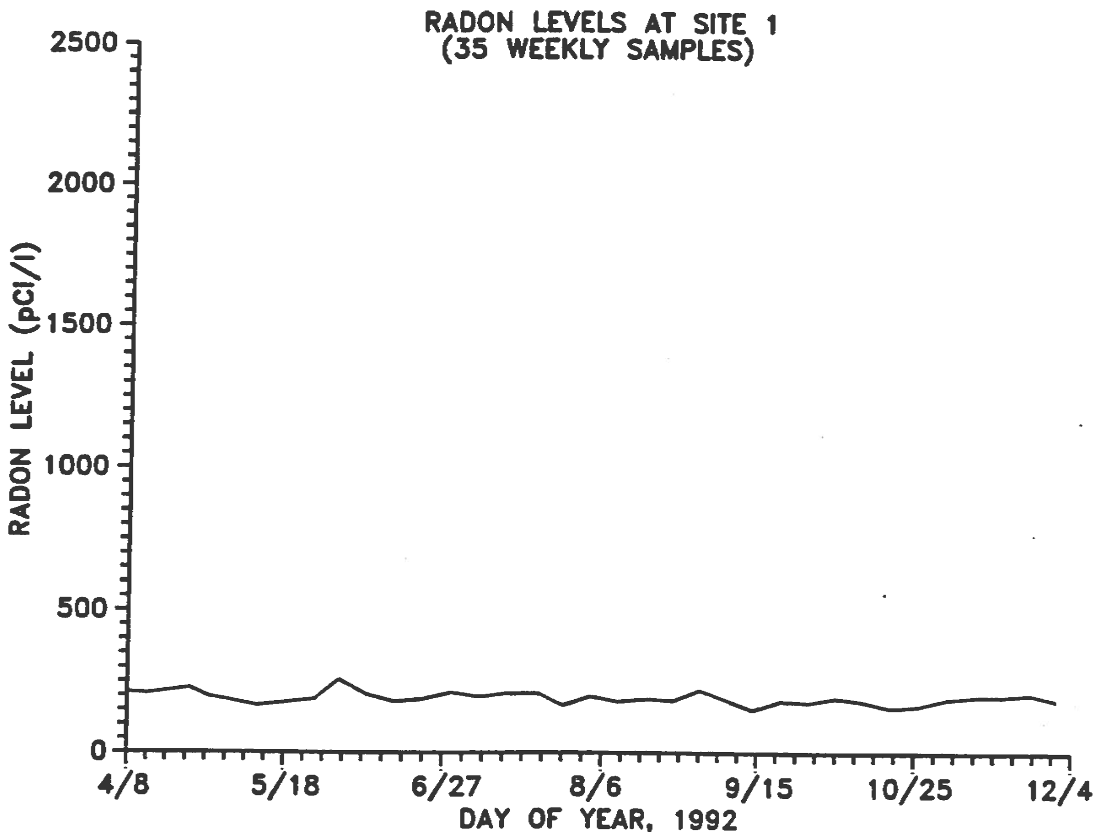

SOIL MOISTURE CALIBRATION CURVE
FOR SITE 10
RESISTIVITY (OHMS)
1000000
100000
10000
1000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE

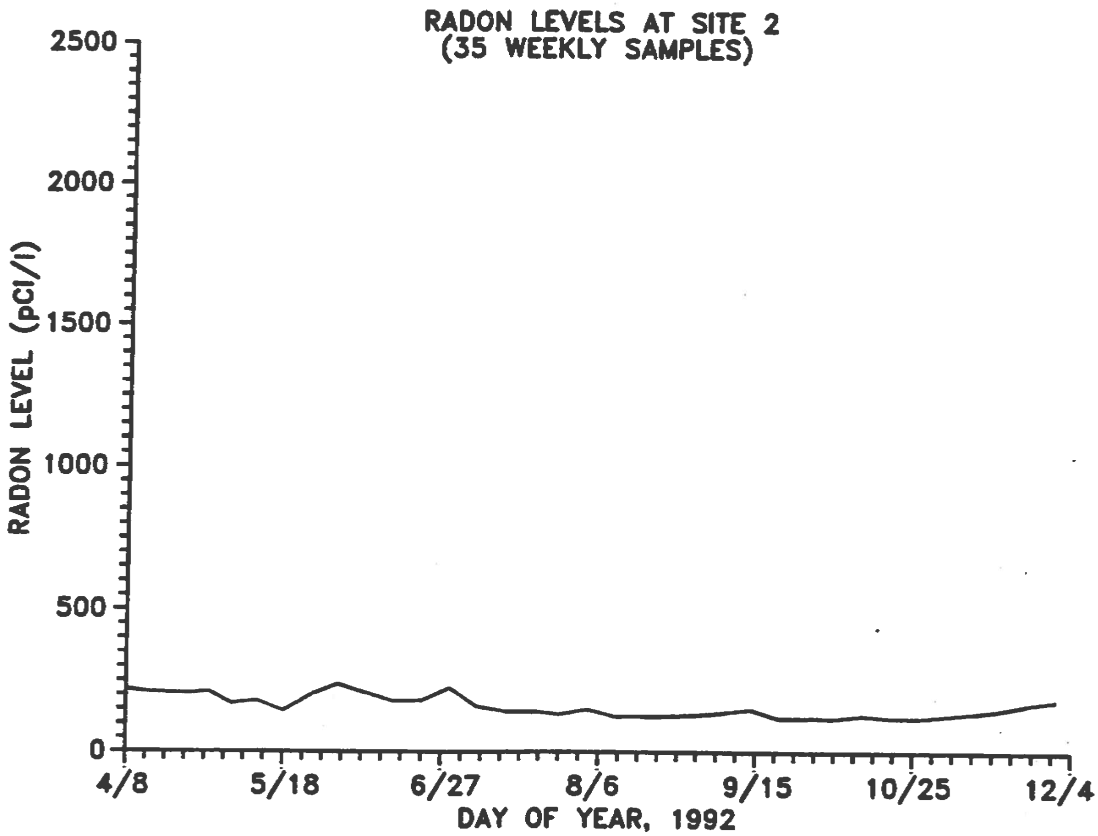

SOIL MOISTURE CALIBRATION CURVE
FOR SITE 11
RESISTIVITY (OHMS)
1000000
100000
10000
1000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE

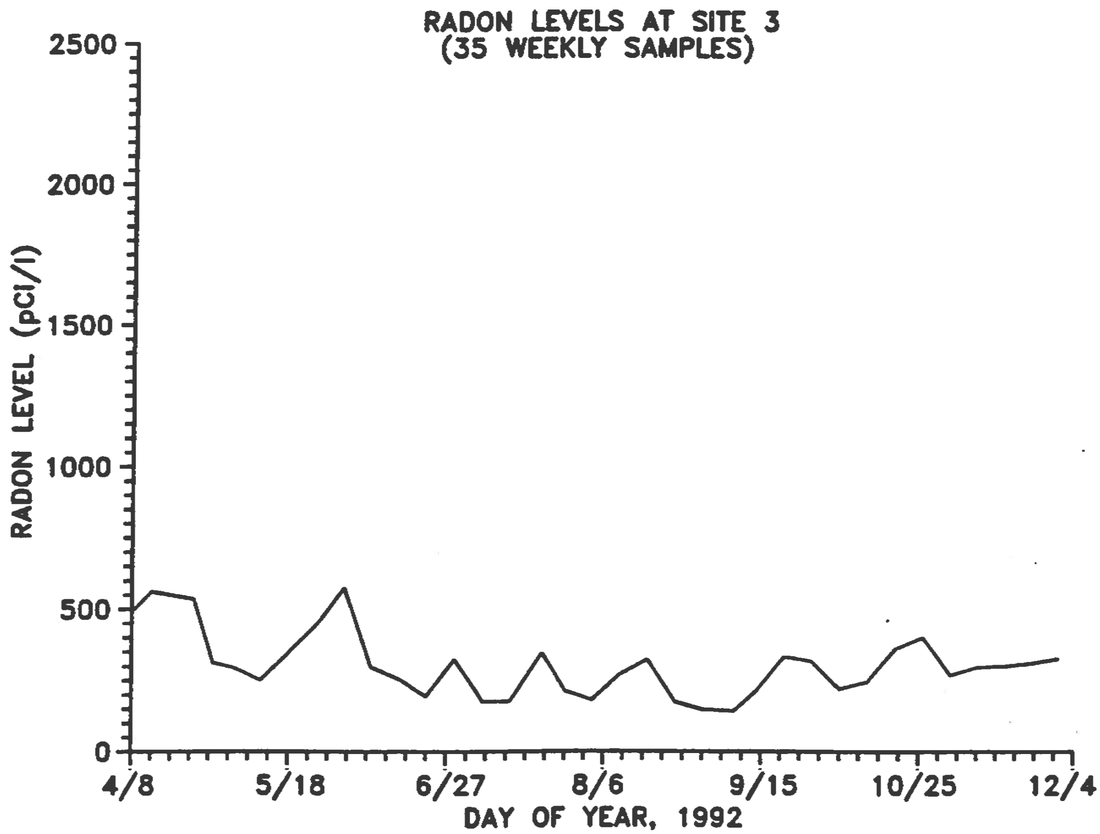

SOIL MOISTURE CALIBRATION CURVE
FOR SITE 12
RESISTIVITY (OHMS)
1000000
100000
10000
1000
100
10
1
0
5
10
15
20
25
30
35
40
45
50
PERCENT SOIL MOISTURE

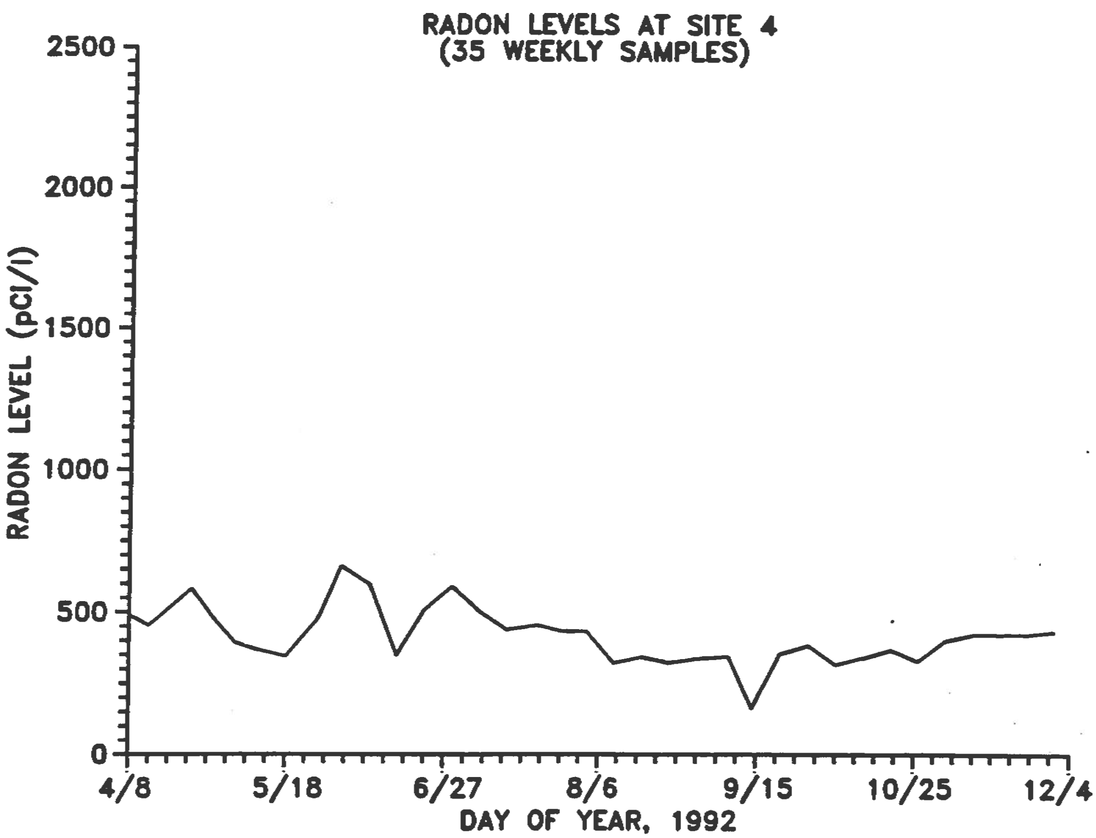
APPENDIX B

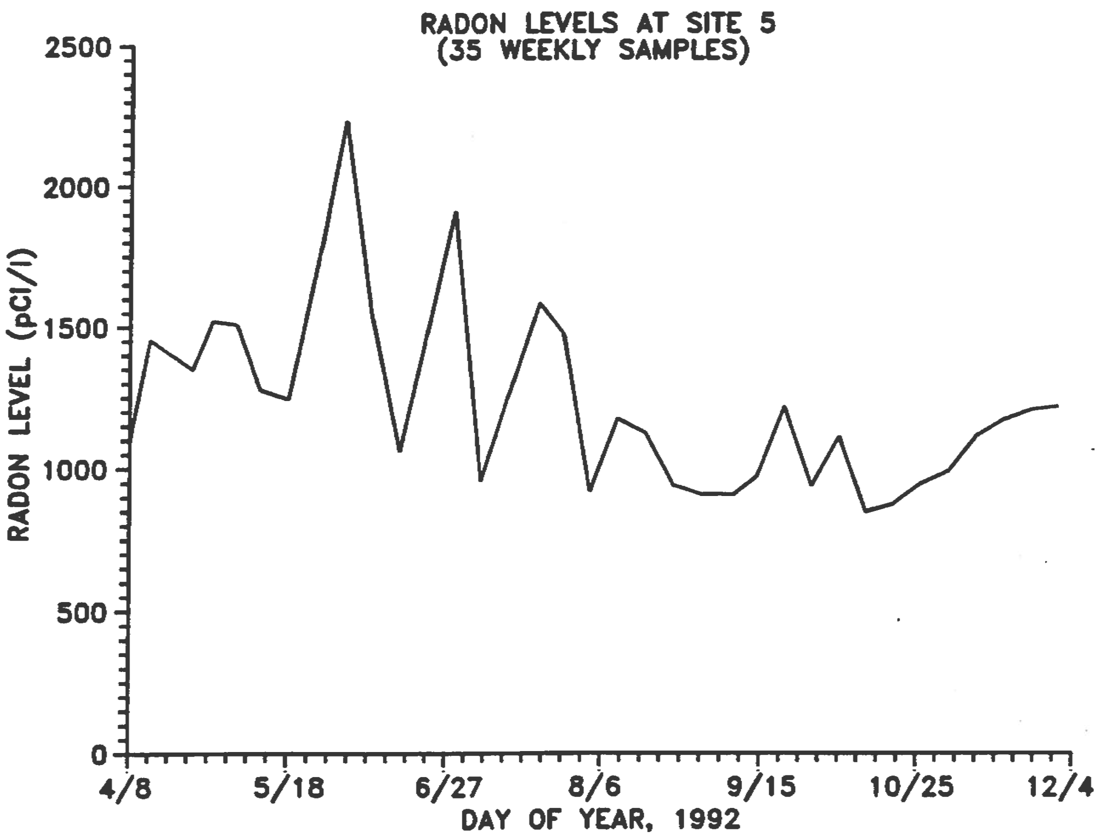
Plots of Weekly Soil-Gas Radon Concentrations by Site

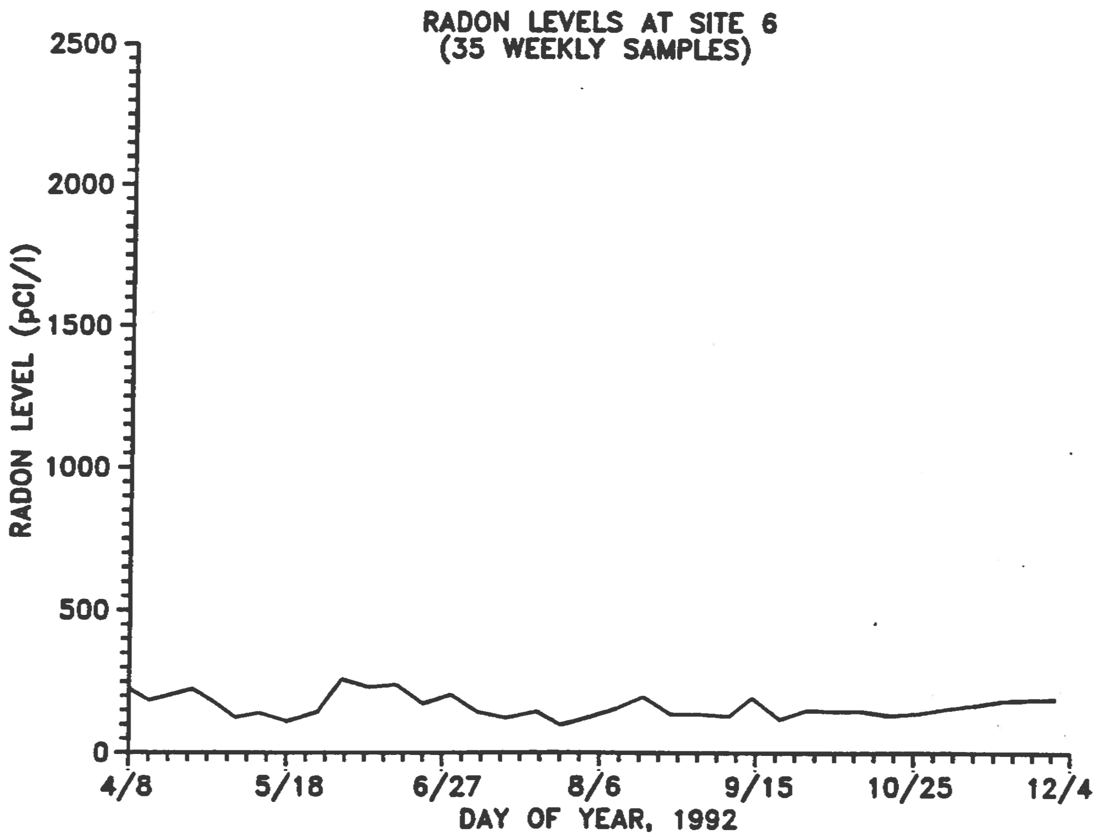

RADON LEVELS AT SITE 1
(35 WEEKLY SAMPLES)
2500
2000
1500
1000
500
0
RADON LEVEL (pCi/l)
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992

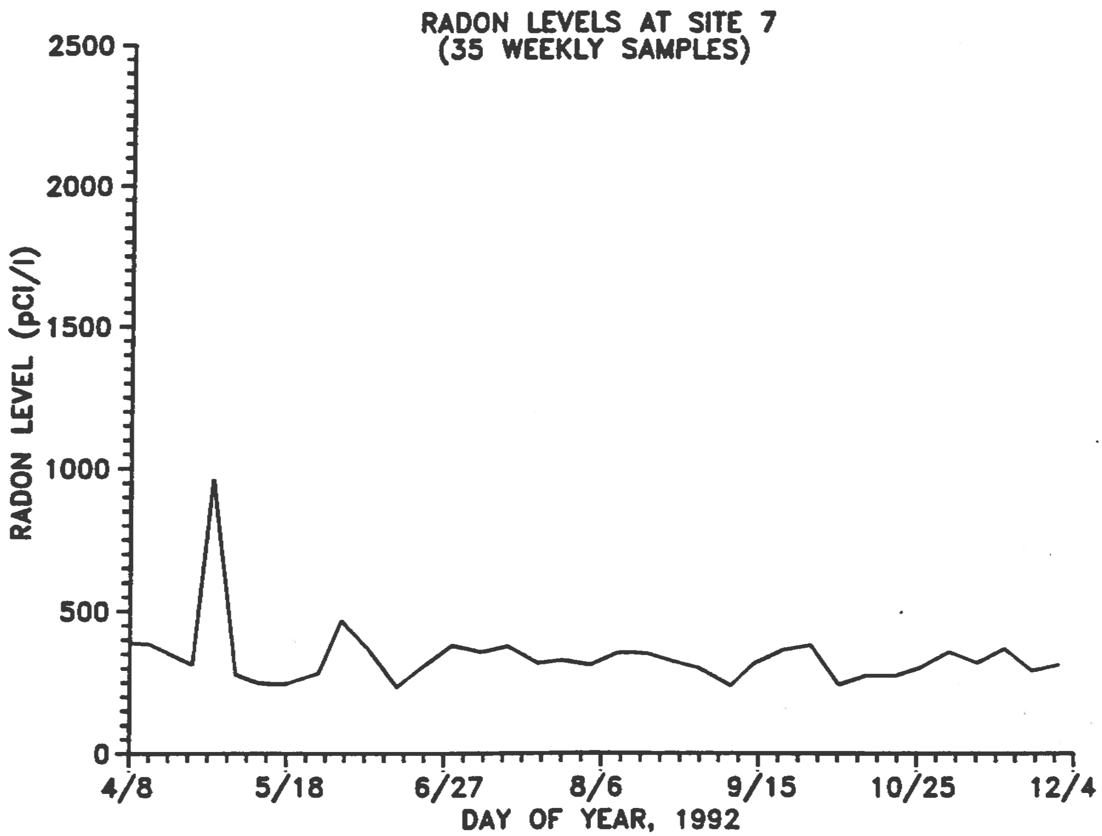

RADON LEVELS AT SITE 2
(35 WEEKLY SAMPLES)
2500
2000
1500
1000
500
0
RADON LEVEL (pCi/l)
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992

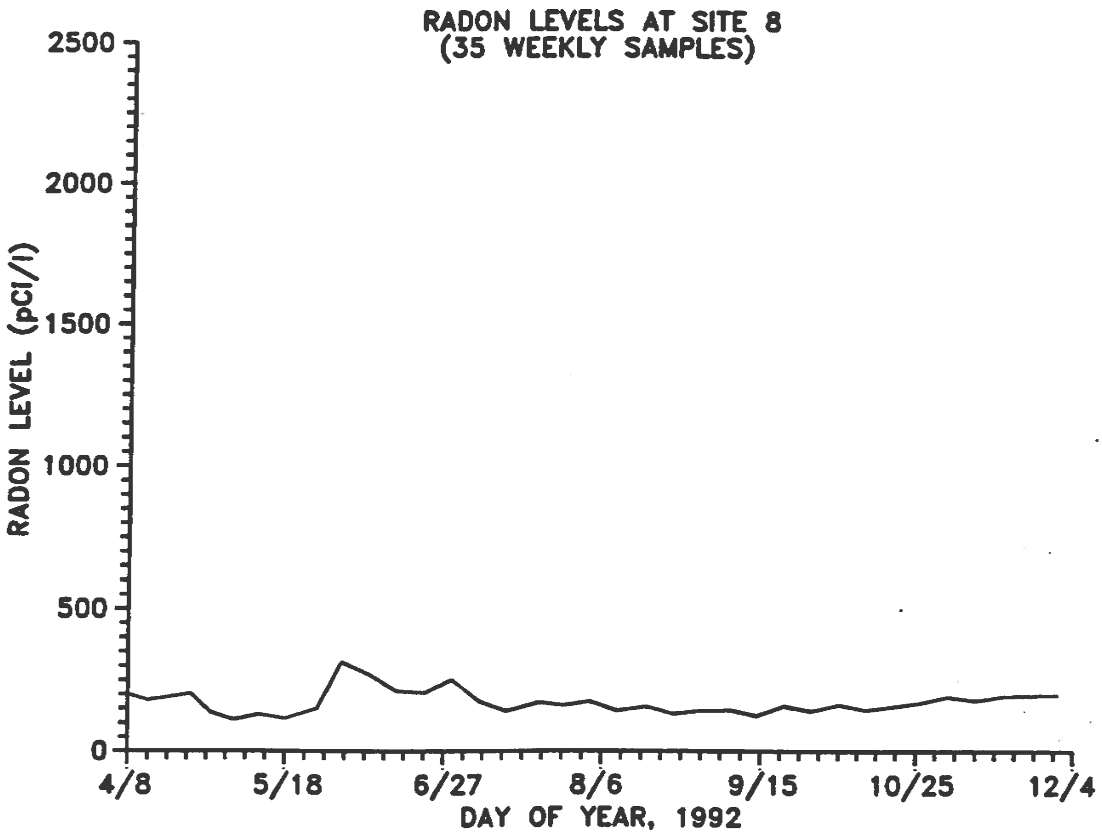

RADON LEVELS AT SITE 3
(35 WEEKLY SAMPLES)
RADON LEVEL (pCi/l)
2500
2000
1500
1000
500
0
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992


RADON LEVELS AT SITE 4
(35 WEEKLY SAMPLES)
RADON LEVEL (pCI/l)
2500
2000
1500
1000
500
0
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992

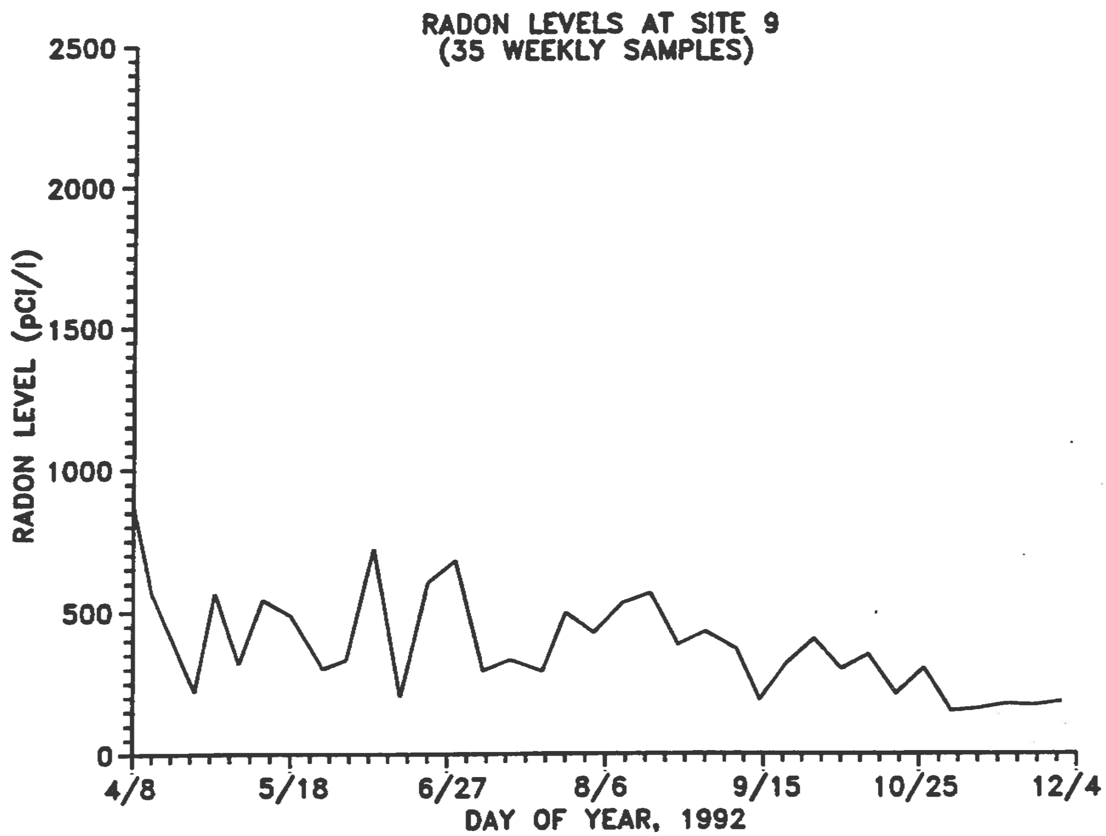

RADON LEVELS AT SITE 5
(35 WEEKLY SAMPLES)
2500
2000
1500
1000
500
0
RADON LEVEL (pCi/l)
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992

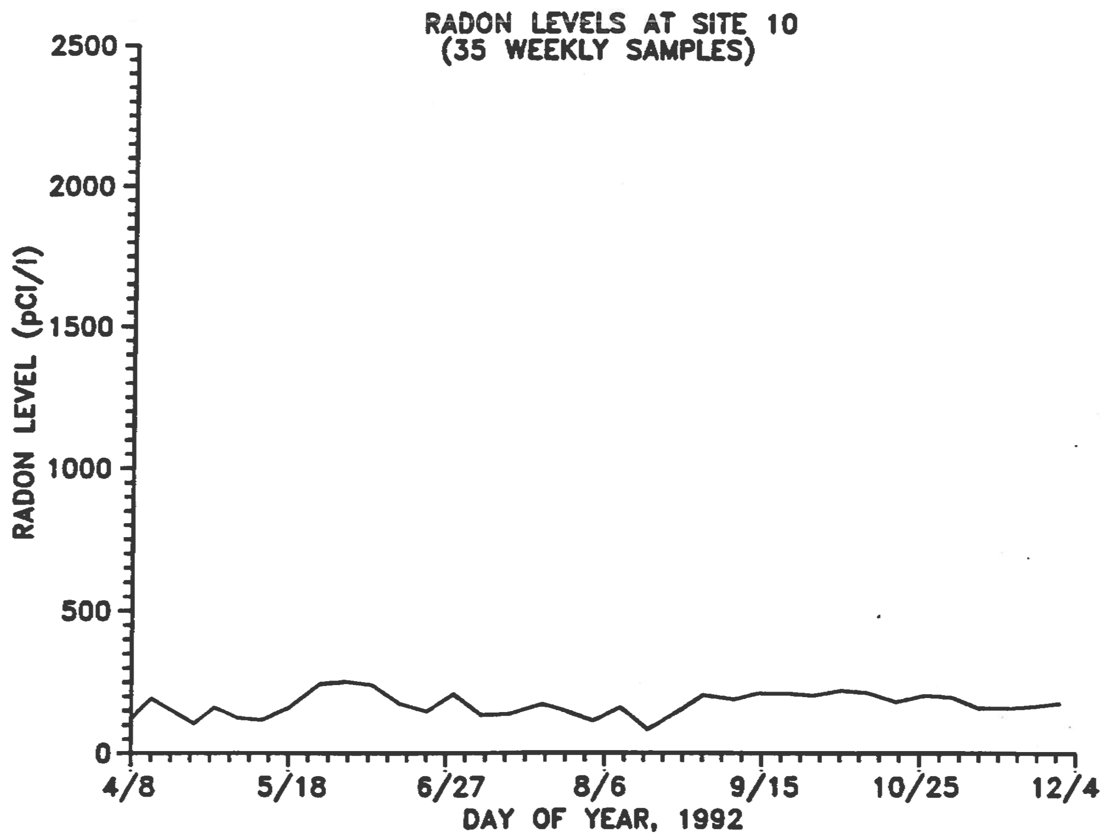

RADON LEVELS AT SITE 6
(35 WEEKLY SAMPLES)
2500
2000
1500
1000
500
0
RADON LEVEL (pCI/l)
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992

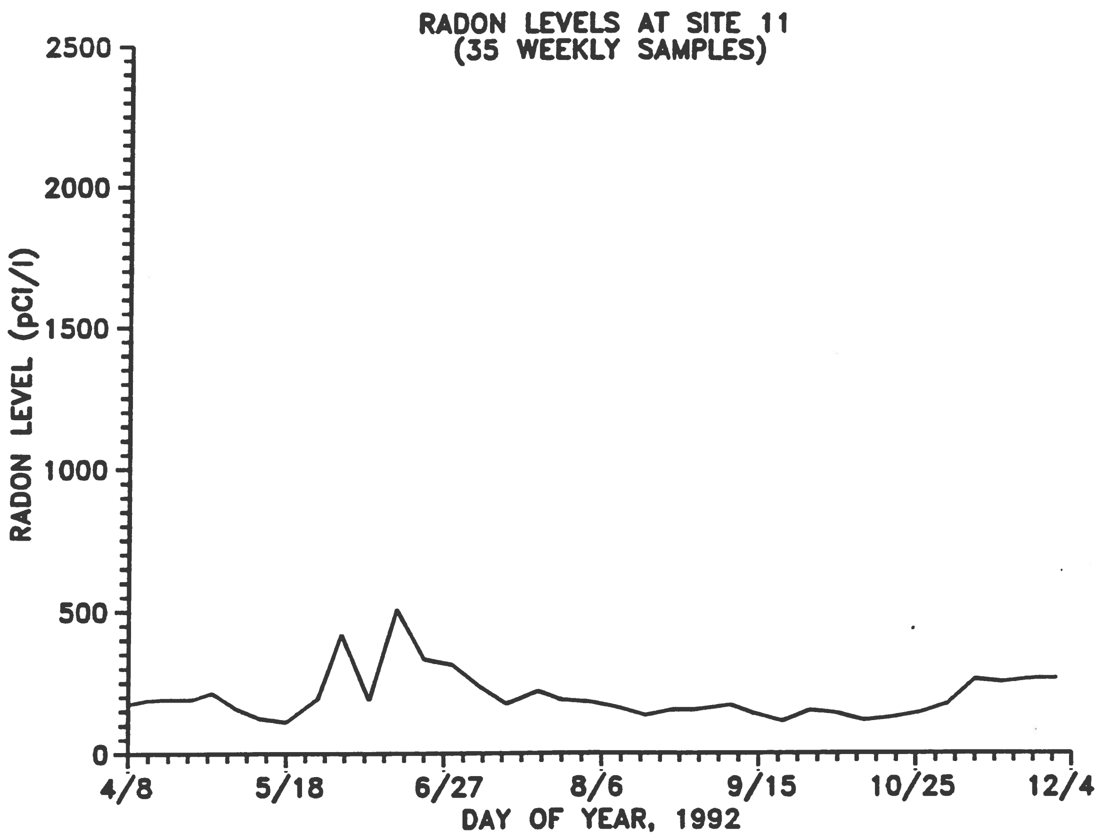

RADON LEVELS AT SITE 7
(35 WEEKLY SAMPLES)
2500
2000
1500
1000
500
0
RADON LEVEL (pCi/l)
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992

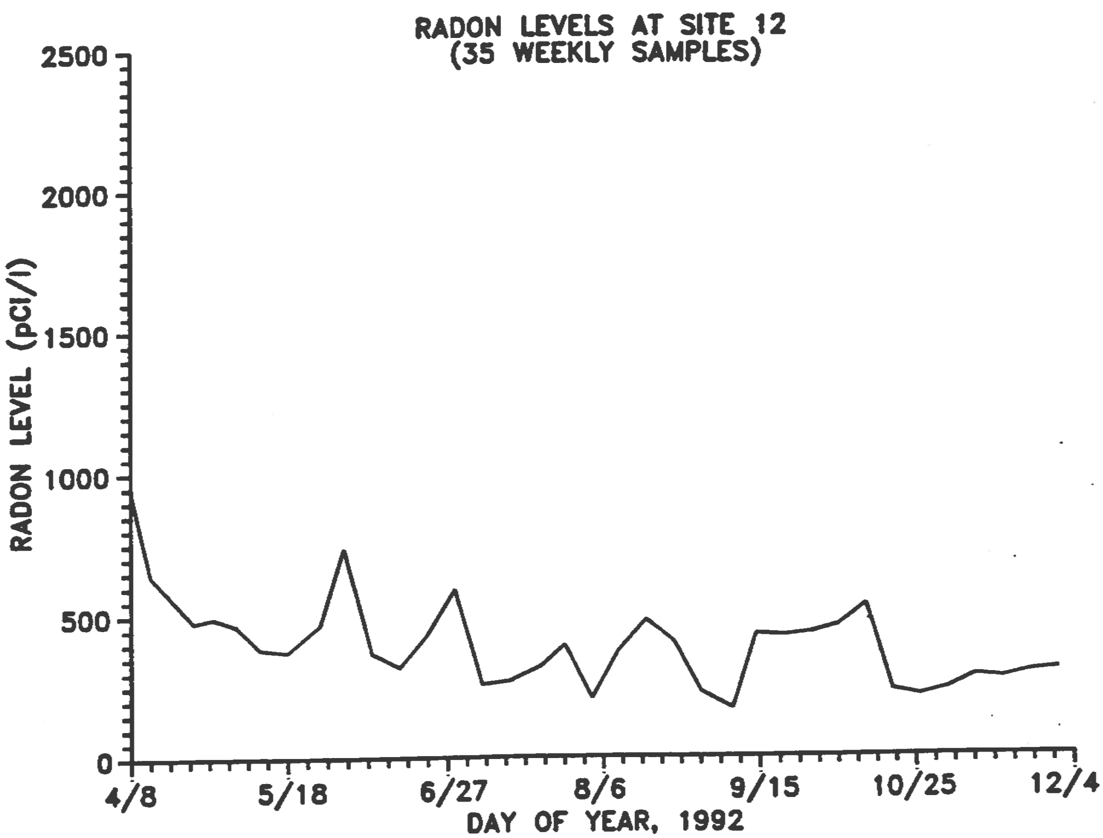


RADON LEVELS AT SITE 8
(35 WEEKLY SAMPLES)
2500
2000
1500
1000
500
0
RADON LEVEL (pCi/l)
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992


RADON LEVELS AT SITE 9
(35 WEEKLY SAMPLES)
RADON LEVEL (pCi/l)
2500
2000
1500
1000
500
0
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992


RADON LEVELS AT SITE 10
(35 WEEKLY SAMPLES)
2500
2000
1500
1000
500
0
RADON LEVEL (pCi/l)
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992


RADON LEVELS AT SITE 11
(35 WEEKLY SAMPLES)
RADON LEVEL (pCI/l)
2500
2000
1500
1000
500
0
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992


RADON LEVELS AT SITE 12
(35 WEEKLY SAMPLES)
RADON LEVEL (pCi/l)
2500
2000
1500
1000
500
0
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992

APPENDIX C

Soil-Gas Radon Data and Weekly Site Rankings

4/8/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1105.0
R11	12	933.1
R10	9	862.0
	---------- 750 pCi/L	
R9	3	490.6
R8	4	489.4
R7	7	387.5
	---------- 250 pCi/L	
R6	6	225.1
R5	2	219.7
R4	1	210.8
R3	8	201.0
R2	11	174.1
R1	10	122.2

4/13/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1453.4
	---------- 750 pCi/L	
R11	12	641.4
R10	3	562.2
R9	9	559.3
R8	4	453.4
R7	7	384.4
	---------- 250 pCi/L	
R6	2	210.6
R5	1	207.0
R4	10	193.4
R3	11	188.6
R2	6	185.1
R1	8	179.3

4/24/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1348.8
	---------- 750 pCi/L	
R11	4	582.8
R10	3	534.4
R9	12	477.5
R8	7	312.9
	---------- 250 pCi/L	
R7	1	227.7
R6	6	224.5
R5	9	221.0
R4	2	204.7
R3	8	203.2
R2	11	191.1
R1	10	104.2

4/29/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1519.8
R11	7	961.4
	---------- 750 pCi/L	
R10	9	562.7
R9	12	493.0
R8	4	488.2
R7	3	312.8
	---------- 250 pCi/L	
R6	11	213.1
R5	2	211.1
R4	1	196.7
R3	6	183.4
R2	10	160.6
R1	8	138.0

5/5/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1506.2
	---------- 750 pCi/L	
R11	12	465.0
R10	4	394.6
R9	9	317.4
R8	3	290.3
R7	7	278.1
	---------- 250 pCi/L	
R6	1	181.3
R5	2	168.7
R4	11	159.3
R3	6	123.5
R2	10	123.1
R1	8	111.0

5/11/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1276.3
	---------- 750 pCi/L	
R11	9	540.9
R10	12	383.2
R9	4	367.2
R8	3	250.6
	---------- 250 pCi/L	
R7	7	248.0
R6	2	179.2
R5	1	165.5
R4	6	140.5
R3	8	129.8
R2	11	124.9
R1	10	116.3

5/18/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1245.2
	---------- 750 pCi/L	
R11	9	484.8
R10	12	372.4
R9	3	346.9
R8	4	344.3
	---------- 250 pCi/L	
R7	7	245.9
R6	1	176.0
R5	10	159.9
R4	2	144.0
R3	8	114.0
R2	11	110.9
R1	6	110.7

5/26/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1779.6
	---------- 750 pCi/L	
R11	4	474.8
R10	12	465.9
R9	3	461.0
R8	9	299.9
R7	7	281.9
	---------- 250 pCi/L	
R6	10	245.7
R5	2	207.4
R4	11	192.6
R3	1	188.9
R2	8	150.8
R1	6	146.0

6/1/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	2230.7
	---------- 750 pCi/L	
R11	12	735.6
R10	4	661.1
R9	3	574.4
R8	7	466.7
R7	11	417.1
R6	9	331.2
R5	8	313.8
R4	6	259.9
R3	1	257.6
R2	10	252.3
	---------- 250 pCi/L	
R1	2	238.2

6/8/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1526.6
		---------------------- 750 pCi/L
R11	9	719.8
R10	4	598.0
R9	12	367.2
R8	7	363.2
R7	3	297.8
R6	8	270.4
		---------------------- 250 pCi/L
R5	10	239.6
R4	6	230.5
R3	2	207.6
R2	1	205.8
R1	11	189.1

6/15/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1061.9
		---------------------- 750 pCi/L
R11	11	505.6
R10	4	347.8
R9	12	318.4
R8	3	256.7
		---------------------- 250 pCi/L
R7	6	239.1
R6	7	232.9
R5	8	211.5
R4	9	204.1
R3	1	181.0
R2	2	176.9
R1	10	173.9

6/22/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1480.2
		---------------------- 750 pCi/L
R11	9	601.8
R10	4	506.9
R9	12	433.8
R8	11	331.7
R7	7	309.8
		---------------------- 250 pCi/L
R6	8	205.3
R5	3	194.3
R4	1	189.5
R3	2	180.3
R2	6	172.5
R1	10	146.7

6/29/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1909.3
		---------------------- 750 pCi/L
R11	9	679.6
R10	4	590.3
R9	12	589.3
R8	7	380.6
R7	3	342.4
R6	11	313.0
R5	8	251.0
		---------------------- 250 pCi/L
R4	2	224.4
R3	1	211.2
R2	10	208.8
R1	6	204.4

7/6/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	957.1
		---------------------- 750 pCi/L
R11	4	500.6
R10	7	355.9
R9	9	293.8
R8	12	255.9
		---------------------- 250 pCi/L
R7	11	235.8
R6	1	195.9
R5	8	175.8
R4	3	175.0
R3	2	159.3
R2	6	142.7
R1	10	133.7

7/13/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1258.1
		---------------------- 750 pCi/L
R11	4	437.6
R10	7	377.7
R9	9	330.0
R8	12	268.5
		---------------------- 250 pCi/L
R7	1	208.8
R6	3	177.0
R5	11	174.5
R4	2	141.6
R3	8	141.1
R2	10	136.7
R1	6	121.2

7/21/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1583.0
		---------------------- 750 pCi/L
R11	4	452.7
R10	3	346.4
R9	12	318.2
R8	7	315.8
R7	9	290.6
		---------------------- 250 pCi/L
R6	11	219.1
R5	1	208.2
R4	8	171.3
R3	10	171.2
R2	6	143.8
R1	2	140.7

7/27/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1474.3
		---------------------- 750 pCi/L
R11	9	495.0
R10	4	432.2
R9	12	393.0
R8	7	326.2
		---------------------- 250 pCi/L
R7	3	212.1
R6	11	187.0
R5	1	167.1
R4	8	159.0
R3	10	146.6
R2	2	130.9
R1	6	97.0

8/3/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	919.3
		---------------------- 750 pCi/L
R11	4	430.4
R10	9	423.9
R9	7	309.9
		---------------------- 250 pCi/L
R8	12	205.0
R7	1	198.1
R6	3	180.8
R5	11	179.3
R4	8	173.7
R3	2	149.5
R2	6	125.0
R1	10	112.9

8/10/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1174.6
		---------- 750 pCi/L
R11	9	528.6
R10	12	372.9
R9	7	352.4
R8	4	320.1
R7	3	269.7
		---------- 250 pCi/L
R6	1	179.4
R5	10	161.0
R4	11	160.3
R3	6	155.1
R2	8	141.0
R1	2	124.3

8/17/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1123.8
		---------- 750 pCi/L
R11	9	563.3
R10	12	479.2
R9	7	351.0
R8	4	342.6
R7	3	322.5
		---------- 250 pCi/L
R6	6	196.4
R5	1	188.7
R4	8	156.3
R3	11	132.9
R2	2	125.3
R1	10	82.0

8/24/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	940.3
		---------- 750 pCi/L
R11	12	404.2
R10	9	382.2
R9	4	322.2
R8	7	322.2
		---------- 250 pCi/L
R7	1	182.1
R6	3	174.7
R5	11	152.5
R4	10	140.9
R3	6	135.3
R2	8	130.0
R1	2	127.6

8/31/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	908.1
		---------- 750 pCi/L
R11	9	429.3
R10	4	336.8
R9	7	296.6
		---------- 250 pCi/L
R8	12	227.5
R7	1	219.7
R6	10	203.6
R5	11	155.0
R4	3	147.2
R3	8	142.6
R2	6	135.3
R1	2	131.3

9/8/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	906.8
		---------- 750 pCi/L
R11	9	367.7
R10	4	343.2
		---------- 250 pCi/L
R9	7	237.8
R8	10	188.1
R7	1	181.5
R6	11	170.0
R5	12	168.7
R4	8	143.2
R3	3	142.0
R2	2	141.7
R1	6	128.1

9/14/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	970.0
		---------- 750 pCi/L
R11	12	427.8
R10	7	318.5
		---------- 250 pCi/L
R9	3	217.0
R8	10	209.8
R7	6	193.8
R6	9	188.8
R5	4	161.9
R4	1	152.2
R3	2	150.5
R2	11	138.9
R1	8	125.1

9/21/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1216.7
		---------- 750 pCi/L
R11	12	422.1
R10	7	362.4
R9	4	353.3
R8	3	332.3
R7	9	318.8
		---------- 250 pCi/L
R6	10	209.7
R5	1	182.4
R4	8	159.6
R3	2	120.6
R2	6	117.0
R1	11	112.4

9/28/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	937.9
		---------- 750 pCi/L
R11	12	433.0
R10	9	404.2
R9	4	383.3
R8	7	379.9
R7	3	315.9
		---------- 250 pCi/L
R6	10	202.3
R5	1	176.9
R4	11	150.9
R3	6	150.1
R2	8	141.2
R1	2	121.0

10/5/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1109.3
		---------- 750 pCi/L
R11	12	458.6
R10	4	315.6
R9	9	298.5
		---------- 250 pCi/L
R8	7	242.5
R7	10	220.3
R6	3	220.2
R5	1	194.1
R4	8	163.0
R3	6	145.0
R2	11	139.6
R1	2	119.2

10/12/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	846.3
		---------------------- 750 pCi/L
R11	12	528.6
R10	9	349.5
R9	4	340.1
R8	7	274.1
		---------------------- 250 pCi/L
R7	3	245.0
R6	10	212.7
R5	1	181.8
R4	6	146.8
R3	8	144.3
R2	2	130.2
R1	11	115.1

10/19/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	874.8
		---------------------- 750 pCi/L
R11	4	368.4
R10	3	360.6
R9	7	272.3
		---------------------- 250 pCi/L
R8	12	228.6
R7	9	210.2
R6	10	180.5
R5	1	157.8
R4	8	157.2
R3	6	131.1
R2	11	125.9
R1	2	121.8

10/26/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	945.6
		---------------------- 750 pCi/L
R11	3	400.1
R10	4	327.7
R9	7	303.1
R8	9	300.0
		---------------------- 250 pCi/L
R7	12	208.6
R6	10	202.3
R5	8	170.0
R4	1	165.9
R3	11	142.3
R2	6	138.3
R1	2	119.6

11/2/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	989.6
		---------------------- 750 pCi/L
R11	4	400.0
R10	7	355.4
R9	3	267.7
		---------------------- 250 pCi/L
R8	12	232.5
R7	9	201.8
R6	10	195.6
R5	8	191.1
R4	1	189.2
R3	11	173.1
R2	6	153.7
R1	2	128.8

11/9/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1113.7
		---------------------- 750 pCi/L
R11	4	422.0
R10	7	317.8
R9	3	295.8
R8	12	277.2
R7	11	260.1
		---------------------- 250 pCi/L
R6	1	198.4
R5	8	177.6
R4	6	167.0
R3	9	159.0
R2	10	157.6
R1	2	138.4

11/16/92

Rank	Site No.	Radon Level (pCi/L)
R12	5	1170.5
		---------------------- 750 pCi/L
R11	4	420.7
R10	7	367.3
R9	3	300.1
R8	12	267.3
		---------------------- 250 pCi/L
R7	11	249.9
R6	1	199.2
R5	8	193.4
R4	6	183.3
R3	9	175.2
R2	10	156.9
R1	2	151.0

11/23/92

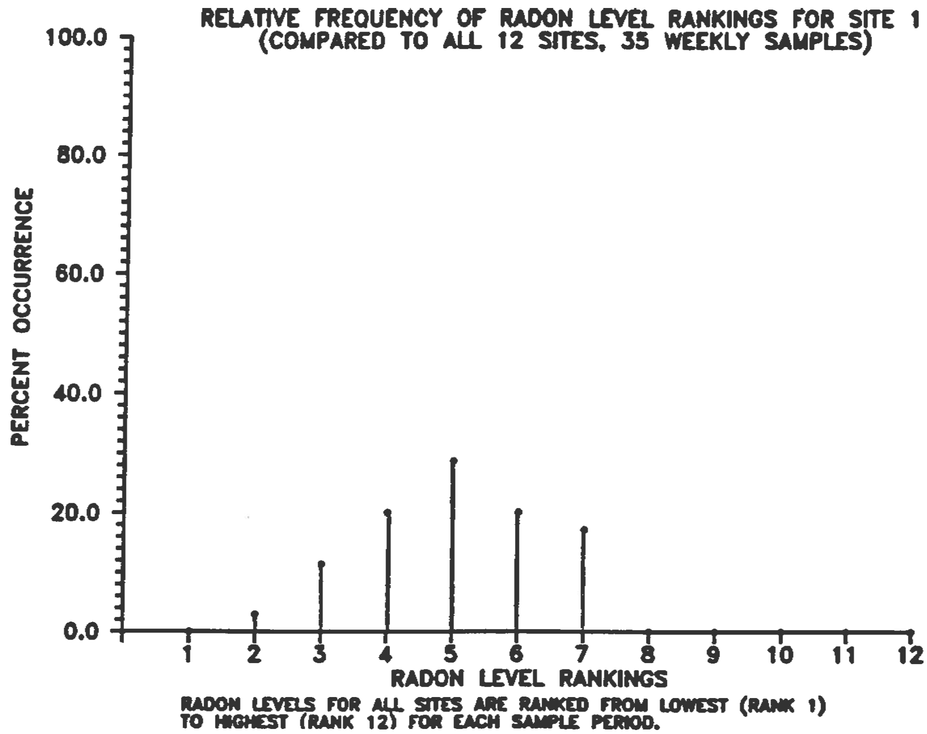
Rank	Site No.	Radon Level (pCi/L)
R12	5	1204.5
		---------------------- 750 pCi/L
R11	4	421.3
R10	3	311.0
R9	12	290.3
R8	7	290.1
R7	11	260.5
		---------------------- 250 pCi/L
R6	1	207.6
R5	8	207.6
R4	6	187.7
R3	2	169.8
R2	9	169.8
R1	10	164.0

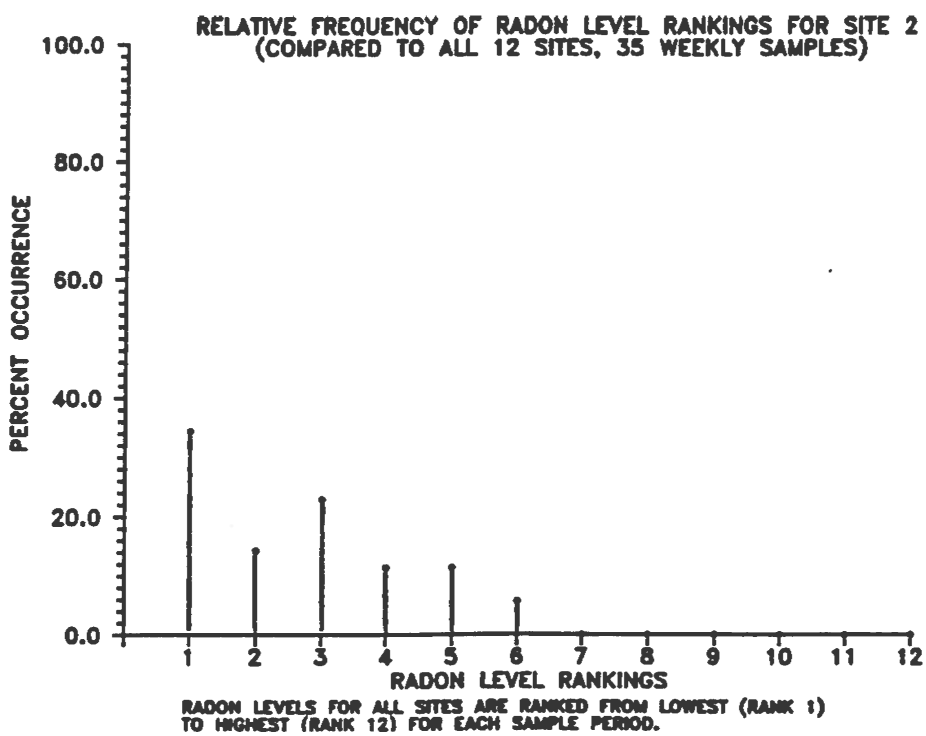
11/30/92

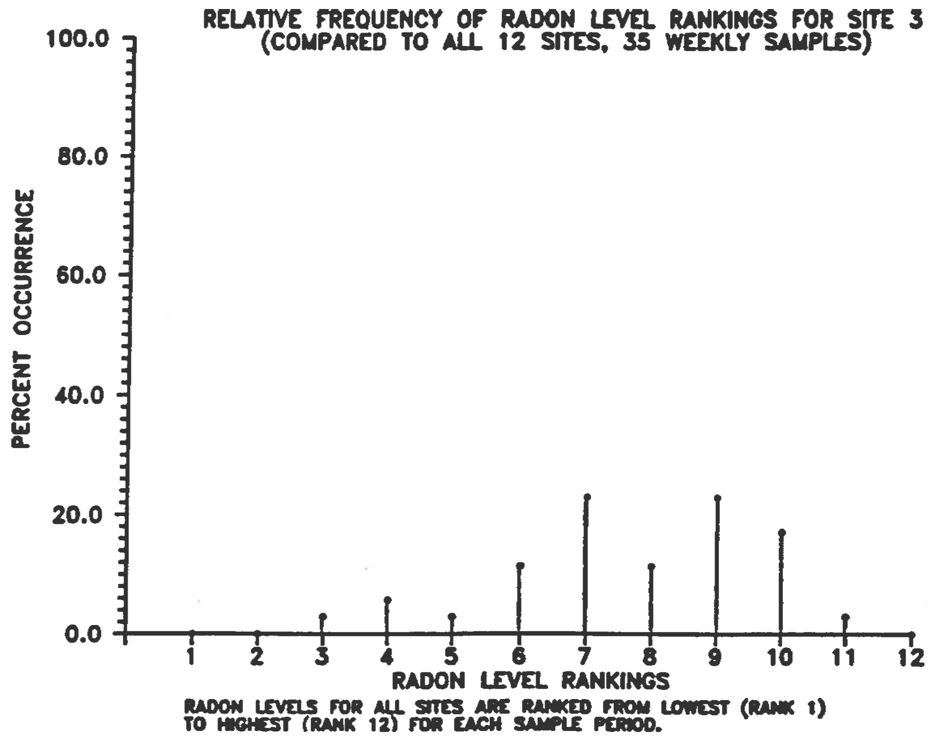
Rank	Site No.	Radon Level (pCi/L)
R12	5	1215.7
		---------------------- 750 pCi/L
R11	4	432.3
R10	3	326.2
R9	7	311.3
R8	12	299.3
R7	11	262.7
		---------------------- 250 pCi/L
R6	8	198.9
R5	6	189.9
R4	1	185.9
R3	2	182.7
R2	9	182.3
R1	10	175.0

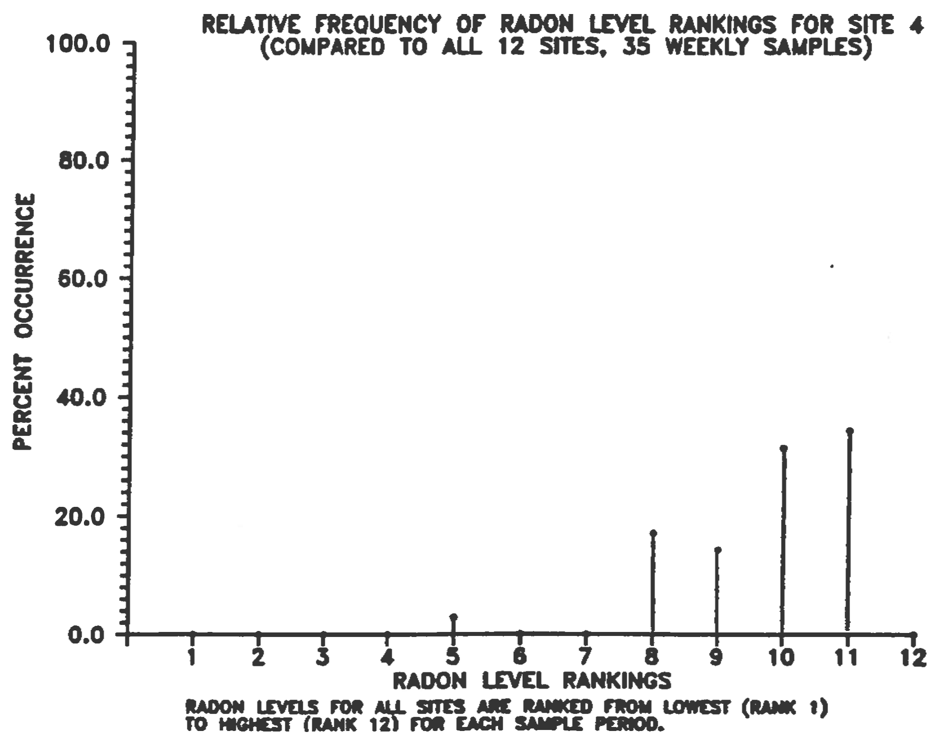
APPENDIX D

Relative Frequencies of Soil-Gas Radon Level Rankings by Site - Total Project Period

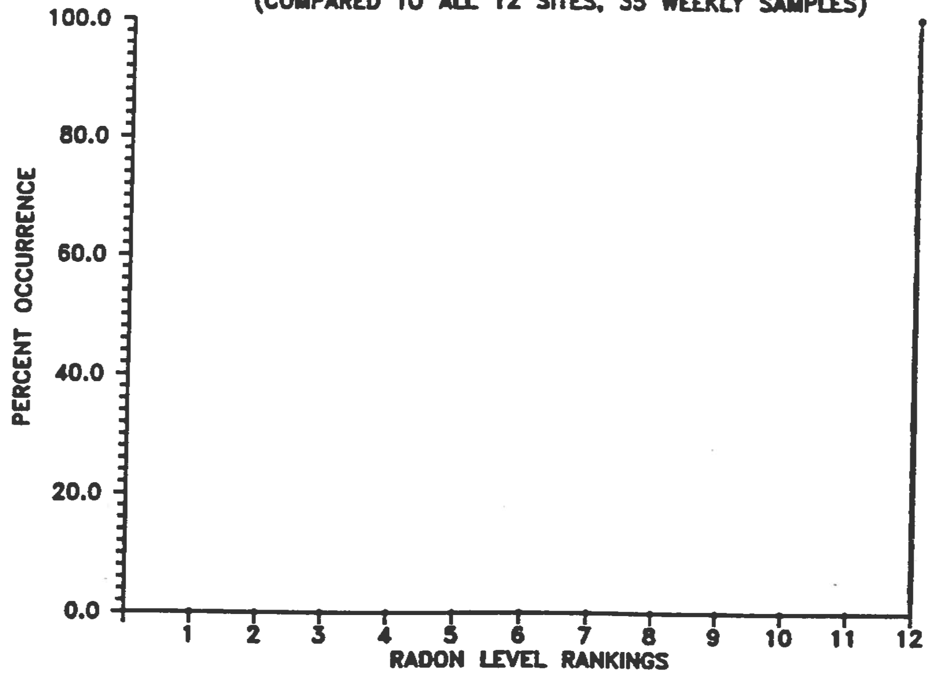

RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 1
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)
PERCENT OCCURRENCE
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
RADON LEVEL RANKINGS
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1)
TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.


RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 2
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)
PERCENT OCCURRENCE
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
RADON LEVEL RANKINGS
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1)
TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.


RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 3
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)
PERCENT OCCURRENCE
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
RADON LEVEL RANKINGS
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1)
TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.

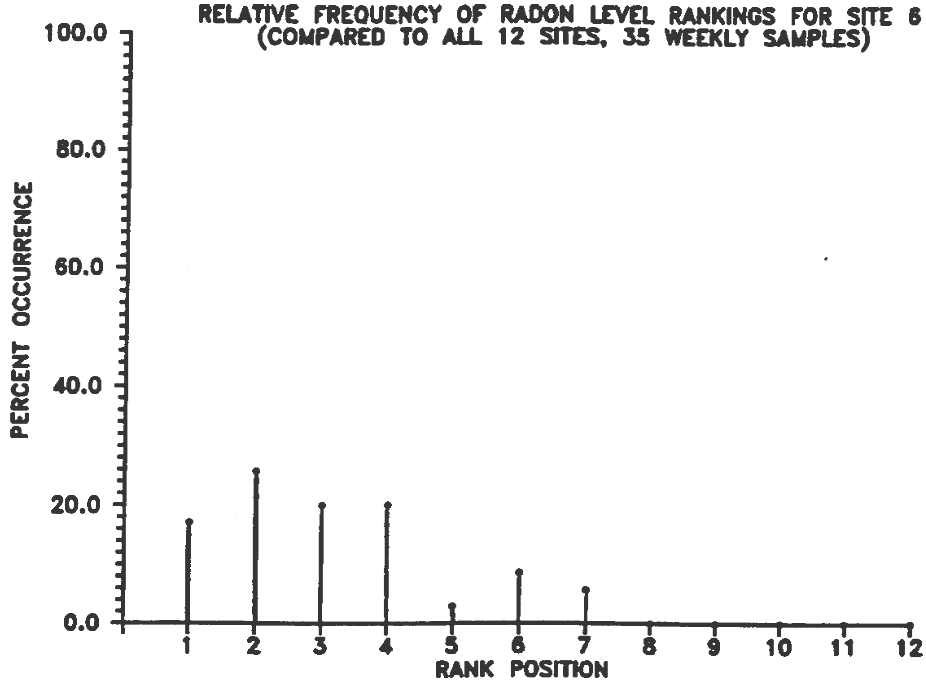

RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 4
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)
PERCENT OCCURRENCE
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
RADON LEVEL RANKINGS
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1)
TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.

RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 5
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)

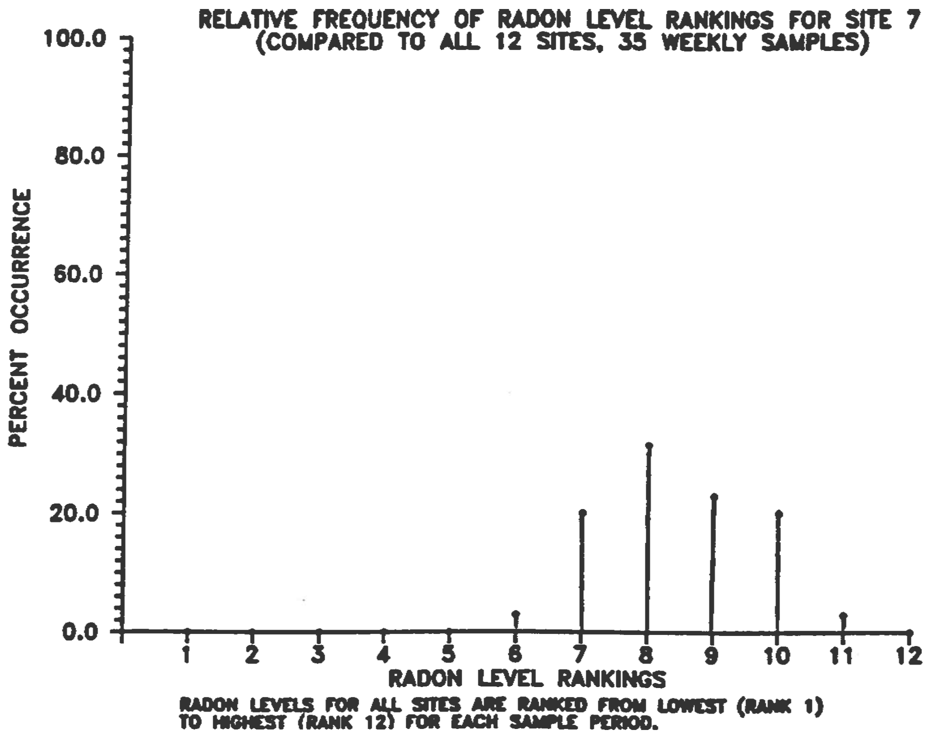


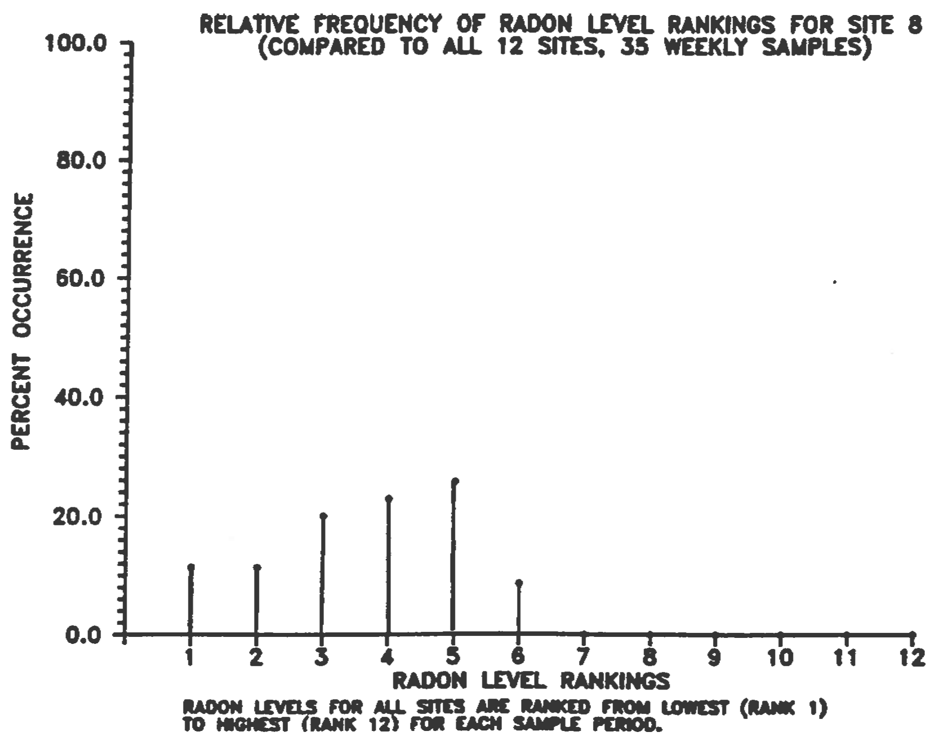
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1) TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.

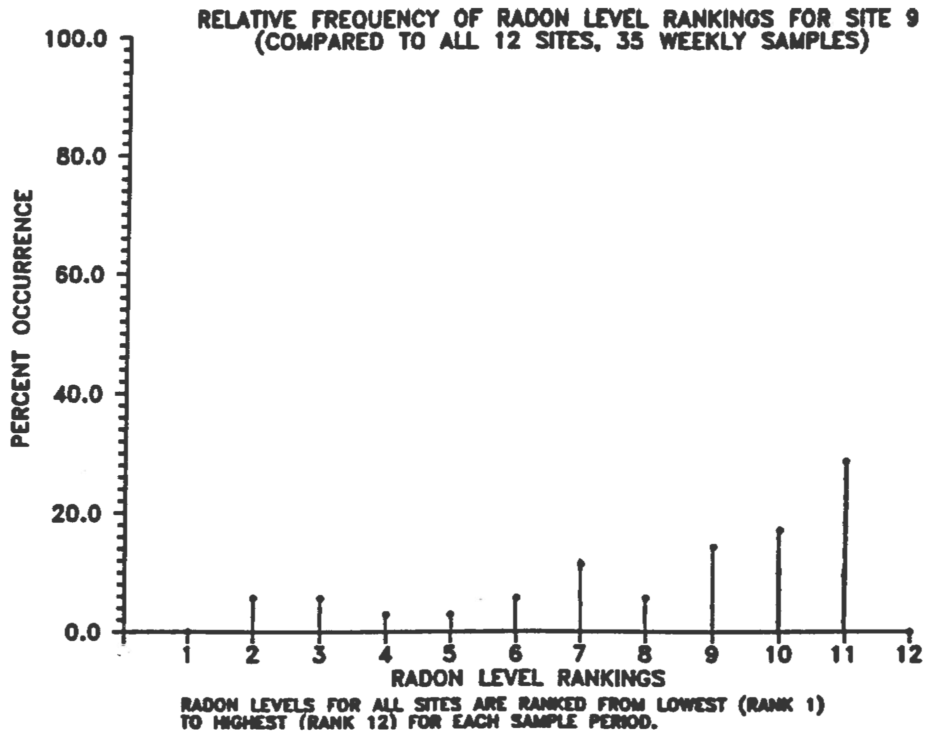
RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 6
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)

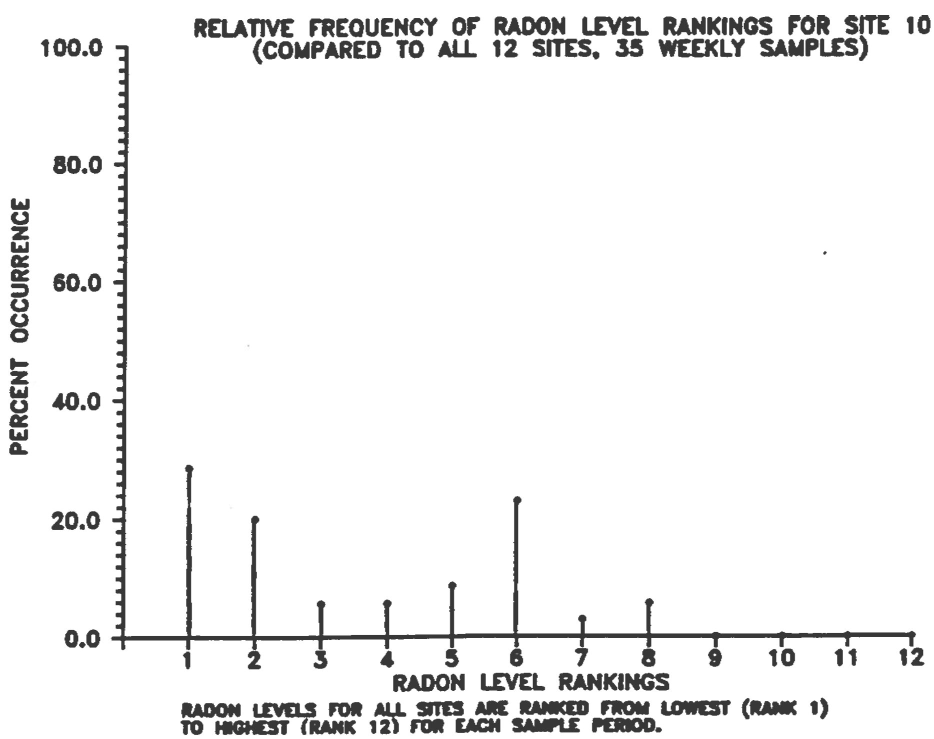


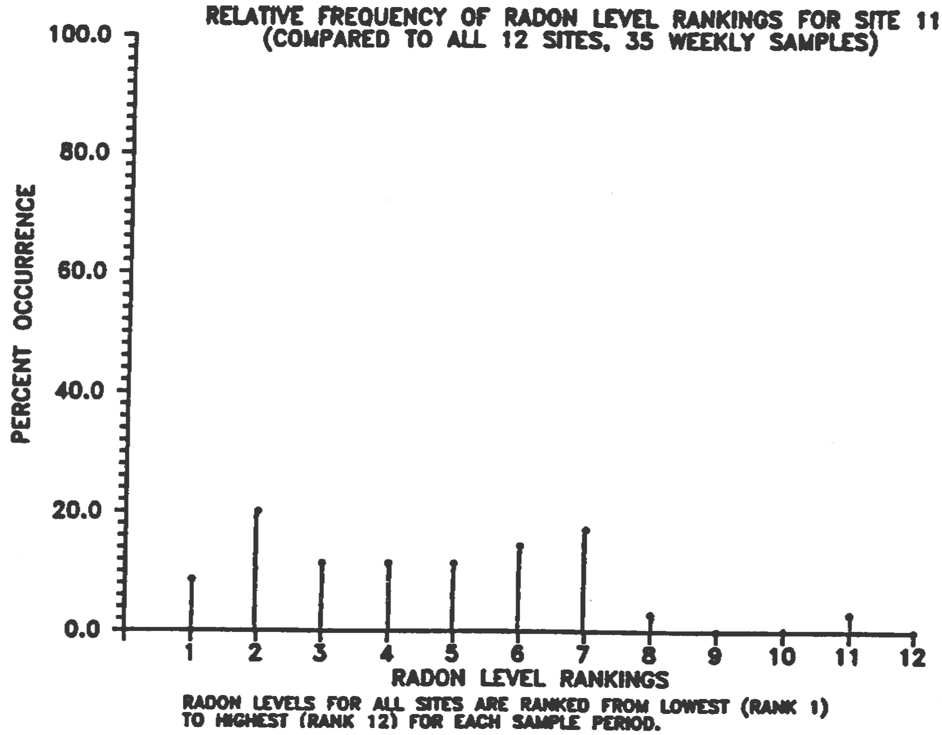
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1) TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.

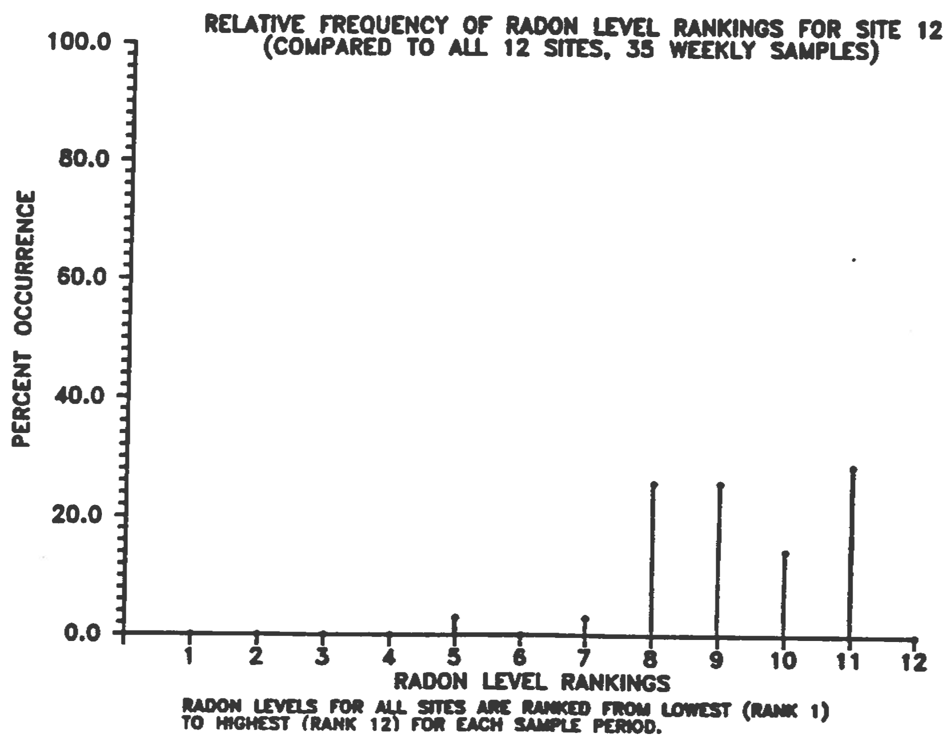

RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 7
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)
PERCENT OCCURRENCE
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
RADON LEVEL RANKINGS
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1)
TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.


RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 8
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)
PERCENT OCCURRENCE
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
RADON LEVEL RANKINGS
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1)
TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.


RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 9
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)
PERCENT OCCURRENCE
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
RADON LEVEL RANKINGS
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1)
TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.


RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 10
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)
PERCENT OCCURRENCE
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
RADON LEVEL RANKINGS
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1)
TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.


RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 11
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)
100.0
80.0
60.0
40.0
20.0
0.0
PERCENT OCCURRENCE
1 2 3 4 5 6 7 8 9 10 11 12
RADON LEVEL RANKINGS
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1)
TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.


RELATIVE FREQUENCY OF RADON LEVEL RANKINGS FOR SITE 12
(COMPARED TO ALL 12 SITES, 35 WEEKLY SAMPLES)
100.0
80.0
60.0
40.0
20.0
0.0
PERCENT OCCURRENCE
1 2 3 4 5 6 7 8 9 10 11 12
RADON LEVEL RANKINGS
RADON LEVELS FOR ALL SITES ARE RANKED FROM LOWEST (RANK 1)
TO HIGHEST (RANK 12) FOR EACH SAMPLE PERIOD.

APPENDIX E

Site Specific Soil Data

SITE SPECIFIC SOIL DATA

Site 1

DATE (1992)	**TIME**	**SOIL TEMPERATURE** (°F)	**SOIL RESISTIVITY** (Ohms)	**SOIL MOISTURE** (%)
9/8	10.50a	60	1000000	2.1
9/14	11.00a	60	1000000	2.1
9/21	12.00p	59	1000000	2.1
9/28	10.40a	58	1000000	2.1
10/5	12.20p	56	1500000	2.0
10/12	9.50a	56	1500000	2.0
10/19	9.55a	50	2000000	1.8
10/26	9.30a	50	2000000	1.8
11/2	10.40a	48	1000000	2.1
11/9	8.40a	40	2000000	1.8
11/16	11.45a	40	2000000	1.8
11/23	11.40a	39	2000000	1.8
11/30	11.55a	37	2000000	1.8

Site 2

DATE (1992)	**TIME**	**SOIL TEMPERATURE** (°F)	**SOIL RESISTIVITY** (Ohms)	**SOIL MOISTURE** (%)
9/8	10.30a	58	1000000	1.0
9/14	10.35a	56	2000000	0.8
9/21	12.15p	56	2000000	0.8
9/28	10.25a	55	2000000	0.8
10/5	12.35p	55	2000000	0.8
10/12	10.05a	52	2000000	0.8
10/19	10.05a	52	2000000	0.8
10/26	9.40a	52	2000000	0.8
11/2	11.00a	49	1000000	1.0
11/9	9.55a	41	2000000	0.8
11/16	12.05p	40	2000000	0.8
11/23	12.00p	40	2000000	0.8
11/30	12.15p	37	2000000	0.8

Site 3

DATE (1992)	TIME	SOIL TEMPERATURE (°F)	SOIL RESISTIVITY (Ohms)	SOIL MOISTURE (%)
9/8	1.20p	58	1000000	7.0
9/14	1.20p	58	2000000	6.8
9/21	10.00a	57	2000000	6.8
9/28	12.15p	56	2000000	6.8

Site 4

DATE (1992)	TIME	SOIL TEMPERATURE (°F)	SOIL RESISTIVITY (Ohms)	SOIL MOISTURE (%)
9/8	1.50p	58	60000	6.1
9/14	1.40p	58	65000	6.0
9/21	10.45a	56	60000	6.1
9/28	1.00p	56	60000	6.1
10/5	11.55a	55	60000	6.1
10/12	12.15p	50	90000	5.8
10/19	1.30p	50	90000	5.8
10/26	11.00a	50	93000	5.7
11/2	1.10p	48	94000	5.6
11/9	11.35a	41	115000	5.1
11/16	10.50a	40	120000	5.0
11/23	9.45a	40	125000	4.9
11/30	11.10a	38	200000	4.5

Site 5

DATE (1992)	TIME	SOIL TEMPERATURE (°F)	SOIL RESISTIVITY (Ohms)	SOIL MOISTURE (%)
9/8	12.45p	60	2000000	4.8
9/14	12.45p	60	1000000	5.2
9/21	2.50p	58	2000000	4.8
9/28	1.30p	58	2000000	4.8
10/5	11.00a	57	2000000	4.8
10/12	11.10a	56	2000000	4.8
10/19	12.15p	56	2000000	4.8
10/26	12.30p	56	2000000	4.8
11/2	11.30a	50	1000000	5.2
11/9	10.05a	40	2000000	4.8
11/16	9.45a	40	2000000	4.8
11/23	9.10a	39	2000000	4.8
11/30	10.00a	37	2000000	4.8

Site 6

No data collected

Site 7

DATE (1992)	TIME	SOIL TEMPERATURE (°F)	SOIL RESISTIVITY (Ohms)	SOIL MOISTURE (%)
6/8	10.57a	58	32000	11.2
6/15	12.30p	55	29000	11.3
6/22	12.40p	59	700	21.0
6/29	10.50a	56	800	20.5
7/6	1.00p	60	600	21.8
7/13	10.30a	60	600	21.8
7/21	1.15p	59	600	21.8
7/27	1.15p	60	600	21.8
8/3	11.35a	61	900	20.1
8/10	1.33p	66	600	21.8
8/17	1.45p	67	600	21.8
8/24	12.15p	67	600	21.8
8/31	1.30p	68	700	22.0
9/8	1.30p	62	750	20.7
9/14	1.25p	60	800	20.5
9/21	10.30a	58	800	20.5
9/28	12.40p	57	800	20.5
10/5	11.40a	55	900	20.1
10/12	12.45p	53	900	20.1
10/19	1.15p	53	950	20.0
10/26	11.10a	53	980	19.9
11/2	12.45p	50	1000	19.8
11/9	11.15a	42	1100	19.7
11/16	10.40a	42	1300	19.5
11/23	9.30a	40	1400	18.8
11/30	10.55a	36	1500	18.5

Site 8

DATE (1992)	TIME	SOIL TEMPERATURE (°F)	SOIL RESISTIVITY (Ohms)	SOIL MOISTURE (%)
6/8	9.35a	54	80000	8.0
6/15	9.25a	55	15000	12.0
6/22	10.15a	58	200000	6.7
6/29	11.45a	59	100000	7.6
7/6	9.25a	60	180000	7.4
7/13	8.30a	60	200000	6.7
7/21	10.25a	55	300000	5.8
7/27	9.35a	57	250000	6.1
8/3	9.38a	64	450000	5.5
8/10	9.37a	62	500000	5.3
8/17	10.00a	62	500000	5.3
8/24	9.30a	58	125000	7.4
8/31	9.20a	56	150000	7.4
9/8	9.35a	55	1000000	5.0
9/14	9.45a	56	1000000	5.0
9/21	1.10p	56	1000000	5.0
9/28	9.20a	55	1000000	5.0
10/5	10.15a	55	1000000	5.0
10/12	10.55a	54	1000000	5.0
10/19	9.30a	53	1000000	5.0
10/26	10.20a	53	1000000	5.0
11/2	9.45a	49	900000	5.0
11/9	9.45a	41	2000000	4.5
11/16	12.55p	40	2000000	4.5
11/23	1.20p	40	2000000	4.5
11/30	9.15a	37	2000000	4.5

Site 9

DATE (1992)	TIME	SOIL TEMPERATURE (°F)	SOIL RESISTIVITY (Ohms)	SOIL MOISTURE (%)
6/8	9.20a	53	11000	16.0
6/15	9.40a	54	4000	18.4
6/22	10.00a	56	3250	19.0
6/29	11.30a	56	3300	19.0
7/6	9.12a	58	18000	15.0
7/13	8.45a	59	19500	14.6
7/21	10.40a	57	36000	13.0
7/27	9.25a	58	39000	12.8
8/3	9.40a	61	47000	12.0
8/10	9.55a	61	48000	12.0
8/17	10.30a	60	45000	12.1
8/24	9.45a	59	45000	12.1
8/31	9.40a	57	50000	11.8
9/8	9.45a	56	55000	11.5
9/14	9.55a	56	65000	10.5
9/21	1.30p	55	70000	10.4
9/28	9.30a	55	70000	10.4
10/5	10.00a	55	70000	10.4
10/12	10.45a	54	75000	10.2
10/19	10.40a	54	75000	10.2
10/26	10.30a	54	75000	10.2
11/2	9.20a	49	65000	10.5
11/9	12.10p	40	75000	10.2
11/16	1.10p	40	75000	10.2
11/23	1.40p	40	75000	10.2
11/30	1.40p	37	80000	10.0

Site 10

DATE (1992)	TIME	SOIL TEMPERATURE (°F)	SOIL RESISTIVITY (Ohms)	SOIL MOISTURE (%)
6/8	10.07a	49	1700	14.9
6/15	10.10a	50	1900	14.5
6/22	10.45a	52	2750	13.4
6/29	1.15p	56	2700	13.4
7/6	1.45p	58	3000	13.0
7/13	9.10a	54	6200	11.8
7/21	9.50a	54	9000	11.3
7/27	10.00a	56	14000	10.6
8/3	9.25a	54	22000	9.9
8/10	10.45a	55	27000	9.5
8/17	11.22a	54	35500	9.0
8/24	10.15a	55	45000	8.8
8/31	10.10a	56	50000	8.6
9/8	10.15a	55	70000	8.0
9/14	10.15a	54	70000	8.0
9/21	12.45p	55	75000	7.7
9/28	10.05a	55	75000	7.7
10/5	1.00p	55	75000	7.7
10/12	10.25a	49	80000	7.5
10/19	10.20a	49	80000	7.5
10/26	9.50a	50	80000	7.5
11/2	10.20a	49	80000	7.5
11/9	9.15a	41	47500	8.7
11/16	12.25p	40	49000	8.6
11/23	12.20p	40	49000	8.6
11/30	12.50p	37	50000	8.6

Site 11

DATE (1992)	TIME	SOIL TEMPERATURE (°F)	SOIL RESISTIVITY (Ohms)	SOIL MOISTURE (%)
6/8	11.25a	54	13500	3.5
6/15	12.00p	55	1200	10.6
6/22	12.15p	56	1800	9.2
6/29	11.15a	58	3000	7.0
7/6	10.30a	59	7000	4.2
7/13	10.05a	59	130000	1.2
7/21	1.35p	60	300000	1.2
7/27	2.00p	60	250000	1.2
8/3	11.50a	60	300000	1.2
8/10	2.00p	62	370000	1.1
8/17	2.30p	63	350000	1.1
8/24	11.00a	60	400000	1.1
8/31	12.30p	58	400000	1.1
9/8	2.05p	58	450000	1.1
9/14	1.45p	57	500000	1.0
9/21	11.00a	56	350000	1.1
9/28	11.00a	56	450000	1.1
10/5	12.05p	56	400000	1.1
10/12	12.20p	51	400000	1.1
10/19	1.40p	51	400000	1.1
10/26	10.45a	51	400000	1.1
11/2	1.30p	49	400000	1.1
11/9	11.50a	41	400000	1.1
11/16	11.05a	40	400000	1.1
11/23	10.00a	40	450000	1.1
11/30	11.20a	38	500000	1.0

Site 12

DATE (1992)	TIME	SOIL TEMPERATURE (°F)	SOIL RESISTIVITY (Ohms)	SOIL MOISTURE (%)
6/8	10.25a	52	1800	38.5
6/15	12.40p	54	1300	40.0
6/22	12.50p	56	1800	38.5
6/29	10.10a	56	1400	39.0
7/6	12.20p	57	1400	39.0
7/13	10.40a	59	1700	38.5
7/21	1.45p	58	2000	37.0
7/27	1.45p	59	2200	36.0
8/3	11.30a	60	3000	32.0
8/10	1.15p	59	7500	22.0
8/17	1.25p	59	18500	19.5
8/24	12.30p	58	30000	18.3
8/31	1.00p	58	32500	18.0
9/8	1.00p	58	47500	17.0
9/14	1.00p	57	50000	17.0
9/21	10.45a	56	60000	16.2
9/28	11.45a	55	60000	16.2
10/5	11.35a	55	60000	16.2
10/12	11.30a	50	80000	15.2
10/19	1.00p	50	80000	15.2
10/26	11.30a	50	80000	15.2
11/2	12.30p	48	80000	15.2
11/9	11.00a	40	60000	16.2
11/16	10.30a	40	62000	16.2
11/23	10.40a	39	65000	16.0
11/30	10.45a	37	69000	15.8

APPENDIX F

Site Specific Weather Data

SITE SPECIFIC WEATHER DATA

Site 1

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	10.56a	*	*	*	*
4/13	12.35p	*	*	*	*
4/24	3.25p	*	23.52	20	*
4/29	12.00p	76	23.42	2	34
5/5	12.02p	68	23.48	8	33
5/11	12.10p	70	23.16	10	37
5/18	11.55a	79	23.48	10	32
5/26	11.40a	66	23.15	0	46
6/1	12.10p	60	23.41	2	61
6/8	12.20p	67	23.32	15	41
6/15	11.00a	54	23.10	15	38
6/22	11.30a	78	23.52	2	48
6/29	12.40p	76	23.27	14	50
7/6	10.10a	82	23.35	0	50
7/13	9.45a	62	23.36	0	59
7/21	9.20a	62	23.37	2	75
7/27	10.35a	79	23.59	0	50
8/3	10.15a	68	23.51	0	60
8/10	12.00p	76	23.67	6	54
8/17	12.17p	60	23.65	5	77
8/24	10.45a	50	23.48	12	85
8/31	10.45a	70	23.45	0	49
9/8	10.50a	70	23.35	13	45
9/14	11.00a	65	23.42	5	43
9/21	12.00p	60	23.52	5	55
9/28	10.40a	60	23.73	0	43
10/5	12.20p	61	23.58	0	45
10/12	9.50a	55	23.51	2	41
10/19	9.55a	55	23.35	0	40
10/26	9.30a	54	23.35	0	38
11/2	10.40a	33	22.86	2	89
11/9	8.40a	32	23.05	5	45
11/16	11.45a	54	23.10	15	30
11/23	11.40a	16	22.79	15	87
11/30	11.55a	19	23.39	25	65

Site 2

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	11.15a	*	*	*	*
4/13	1.00p	*	*	*	*
4/24	2.40p	*	23.23	14	*
4/29	12.18p	75	23.13	2	32
5/5	12.17p	68	23.18	8	32
5/11	12.25p	66	23.48	7	38
5/18	12.10p	76	23.20	3	33
5/26	12.00p	68	22.89	0	45
6/1	12.30p	48	23.12	6	68
6/8	12.35p	62	23.04	2	45
6/15	10.45a	52	23.00	16	38
6/22	11.15a	76	23.25	0	52
6/29	12.25p	78	22.93	4	55
7/6	9.50a	80	23.09	0	55
7/13	9.35a	58	23.09	3	64
7/21	9.35a	66	23.10	0	70
7/27	10.20a	73	23.32	0	51
8/3	9.50a	67	23.23	3	57
8/10	11.07a	86	23.41	4	52
8/17	11.43a	65	23.39	3	75
8/24	10.30a	50	23.20	5	85
8/31	10.30a	66	23.18	0	50
9/8	10.30a	65	23.09	16	47
9/14	10.35a	68	23.20	0	42
9/21	12.15p	59	23.25	3	55
9/28	10.25a	55	23.45	0	44
10/5	12.35p	60	23.29	0	47
10/12	10.05a	55	23.24	0	41
10/19	10.05a	56	23.06	0	40
10/26	9.40a	54	23.10	0	38
11/2	11.00a	33	22.61	3	89
11/9	9.55a	30	22.78	7	52
11/16	12.05p	54	23.08	13	31
11/23	12.00p	15	22.55	10	87
11/30	12.15p	20	23.09	31	64

Site 3

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	9.55a	*	*	*	*
4/13	10.35a	*	*	*	*
4/24	4.40p	*	23.48	12	*
4/29	10.07a	68	23.44	2	34
5/5	10.15a	69	23.45	3	28
5/11	10.32a	62	23.18	14	40
5/18	10.22a	75	23.48	6	37
5/26	10.15a	65	23.18	0	52
6/1	10.20a	49	23.41	15	62
6/8	10.40a	68	23.34	3	46
6/15	1.00p	60	23.04	18	39
6/22	1.10p	75	23.47	4	50
6/29	10.35a	70	23.24	18	65
7/6	12.40p	86	23.31	10	42
7/13	10.55a	72	23.32	0	50
7/21	1.00p	75	23.29	0	65
7/27	1.00p	89	23.53	0	40
8/3	11.10a	65	23.55	4	60
8/10	12.50p	77	23.74	14	60
8/17	1.05p	53	23.66	6	86
8/24	12.45p	50	23.46	18	83
8/31	1.20p	62	23.42	12	50
9/8	1.20p	65	23.31	30	40
9/14	1.20p	71	23.40	10	40
9/21	10.00a	52	23.50	5	64
9/28	12.15p	63	23.72	0	44
10/5	11.20a	54	23.60	0	43
10/12	11.50a	56	23.42	25	41
10/19	12.45p	58	23.21	22	38
10/26	12.00p	56	23.25	10	35
11/2	12.05p	28	22.90	10	93
11/9	10.30a	32	23.08	25	56
11/16	10.10a	41	23.10	10	43
11/23	11.00a	19	22.97	15	84
11/30	10.20a	13	23.37	27	74

Site 4

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	10.40a	*	*	*	*
4/13	11.10a	*	*	*	*
4/24	3.50p	*	23.54	20	*
4/29	10.50a	71	23.48	3	35
5/5	10.50a	70	23.52	3	35
5/11	11.00a	70	23.40	8	38
5/18	10.51a	86	23.52	2	32
5/26	10.50a	68	23.20	0	48
6/1	10.55a	51	23.46	2	68
6/8	11.12a	74	23.37	4	44
6/15	12.15p	62	23.08	12	38
6/22	12.30p	81	23.55	0	50
6/29	11.05a	69	23.28	12	68
7/6	1.10p	85	23.35	18	43
7/13	10.15a	75	23.38	0	50
7/21	1.30p	79	23.29	0	60
7/27	1.35p	89	23.60	0	50
8/3	11.40a	63	23.57	5	60
8/10	1.45p	75	23.76	6	56
8/17	2.15p	70	23.69	2	72
8/24	12.00p	50	23.52	13	80
8/31	1.45p	60	23.47	0	80
9/8	1.50p	63	23.38	30	40
9/14	1.40p	72	23.45	10	40
9/21	10.45a	60	23.56	5	63
9/28	1.00p	62	23.73	0	40
10/5	11.55a	60	23.63	0	45
10/12	12.15p	58	23.46	10	41
10/19	1.30p	62	23.21	17	35
10/26	11.00a	58	23.28	0	34
11/2	1.10p	26	22.91	3	95
11/9	11.35a	32	23.13	18	55
11/16	10.50a	44	23.11	17	40
11/23	9.45a	19	22.81	12	85
11/30	11.10a	17	23.60	30	65

Site 5

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	3.15p	*	*	*	*
4/13	10.00a	*	*	*	*
4/24	4.10p	*	23.41	20	*
4/29	9.47a	72	23.38	0	34
5/5	9.40a	62	23.40	0	38
5/11	10.00a	60	23.42	14	40
5/18	9.55a	71	23.40	5	39
5/26	9.50a	60	23.10	0	51
6/1	9.44a	55	23.32	8	45
6/8	10.10a	70	23.28	6	46
6/15	1.30p	63	22.96	23	40
6/22	1.30p	78	23.41	9	50
6/29	9.55a	66	23.24	14	70
7/6	11.45a	80	23.35	18	45
7/13	12.00p	62	23.35	10	60
7/21	12.40p	68	23.21	0	69
7/27	12.20p	80	23.51	2	49
8/3	10.50a	67	23.48	9	63
8/10	12.25p	80	23.58	14	52
8/17	12.45p	52	23.59	2	88
8/24	1.10p	52	23.40	14	80
8/31	12.45p	74	23.36	0	46
9/8	12.45p	67	23.25	26	40
9/14	12.45p	67	23.35	5	39
9/21	2.50p	52	23.44	6	60
9/28	1.30p	63	23.75	0	40
10/5	11.00a	52	23.52	3	43
10/12	11.10a	56	23.39	20	41
10/19	12.15p	58	23.19	20	38
10/26	12.30p	58	23.22	15	33
11/2	11.30a	29	22.86	5	90
11/9	10.05a	30	22.99	23	58
11/16	9.45a	39	23.12	8	44
11/23	9.10a	18	22.79	10	84
11/30	10.00a	12	23.40	30	75

Site 6

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	2.50p	*	*	*	*
4/13	1.55p	*	*	*	*
4/24	1.50p	*	23.51	5	*
4/29	1.00p	80	23.35	3	33
5/5	12.50p	80	23.46	0	32
5/11	12.55p	72	23.50	4	36
5/18	12.37p	72	23.45	4	33
5/26	12.30p	74	23.10	6	42
6/1	1.00p	54	23.38	3	62
6/8	9.47a	62	23.31	0	49
6/15	10.30a	50	23.00	12	39
6/22	10.30a	76	23.50	0	48
6/29	1.00p	79	23.48	12	48
7/6	9.40a	78	23.34	0	52
7/13	9.00a	60	23.33	4	60
7/21	10.10a	62	23.32	0	75
7/27	9.50a	73	23.57	0	52
8/3	9.00a	64	23.47	0	61
8/10	10.15a	72	23.67	2	56
8/17	10.50a	59	23.62	7	76
8/24	10.00a	50	23.45	8	86
8/31	10.00a	60	23.44	3	53
9/8	10.00a	65	23.38	3	48
9/14	10.10a	61	23.40	0	40
9/21	2.00p	62	23.50	0	50
9/28	9.50a	53	23.65	0	42
10/5	10.30a	50	23.53	0	43
10/12	10.35a	56	23.57	7	42
10/19	10.50a	56	23.37	13	38
10/26	10.05a	55	23.41	10	35
11/2	10.00a	33	22.85	6	90
11/9	9.35a	29	23.13	22	60
11/16	12.40p	55	23.10	10	29
11/23	1.05p	17	22.95	22	88
11/30	1.30p	21	23.30	28	60

Site 7

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	10.27a	*	*	*	*
4/13	11.00a	*	*	*	*
4/24	11.30a	*	23.58	2	*
4/29	10.35a	64	23.48	0	40
5/5	10.30a	76	23.50	0	35
5/11	10.45a	66	23.40	3	40
5/18	10.40a	78	23.50	2	36
5/26	10.35a	69	23.21	0	49
6/1	10.35a	48	23.46	0	68
6/8	10.57a	89	23.37	2	42
6/15	12.30p	62	23.80	2	38
6/22	12.40p	84	23.53	0	49
6/29	10.50a	70	23.26	7	60
7/6	1.00p	89	23.35	8	43
7/13	10.30a	67	23.38	8	52
7/21	1.15p	78	23.30	0	63
7/27	1.15p	88	23.58	0	43
8/3	11.35a	63	23.59	0	61
8/10	1.33p	80	23.75	6	55
8/17	1.45p	70	23.68	2	68
8/24	12.15p	51	23.51	7	82
8/31	1.30p	60	23.47	4	80
9/8	1.30p	65	23.36	26	40
9/14	1.25p	71	23.42	5	40
9/21	10.30a	56	23.55	4	63
9/28	12.40p	65	23.76	0	40
10/5	11.40a	55	23.62	0	48
10/12	12.45p	59	23.54	12	41
10/19	1.15p	61	23.32	7	35
10/26	11.10a	58	23.37	10	33
11/2	12.45p	27	22.90	7	94
11/9	11.15a	32	23.12	7	58
11/16	10.40a	44	23.12	20	40
11/23	9.30a	19	22.95	7	83
11/30	10.55a	15	23.62	20	66

Site 8

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	2.10p	*	*	*	*
4/13	2.15p	*	*	*	*
4/24	1.30p	*	23.50	2	*
4/29	1.21p	81	23.35	0	31
5/5	1.05p	78	23.44	2	32
5/11	1.07p	68	23.50	5	32
5/18	12.50p	78	23.45	0	32
5/26	12.40p	76	23.14	0	40
6/1	1.10p	60	23.40	5	55
6/8	9.35a	64	23.32	0	48
6/15	9.25a	59	23.06	4	40
6/22	10.15a	68	23.50	0	50
6/29	11.45a	77	23.32	11	48
7/6	9.25a	69	23.35	0	55
7/13	8.30a	55	23.36	5	60
7/21	10.25a	67	23.35	0	70
7/27	9.35a	69	23.59	0	52
8/3	9.38a	65	23.49	2	59
8/10	9.37a	74	23.70	6	58
8/17	10.00a	59	23.60	4	76
8/24	9.30a	50	23.45	6	80
8/31	9.20a	60	23.45	3	55
9/8	9.35a	60	23.35	6	50
9/14	9.45a	59	23.48	4	40
9/21	1.10p	63	23.49	5	55
9/28	9.20a	48	23.70	0	42
10/5	10.15a	50	23.61	0	44
10/12	10.55a	56	23.52	12	40
10/19	9.30a	50	23.31	0	39
10/26	10.20a	56	23.42	0	36
11/2	9.45a	32	22.82	2	92
11/9	9.45a	31	23.05	21	57
11/16	12.55p	56	23.14	12	38
11/23	1.20p	16	22.81	15	89
11/30	9.15a	10	23.44	0	80

Site 9

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	2.00p	*	*	*	*
4/13	2.30p	*	*	*	*
4/24	10.30a	*	23.56	0	*
4/29	1.34p	82	23.38	0	32
5/5	1.15p	78	23.50	0	32
5/11	1.07p	70	23.50	8	35
5/18	1.00p	74	23.48	2	32
5/26	12.50p	78	23.15	0	40
6/1	1.30p	60	23.42	3	54
6/8	9.20a	59	23.36	0	48
6/15	9.40a	60	23.06	4	41
6/22	10.00a	73	23.56	0	50
6/29	11.30a	76	23.41	5	50
7/6	9.12a	71	23.39	0	55
7/13	8.45a	55	23.38	0	65
7/21	10.40a	68	23.39	0	65
7/27	9.25a	69	23.62	0	52
8/3	9.40a	65	23.51	0	59
8/10	9.55a	72	23.71	2	58
8/17	10.30a	64	23.65	2	75
8/24	9.45a	50	23.50	4	85
8/31	9.40a	60	23.47	3	54
9/8	9.45a	60	23.39	3	50
9/14	9.55a	60	23.50	2	40
9/21	1.30p	63	23.51	3	50
9/28	9.30a	50	23.75	0	42
10/5	10.00a	49	23.61	0	45
10/12	10.45a	56	23.50	12	41
10/19	10.40a	54	23.38	10	40
10/26	10.30a	56	23.41	0	35
11/2	9.20a	32	22.85	0	92
11/9	12.10p	32	23.09	17	55
11/16	1.10p	56	23.12	7	30
11/23	1.40p	16	22.78	11	87
11/30	1.40p	22	23.51	18	60

Site 10

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	2.30p	*	*	*	*
4/13	2.35p	*	*	*	*
4/24	2.20p	*	23.45	4	*
4/29	12.40p	72	23.31	2	37
5/5	12.40p	70	23.38	2	35
5/11	12.40p	64	23.51	10	40
5/18	12.25p	68	23.41	8	33
5/26	12.15p	64	23.08	3	47
6/1	12.45p	56	23.32	3	62
6/8	10.07a	62	23.25	2	60
6/15	10.10a	50	22.90	15	40
6/22	10.45a	72	23.44	0	50
6/29	1.15p	78	23.49	14	50
7/6	1.45p	82	23.38	16	50
7/13	9.10a	53	23.29	7	69
7/21	9.50a	62	23.29	0	70
7/27	10.00a	70	23.52	2	53
8/3	9.25a	60	23.43	0	60
8/10	10.45a	70	23.62	2	57
8/17	11.22a	54	23.57	4	85
8/24	10.15a	53	23.40	2	90
8/31	10.10a	65	23.40	3	50
9/8	10.15a	65	23.31	5	48
9/14	10.15a	65	23.40	4	41
9/21	12.45p	60	23.46	6	55
9/28	10.05a	50	23.65	0	44
10/5	1.00p	61	23.49	0	45
10/12	10.25a	56	23.43	6	41
10/19	10.20a	52	23.28	7	40
10/26	9.50a	55	23.32	0	37
11/2	10.20a	32	22.87	7	90
11/9	9.15a	29	23.00	20	60
11/16	12.25p	55	23.11	12	30
11/23	12.20p	16	22.85	13	88
11/30	12.50p	20	23.45	30	60

Site 11

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	3.05p	*	*	*	*
4/13	11.20a	*	*	*	*
4/24	11.40a	*	23.59	4	*
4/29	11.05a	73	23.46	4	36
5/5	11.00a	66	23.54	2	35
5/11	11.15a	66	23.22	6	36
5/18	11.03a	83	23.55	2	33
5/26	11.00a	66	23.21	0	47
6/1	11.05a	49	23.48	5	66
6/8	11.25a	72	23.38	3	47
6/15	12.00p	59	23.10	10	39
6/22	12.15p	78	23.55	2	50
6/29	11.15a	72	23.30	14	65
7/6	10.30a	75	23.40	0	57
7/13	10.05a	70	23.40	0	55
7/21	1.35p	78	23.30	2	59
7/27	2.00p	83	23.59	2	45
8/3	11.50a	62	23.57	7	60
8/10	2.00p	74	23.77	10	56
8/17	2.30p	70	23.71	2	70
8/24	11.00a	50	23.53	8	80
8/31	12.30p	74	23.50	3	45
9/8	2.05p	65	23.47	30	40
9/14	1.45p	72	23.46	10	40
9/21	11.00a	62	23.56	6	60
9/28	11.00a	60	23.72	0	43
10/5	12.05p	60	23.64	0	43
10/12	12.20p	60	23.48	12	41
10/19	1.40p	62	23.28	18	35
10/26	10.45a	58	23.30	12	34
11/2	1.30p	26	22.95	10	95
11/9	11.50a	32	23.13	19	55
11/16	11.05a	44	23.14	18	40
11/23	10.00a	19	22.84	13	84
11/30	11.20a	18	23.52	25	65

Site 12

DATE (1992)	TIME	AIR TEMP (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)	RELATIVE HUMIDITY (%)
4/8	10.15a	*	*	*	*
4/13	10.20a	*	*	*	*
4/24	11.20a	*	23.56	4	*
4/29	10.25a	66	23.46	0	35
5/5	10.00a	63	23.50	0	39
5/11	10.10a	59	23.42	16	40
5/18	10.08a	72	23.50	2	39
5/26	10.00a	58	23.18	0	56
6/1	10.00a	52	23.44	6	62
6/8	10.25a	66	23.36	2	46
6/15	12.40p	61	23.08	15	39
6/22	12.50p	84	23.52	0	50
6/29	10.10a	66	23.30	10	70
7/6	12.20p	79	23.35	18	46
7/13	10.40a	70	23.35	8	52
7/21	1.45p	78	23.30	5	60
7/27	1.45p	88	23.58	2	47
8/3	11.30a	63	23.58	3	60
8/10	1.15p	90	23.75	6	56
8/17	1.25p	68	23.68	0	83
8/24	12.30p	50	23.51	12	83
8/31	1.00p	65	23.42	6	43
9/8	1.00p	65	23.34	30	40
9/14	1.00p	72	23.45	8	40
9/21	10.45a	56	23.54	6	64
9/28	11.45a	62	23.74	2	43
10/5	11.35a	55	23.62	0	45
10/12	11.30a	58	23.46	24	40
10/19	1.00p	60	23.23	18	37
10/26	11.30a	60	23.30	14	33
11/2	12.30a	28	22.91	14	94
11/9	11.00a	31	23.10	20	55
11/16	10.30a	44	23.10	20	40
11/23	10.40a	18	22.91	19	85
11/30	10.45a	14	23.51	22	69

[1]AIR PRESSURE = Barometric pressure in inches of mercury.
* indicates missing data

APPENDIX G

Regional Weather Data

REGIONAL WEATHER DATA
Data from Federal Aviation Administration, Brees Field, Laramie, Wyoming

DATE (1992)	TEMPERATURE HIGH (°F)	LOW (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)[3]	DAILY PRECIP (in.)	ACCUM PRECIP (in.)[2]
4/1	49	11	23.02	11.50	0.00	*
4/2	48	27	22.97	11.50	0.01	*
4/3	60	23	22.89	11.50	0.00	*
4/4	62	28	22.83	5.75	0.00	*
4/5	59	30	22.81	11.50	0.00	*
4/6	54	30	22.89	17.25	0.00	*
4/7	54	28	22.97	12.65	0.00	*
4/8	59	32	22.90	17.25	0.00	0.01
4/9	63	32	22.85	16.10	0.00	*
4/10	56	44	22.82	16.10	0.00	*
4/11	56	39	22.95	14.95	0.00	*
4/12	70	36	22.98	10.35	0.00	*
4/13	68	38	23.01	10.35	0.00	0.00
4/14	52	41	22.98	5.75	0.06	*
4/15	55	38	22.96	9.20	0.07	*
4/16	45	36	22.93	10.35	0.38	*
4/17	58	33	22.75	18.40	0.16	*
4/18	42	30	22.78	21.85	0.03	*
4/19	40	30	22.83	25.30	0.00	*
4/20	46	28	22.88	19.55	0.00	*
4/21	55	22	22.81	12.65	0.00	*
4/22	53	31	22.79	10.35	0.00	*
4/23	45	25	23.02	20.70	0.00	*
4/24	52	21	23.18	11.50	0.00	0.19
4/25	55	20	23.18	5.75	0.00	*
4/26	63	30	23.12	10.35	0.00	*
4/27	70	33	23.07	13.80	0.00	*
4/28	69	45	23.09	8.05	0.00	*
4/29	74	33	23.05	10.35	0.00	0.00
4/30	76	43	22.86	17.25	0.00	*
5/1	68	38	22.94	10.35	0.00	*
5/2	59	36	23.21	5.75	0.02	*
5/3	65	28	23.24	5.75	0.00	*
5/4	66	30	23.16	5.75	0.00	*
5/5	66	32	23.11	10.35	0.00	0.02
5/6	71	34	23.11	10.35	0.00	*
5/7	69	41	23.10	10.35	0.00	*
5/8	65	39	22.95	11.50	0.00	*
5/9	65	38	22.70	10.35	0.63	*
5/10	56	33	22.76	11.50	0.00	*
5/11	66	39	22.88	16.10	0.00	0.63

DATE (1992)	TEMPERATURE HIGH (°F)	LOW (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)[3]	DAILY PRECIP (in.)	ACCUM PRECIP (in.)[2]
5/12	65	37	23.01	14.95	0.00	*
5/13	60	43	23.01	11.50	0.02	*
5/14	66	38	22.97	9.20	0.00	*
5/15	68	37	22.88	10.35	0.00	*
5/16	66	40	22.98	13.80	0.00	*
5/17	71	38	23.13	10.35	0.00	*
5/18	75	40	23.12	9.20	0.00	0.02
5/19	76	39	23.03	13.80	0.00	*
5/20	71	45	22.91	5.75	0.03	*
5/21	60	43	22.95	6.90	1.12	*
5/22	51	41	23.17	10.35	0.00	*
5/23	56	40	23.16	16.10	0.00	*
5/24	67	38	23.05	8.05	0.00	*
5/25	67	38	23.05	8.05	0.06	*
5/26	64	35	22.89	10.35	0.47	1.21
5/27	44	36	22.86	9.20	0.48	*
5/28	56	36	22.95	9.20	0.00	*
5/29	60	34	22.96	9.20	0.00	*
5/30	51	42	22.98	4.60	0.03	*
5/31	50	33	23.06	11.50	0.38	*
6/1	55	39	23.07	9.20	0.02	1.42
6/2	68	33	22.96	9.20	0.00	*
6/3	69	38	22.94	12.65	0.00	*
6/4	68	40	22.90	11.50	0.00	*
6/5	60	38	22.87	13.80	0.05	*
6/6	62	36	22.88	16.10	0.00	*
6/7	62	46	22.96	13.80	0.00	*
6/8	62	38	23.02	14.95	0.13	0.07
6/9	66	37	23.00	9.20	0.01	*
6/10	70	39	23.04	5.75	0.00	*
6/11	71	45	23.09	10.35	0.21	*
6/12	69	43	23.01	11.50	0.10	*
6/13	69	45	22.88	9.20	0.00	*
6/14	68	44	22.85	17.25	0.00	*
6/15	63	41	22.79	17.25	0.00	0.45
6/16	59	37	22.80	11.50	0.00	*
6/17	64	41	22.98	16.10	0.00	*
6/18	75	38	23.08	6.90	0.00	*
6/19	73	39	23.08	12.65	0.09	*
6/20	74	44	23.06	11.50	0.41	*
6/21	74	41	23.13	11.50	0.00	*
6/22	79	45	23.07	9.20	0.00	0.50
6/23	78	50	23.05	5.75	0.00	*
6/24	77	51	22.98	8.05	0.30	*
6/25	63	49	23.04	9.20	0.18	*
6/26	69	45	23.00	8.05	0.22	*
6/27	66	42	23.01	6.90	0.00	*
6/28	68	46	23.02	8.05	0.32	*

DATE (1992)	TEMPERATURE HIGH (°F)	LOW (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)[3]	DAILY PRECIP (in.)	ACCUM PRECIP (in.)[2]
6/29	77	47	22.98	14.95	0.00	1.02
6/30	79	50	22.81	13.80	0.00	*
7/1	65	46	22.85	11.50	0.01	*
7/2	55	41	22.99	8.05	0.20	*
7/3	70	38	23.07	10.35	0.00	*
7/4	80	45	23.01	11.50	0.00	*
7/5	82	43	23.00	13.80	0.00	*
7/6	84	49	23.01	12.65	0.00	0.21
7/7	66	45	23.07	11.50	0.00	*
7/8	73	51	23.04	14.95	0.00	*
7/9	74	51	23.10	19.55	0.00	*
7/10	78	48	23.00	16.10	0.00	*
7/11	77	48	22.93	17.25	0.19	*
7/12	68	47	22.94	12.65	0.16	*
7/13	69	45	23.00	12.65	0.00	0.35
7/14	76	43	23.00	17.25	0.00	*
7/15	73	47	23.02	8.05	0.03	*
7/16	65	44	23.15	4.60	0.09	*
7/17	73	41	23.17	6.90	0.00	*
7/18	78	45	23.18	3.45	0.00	*
7/19	71	44	23.16	13.80	0.46	*
7/20	69	46	23.12	13.80	0.29	*
7/21	76	50	23.06	14.95	0.00	0.86
7/22	74	41	23.07	10.35	0.00	*
7/23	75	50	23.06	14.95	0.16	*
7/24	76	50	23.11	10.35	0.01	*
7/25	71	51	23.18	8.05	0.00	*
7/26	75	45	23.20	8.05	0.00	*
7/27	79	42	23.19	6.90	0.00	0.46
7/28	82	45	23.15	20.70	0.00	*
7/29	81	45	23.07	12.65	0.00	*
7/30	73	50	23.15	8.05	0.00	*
7/31	81	47	23.17	8.05	0.00	*
8/1	81	45	23.23	8.05	0.07	*
8/2	84	43	23.18	20.70	0.06	*
8/3	73	49	23.15	23.00	0.28	0.15
8/4	82	44	23.09	11.50	0.00	*
8/5	80	49	23.10	10.35	0.00	*
8/6	71	50	23.07	6.90	0.00	*
8/7	82	48	23.09	11.50	0.00	*
8/8	82	52	23.12	13.80	0.00	*
8/9	84	50	23.18	10.35	0.00	*
8/10	80	50	23.25	13.80	0.00	0.28
8/11	75	49	23.25	6.90	0.00	*
8/12	69	48	23.24	13.80	0.00	*
8/13	78	43	23.22	11.50	0.00	*
8/14	81	47	23.24	12.65	0.00	*
8/15	82	40	23.20	6.90	0.00	*

DATE (1992)	TEMPERATURE HIGH (°F)	LOW (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)[3]	DAILY PRECIP (in.)	ACCUM PRECIP (in.)[2]
8/16	69	55	23.13	8.05	0.03	*
8/17	66	49	23.16	13.80	0.24	0.03
8/18	74	42	23.20	11.50	0.00	*
8/19	79	43	23.17	6.90	0.00	*
8/20	82	42	23.10	12.65	0.06	*
8/21	81	44	23.07	11.50	0.14	*
8/22	74	55	22.97	13.80	0.03	*
8/23	62	48	22.98	8.05	0.04	*
8/24	54	44	23.07	14.95	0.01	0.51
8/25	57	42	23.12	13.80	0.03	*
8/26	62	36	23.19	12.65	0.00	*
8/27	71	31	23.19	13.80	0.00	*
8/28	77	41	23.09	13.80	0.00	*
8/29	68	43	23.08	12.65	0.00	*
8/30	72	38	23.09	6.90	0.00	*
8/31	68	40	23.04	10.35	0.20	0.04
9/1	62	46	22.99	10.35	0.07	*
9/2	70	41	23.06	13.80	0.00	*
9/3	74	40	23.09	11.50	0.00	*
9/4	76	47	22.94	13.80	0.00	*
9/5	65	41	23.02	16.10	0.00	*
9/6	70	36	23.03	14.95	0.00	*
9/7	63	41	23.10	11.50	0.00	*
9/8	74	37	22.93	17.25	0.00	0.27
9/9	70	45	23.04	9.20	0.00	*
9/10	71	37	23.15	9.20	0.00	*
9/11	81	39	23.08	13.80	0.00	*
9/12	75	46	23.00	18.40	0.00	*
9/13	74	44	22.98	16.10	0.00	*
9/14	76	35	23.00	12.65	0.00	0.00
9/15	75	46	23.00	17.25	0.00	*
9/16	75	46	23.06	12.65	0.00	*
9/17	69	35	23.01	19.55	0.05	*
9/18	71	29	23.06	13.80	0.00	*
9/19	72	36	22.94	13.80	0.00	*
9/20	68	44	22.87	16.10	0.00	*
9/21	76	35	23.14	8.05	0.00	0.05
9/22	62	40	23.03	8.05	0.00	*
9/23	79	44	23.07	11.50	0.00	*
9/24	74	42	22.87	12.65	0.00	*
9/25	58	33	22.95	17.25	0.03	*
9/26	59	28	23.13	9.20	0.00	*
9/27	66	41	23.16	13.80	0.00	*
9/28	68	34	23.25	11.50	0.00	0.03
9/29	72	32	23.27	6.90	0.00	*
9/30	74	30	23.27	6.90	0.00	*
10/1	75	32	23.18	8.05	0.00	*
10/2	77	31	23.06	10.35	0.00	*

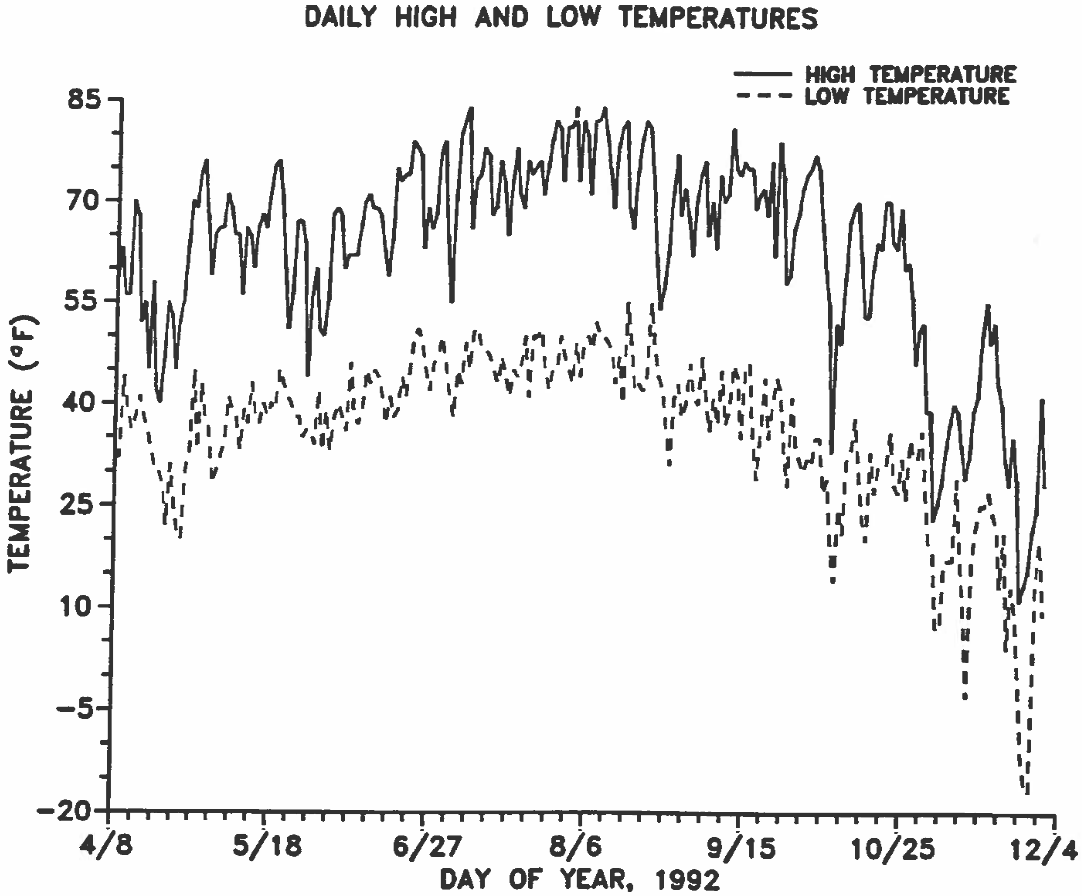
DATE (1992)	TEMPERATURE HIGH (°F)	LOW (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)[3]	DAILY PRECIP (in.)	ACCUM PRECIP (in.)[2]
10/3	75	35	22.94	12.65	0.00	*
10/4	67	35	22.96	11.50	0.00	*
10/5	60	27	23.15	8.05	0.00	0.00
10/6	55	29	23.02	13.80	0.07	*
10/7	33	19	23.10	13.80	0.06	*
10/8	52	14	22.93	11.50	0.00	*
10/9	49	25	22.94	13.80	0.00	*
10/10	58	21	23.10	10.35	0.00	*
10/11	67	32	23.14	16.10	0.00	*
10/12	69	33	23.05	13.80	0.00	0.13
10/13	70	38	22.86	17.25	0.00	*
10/14	62	30	22.86	16.10	0.00	*
10/15	53	23	22.94	17.25	0.00	*
10/16	53	20	23.04	12.65	0.00	*
10/17	60	33	23.06	13.80	0.00	*
10/18	64	27	23.06	6.90	0.00	*
10/19	63	31	23.01	12.65	0.00	0.00
10/20	70	31	23.06	8.05	0.00	*
10/21	70	31	23.04	11.50	0.00	*
10/22	64	36	23.21	8.05	0.00	*
10/23	63	28	23.38	4.60	0.00	*
10/24	69	27	23.21	4.60	0.00	*
10/25	60	32	23.08	8.05	0.00	*
10/26	61	26	23.05	5.75	0.00	0.00
10/27	56	35	23.02	8.05	0.03	*
10/28	46	32	22.86	17.25	0.05	*
10/29	51	32	22.73	9.20	0.01	*
10/30	52	36	22.71	9.20	0.06	*
10/31	39	27	22.78	11.50	0.00	*
11/1	39	19	22.65	13.80	0.28	*
11/2	23	18	22.92	17.25	0.20	0.43
11/3	25	7	22.94	9.20	0.00	*
11/4	28	7	22.89	6.90	0.00	*
11/5	33	17	22.96	8.05	0.00	*
11/6	37	17	22.91	11.50	0.00	*
11/7	40	17	22.84	13.80	0.00	*
11/8	39	29	22.77	11.50	0.00	*
11/9	34	17	22.76	11.50	0.00	0.20
11/10	29	9	22.99	6.90	0.00	*
11/11	32	-3	22.98	4.60	0.00	*
11/12	39	17	23.06	11.50	0.00	*
11/13	41	22	23.07	13.80	0.00	*
11/14	50	25	23.16	8.05	0.00	*
11/15	55	25	23.10	8.05	0.00	*
11/16	49	27	23.01	9.20	0.00	0.00
11/17	52	24	22.92	5.75	0.00	*
11/18	43	22	22.92	8.05	0.00	*
11/19	40	13	22.83	6.90	0.00	*

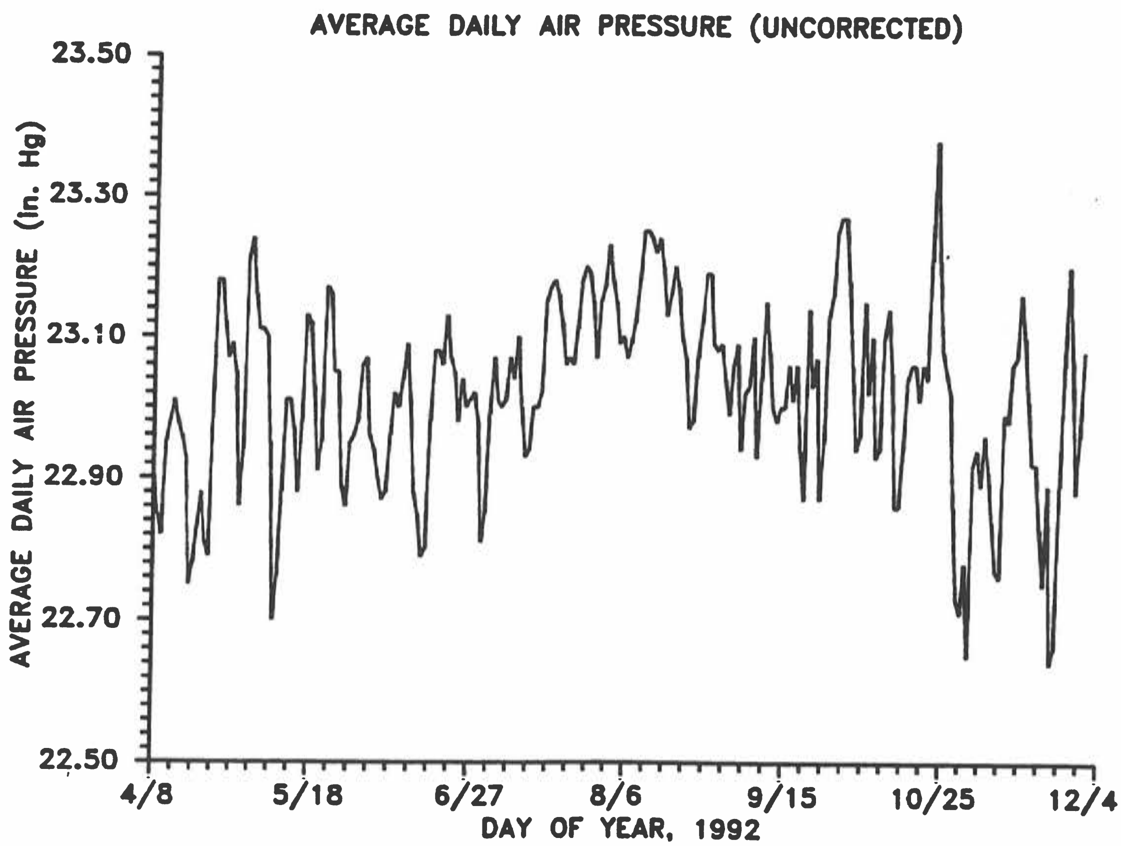
DATE (1992)	TEMPERATURE HIGH (°F)	LOW (°F)	AIR PRESSURE (in. merc.)[1]	WIND VELOCITY (mph)[3]	DAILY PRECIP (in.)	ACCUM PRECIP (in.)[2]
11/20	32	21	22.75	8.05	0.04	*
11/21	28	4	22.89	8.05	0.08	*
11/22	35	13	22.64	12.65	0.00	*
11/23	29	9	22.66	11.50	0.32	0.12
11/24	11	-1	22.89	6.90	0.04	*
11/25	13	-12	23.06	4.60	0.01	*
11/26	15	-16	23.20	4.60	0.00	*
11/27	21	-17	23.07	5.75	0.00	*
11/28	24	13	22.88	8.05	0.16	*
11/29	41	20	22.96	16.10	0.00	*
11/30	28	9	23.08	20.00	0.00	0.53

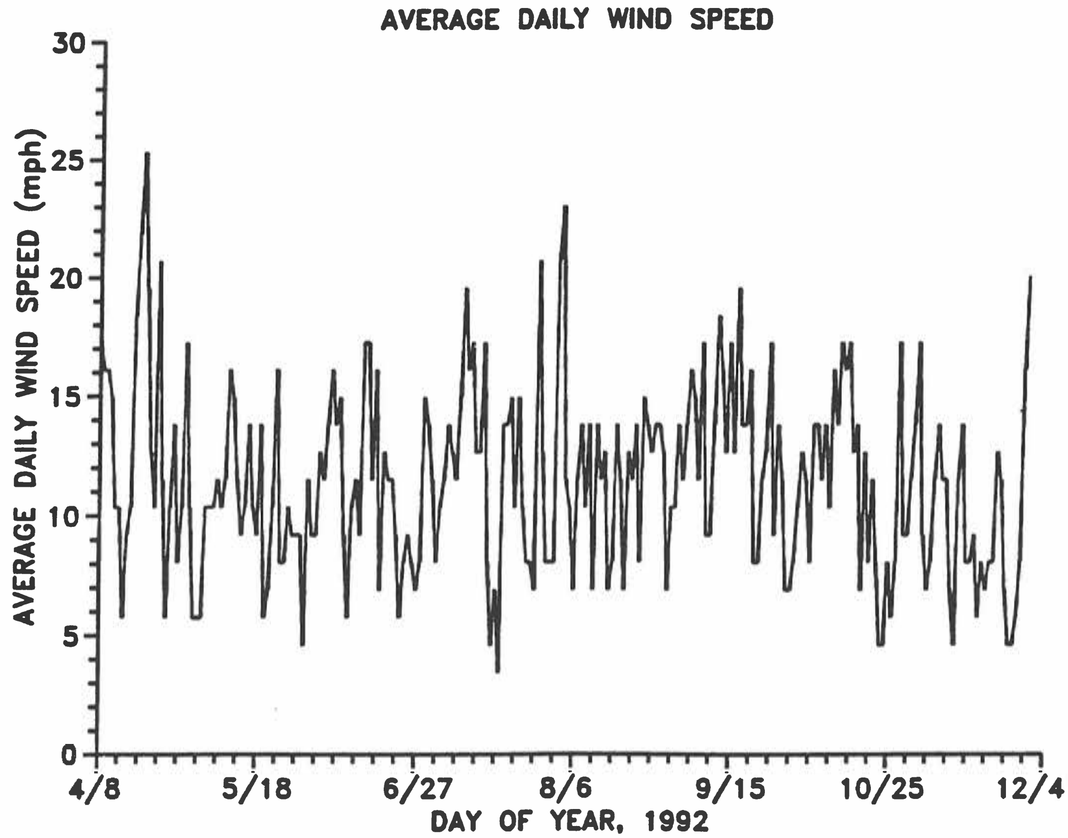
[1]AIR PRESSURE = Daily average barometric pressure measured in inches of mercury.

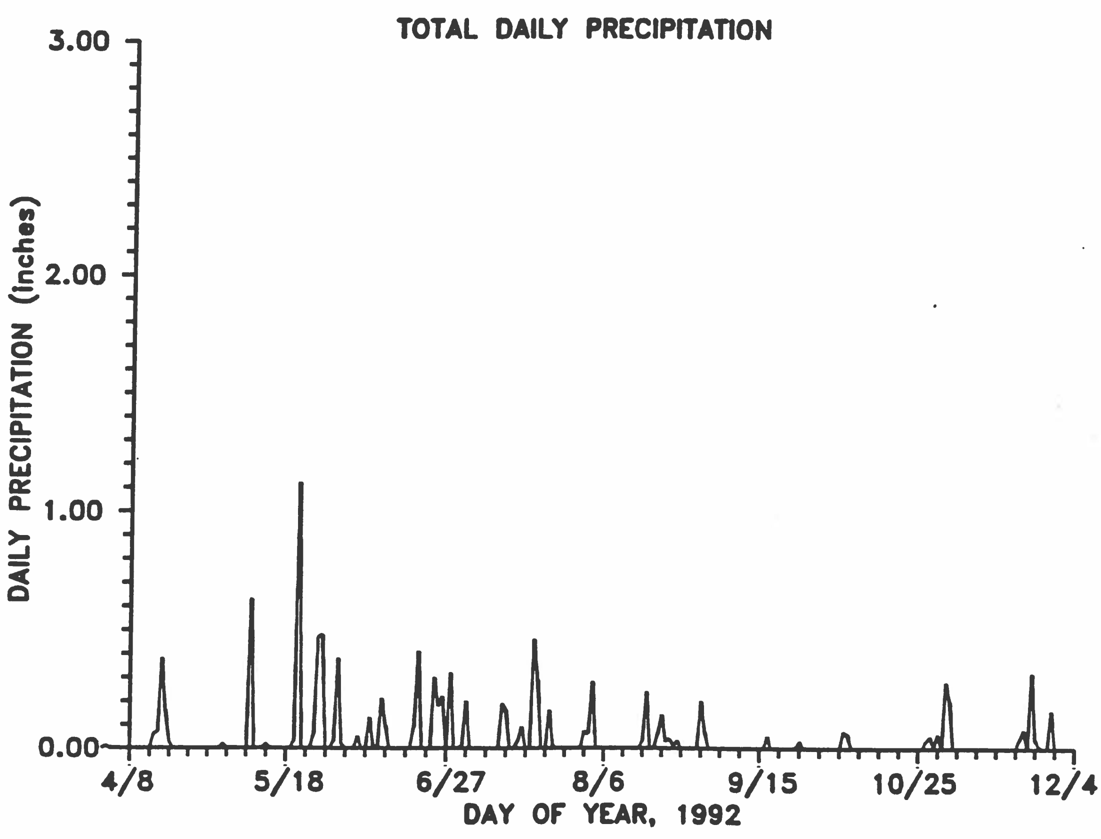
[2]ACCUM PRECIP = Weekly accumulated precipitation (totalled for 7 days previous to sample day) in inches.

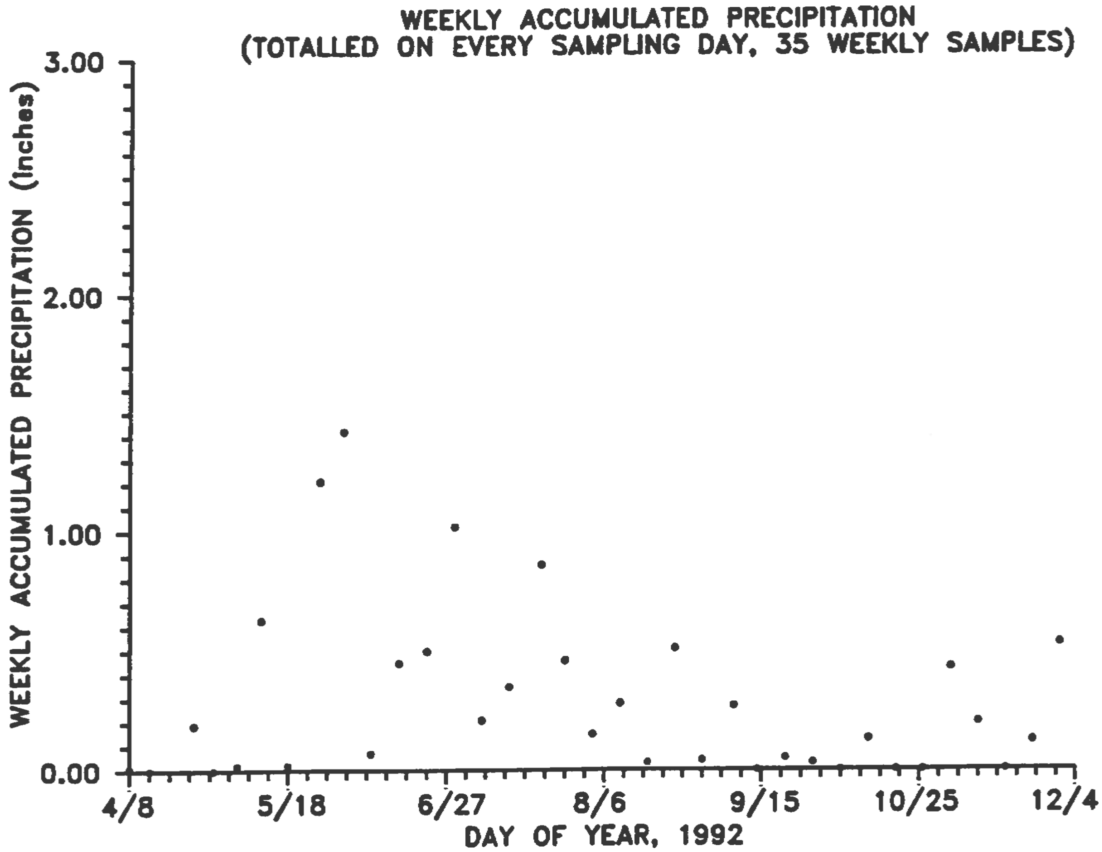
[3]WIND VELOCITY = Daily average.


DAILY HIGH AND LOW TEMPERATURES
HIGH TEMPERATURE
LOW TEMPERATURE
TEMPERATURE (°F)
85
70
55
40
25
10
-5
-20
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992


AVERAGE DAILY AIR PRESSURE (UNCORRECTED)
AVERAGE DAILY AIR PRESSURE (In. Hg)
23.50
23.30
23.10
22.90
22.70
22.50
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992


AVERAGE DAILY WIND SPEED
AVERAGE DAILY WIND SPEED (mph)
30
25
20
15
10
5
0
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992


TOTAL DAILY PRECIPITATION
DAILY PRECIPITATION (inches)
3.00
2.00
1.00
0.00
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992


WEEKLY ACCUMULATED PRECIPITATION
(TOTALLED ON EVERY SAMPLING DAY, 35 WEEKLY SAMPLES)
WEEKLY ACCUMULATED PRECIPITATION (Inches)
3.00
2.00
1.00
0.00
4/8
5/18
6/27
8/6
9/15
10/25
12/4
DAY OF YEAR, 1992

APPENDIX H

Statistical Data and Linear Correlation Coefficients for Soil-Gas Radon and Environmental Factors for Each Site

SITE 1

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	60.5	62.0	62.2	16.3	16.0	82.0
AIRPRES	33	2	23.37	23.41	23.39	0.22	22.79	23.73
WINDVEL	33	2	6.4	5.0	5.7	6.9	0.0	25.0
HUMIDITY	32	3	51.4	47.0	50.3	16.2	30.0	89.0
SOILTEMP	13	22	50.2	50.0	50.6	8.7	37.0	60.0
RESISTIV	13	22	1538461	1500000	1545455	477037	1000000	2000000
RADON	35	0	192.0	189.2	191.1	20.7	152.2	257.6
GAMMA	2	33	7.85	7.85	7.85	0.07	7.80	7.90
SOILMOIS	13	22	1.9	2.0	1.9	0.1	1.8	2.1
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.533							
WINDVEL	-0.388	-0.262						
HUMIDITY	-0.494	-0.193	0.054					
SOILTEMP	0.851	0.678	-0.579	-0.339				
RESISTIV	-0.528	-0.361	0.314	-0.101	-0.795			
RADON	-0.073	-0.118	0.108	0.298	-0.559	0.268		
SOILMOIS	0.552	0.405	-0.351	0.074	0.822	-0.992	-0.246	
ACCUMPP	0.034	-0.204	0.027	0.278	-0.395	-0.032	0.349	0.009

SITE 2

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	59.5	63.5	60.8	16.5	15.0	86.0
AIRPRES	33	2	23.13	23.13	23.14	0.21	22.55	23.48
WINDVEL	33	2	4.9	3.0	4.0	6.7	0.0	31.0
HUMIDITY	32	3	52.3	50.5	51.3	16.0	31.0	89.0
SOILTEMP	13	22	49.5	52.0	49.8	7.3	37.0	58.0
RESISTIV	13	22	1846154	2000000	1909091	375534	1000000	2000000
RADON	35	0	160.0	149.5	158.0	36.1	119.2	238.2
GAMMA	2	33	7.90	7.90	7.90	0.00	7.90	7.90
SOILMOIS	13	22	0.8	0.8	0.8	0.1	0.8	1.0
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.582							
WINDVEL	-0.521	-0.179						
HUMIDITY	-0.467	-0.374	0.074					
SOILTEMP	0.832	0.570	-0.626	-0.351				
RESISTIV	-0.026	0.354	-0.150	-0.394	-0.244			
RADON	0.047	-0.228	0.279	-0.083	-0.713	0.062		
SOILMOIS	0.026	-0.354	0.150	0.394	0.244	-1.000	-0.062	
ACCUMPP	-0.003	-0.182	0.088	0.321	-0.418	-0.539	0.431	0.539

SITE 3

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	59.3	62.5	60.4	17.6	13.0	89.0
AIRPRES	33	2	23.36	23.40	23.36	0.20	22.90	23.74
WINDVEL	33	2	10.6	10.0	10.0	8.7	0.0	30.0
HUMIDITY	32	3	52.6	48.0	51.5	16.9	28.0	93.0
SOILTEMP	4	31	57.3	57.5	57.3	1.0	56.0	58.0
RESISTIV	4	31	1750000	2000000	1750000	500000	1000000	2000000
RADON	35	0	303.9	297.8	297.1	112.8	142.0	574.4
GAMMA	2	33	14.35	14.35	14.35	1.63	13.20	15.50
SOILMOIS	4	31	6.9	6.8	6.9	0.1	6.8	7.0
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.450							
WINDVEL	-0.464	-0.339						
HUMIDITY	-0.562	-0.136	0.140					
SOILTEMP	0.450	-0.972	0.761	-0.333				
RESISTIV	-0.189	0.652	-0.951	0.406	-0.522			
RADON	-0.249	-0.070	-0.036	0.098	-0.815	0.821		
SOILMOIS	0.189	-0.652	0.951	-0.406	0.522	-1.000	-0.821	
ACCUMPP	0.024	-0.216	0.071	0.297	0.430	-0.986	0.215	0.986

SITE 4

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	61.9	63.0	63.2	18.1	17.0	89.0
AIRPRES	33	2	23.40	23.46	23.42	0.22	22.81	23.76
WINDVEL	33	2	7.9	5.0	7.0	8.6	0.0	30.0
HUMIDITY	32	3	52.7	49.0	51.4	16.8	32.0	95.0
SOILTEMP	13	22	49.2	50.0	49.5	7.3	38.0	58.0
RESISTIV	13	22	94769	90000	88364	39586	60000	200000
RADON	35	0	416.1	420.7	413.8	98.3	161.9	661.1
GAMMA	2	33	11.45	11.45	11.45	0.21	11.30	11.60
SOILMOIS	13	22	5.6	5.8	5.7	0.5	4.5	6.1
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.471							
WINDVEL	-0.442	-0.203						
HUMIDITY	-0.518	-0.197	-0.032					
SOILTEMP	0.862	0.538	-0.383	-0.412				
RESISTIV	-0.811	-0.254	0.539	0.356	-0.891			
RADON	0.029	-0.113	0.001	0.145	-0.722	0.581		
SOILMOIS	0.869	0.451	-0.495	-0.421	0.967	-0.950	-0.634	
ACCUMPP	-0.004	-0.143	-0.063	0.294	-0.400	0.599	0.475	-0.490

SITE 5

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	58.5	62.0	60.1	17.0	12.0	80.0
AIRPRES	33	2	23.32	23.36	23.33	0.21	22.79	23.75
WINDVEL	33	2	10.3	9.0	9.8	8.6	0.0	30.0
HUMIDITY	32	3	52.8	46.0	51.6	16.5	33.0	90.0
SOILTEMP	13	22	51.3	56.0	51.8	8.9	37.0	60.0
RESISTIV	13	22	1846154	2000000	1909091	375534	1000000	2000000
RADON	35	0	1236.7	1174.6	1207.2	318.3	846.3	2230.7
GAMMA	2	33	14.30	14.30	14.30	0.00	14.30	14.30
SOILMOIS	13	22	4.9	4.8	4.8	0.2	4.8	5.2
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.489							
WINDVEL	-0.309	-0.234						
HUMIDITY	-0.534	-0.239	0.004					
SOILTEMP	0.917	0.547	-0.312	-0.613				
RESISTIV	-0.042	0.242	0.371	-0.275	-0.184			
RADON	0.120	-0.042	-0.302	0.026	-0.667	0.190		
SOILMOIS	0.042	-0.242	-0.371	0.275	0.184	-1.000	-0.190	
ACCUMPP	0.001	-0.188	0.035	0.233	-0.444	-0.200	0.682	0.200

SITE 6

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	59.1	60.5	60.4	16.2	17.0	80.0
AIRPRES	33	2	23.38	23.41	23.39	0.20	22.85	23.67
WINDVEL	33	2	5.9	4.0	5.0	7.1	0.0	28.0
HUMIDITY	32	3	51.8	48.5	50.7	16.6	29.0	90.0
SOILTEMP	0	35	*	*	*	*	*	*
RESISTIV	0	35	*	*	*	*	*	*
RADON	35	0	163.68	150.10	162.00	40.11	97.00	259.90
GAMMA	2	33	7.90	7.90	7.90	0.14	7.80	8.00
SOILMOIS	0	35	*	*	*	*	*	*
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.521							
WINDVEL	-0.720	-0.482						
HUMIDITY	-0.526	-0.267	0.227					
SOILTEMP	*	*	*	*				
RESISTIV	*	*	*	*	*			
RADON	-0.254	-0.258	0.269	0.083	*	*		
SOILMOIS	*	*	*	*	*	*	*	
ACCUMPP	0.087	-0.165	0.064	0.248	*	*	0.209	*

* indicates missing data

SITE 7

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	61.8	64.5	63.1	18.8	15.0	89.0
AIRPRES	33	2	23.44	23.47	23.45	0.21	22.90	23.80
WINDVEL	33	2	5.4	4.0	4.6	6.4	0.0	26.0
HUMIDITY	32	3	52.7	48.5	51.4	16.3	33.0	94.0
SOILTEMP	26	9	56.0	57.8	56.3	8.3	36.0	68.0
RESISTIV	26	9	3134	800	2037	8071	600	32000
RADON	35	0	339.8	317.8	322.4	120.0	232.9	961.4
GAMMA	2	33	9.95	9.95	9.95	0.21	9.80	10.10
SOILMOIS	26	9	19.9	20.5	20.2	2.7	11.2	22.0
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.398							
WINDVEL	-0.416	-0.278						
HUMIDITY	-0.538	-0.306	-0.016					
SOILTEMP	0.737	0.481	-0.404	-0.014				
RESISTIV	0.201	0.167	-0.187	-0.250	-0.017			
RADON	0.010	-0.003	-0.174	0.008	0.078	-0.132		
SOILMOIS	0.067	-0.047	0.046	0.240	0.309	-0.942	0.215	
ACCUMPP	-0.017	-0.148	-0.130	0.277	0.022	-0.013	-0.033	0.069

SITE 8

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	58.3	60.0	60.0	16.8	10.0	81.0
AIRPRES	33	2	23.38	23.44	23.39	0.21	22.81	23.70
WINDVEL	33	2	4.0	2.0	3.3	5.1	0.0	21.0
HUMIDITY	32	3	52.3	50.0	51.1	16.7	31.0	92.0
SOILTEMP	26	9	54.0	55.0	54.3	7.1	37.0	63.5
RESISTIV	26	9	767308	700000	747292	648825	15000	2000000
RADON	35	0	172.3	163.0	168.4	43.2	111.0	313.8
GAMMA	2	33	7.90	7.90	7.90	0.00	7.90	7.90
SOILMOIS	26	9	5.9	5.2	5.7	1.7	4.5	12.0
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.416							
WINDVEL	-0.343	-0.405						
HUMIDITY	-0.624	-0.316	0.181					
SOILTEMP	0.803	0.591	-0.427	-0.211				
RESISTIV	-0.740	-0.341	0.486	0.110	-0.849			
RADON	-0.174	-0.297	0.117	0.215	-0.265	-0.055		
SOILMOIS	0.392	-0.103	-0.189	-0.164	0.372	-0.713	0.368	
ACCUMPP	0.120	-0.157	0.005	0.176	0.088	-0.356	0.443	0.352

SITE 9

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	59.1	60.0	60.4	15.7	16.0	82.0
AIRPRES	33	2	23.41	23.47	23.42	0.22	22.78	23.75
WINDVEL	33	2	3.5	2.0	2.8	5.0	0.0	18.0
HUMIDITY	32	3	51.5	50.0	50.3	16.1	30.0	92.0
SOILTEMP	26	9	53.6	55.5	54.0	6.8	37.0	61.0
RESISTIV	26	9	49771	52500	50450	25816	3250	80000
RADON	35	0	384.2	331.2	372.2	174.7	159.0	862.0
GAMMA	2	33	7.90	7.90	7.90	0.14	7.80	8.00
SOILMOIS	26	9	12.4	11.7	12.2	2.9	10.0	19.0
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.460							
WINDVEL	-0.606	-0.279						
HUMIDITY	-0.534	-0.286	0.066					
SOILTEMP	0.783	0.609	-0.747	-0.025				
RESISTIV	-0.604	-0.083	0.476	-0.044	-0.489			
RADON	0.590	0.477	-0.363	-0.119	0.558	-0.610		
SOILMOIS	0.542	0.021	-0.340	-0.059	0.347	-0.963	0.568	
ACCUMPP	0.152	-0.132	0.000	0.180	0.073	-0.536	-0.016	0.567

SITE 10

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	57.5	60.5	58.8	15.2	16.0	82.0
AIRPRES	33	2	23.34	23.40	23.35	0.20	22.85	23.65
WINDVEL	33	2	6.3	4.0	5.5	6.8	0.0	30.0
HUMIDITY	32	3	53.7	50.0	52.6	16.7	30.0	90.0
SOILTEMP	26	9	51.2	54.0	51.5	5.7	37.0	58.0
RESISTIV	26	9	42356	48250	42481	30022	1700	80000
RADON	35	0	171.7	171.2	171.8	41.6	82.0	252.3
GAMMA	2	33	7.35	7.35	7.35	0.07	7.30	7.40
SOILMOIS	26	9	9.7	8.7	9.6	2.4	7.5	14.9
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.531							
WINDVEL	-0.495	-0.325						
HUMIDITY	-0.489	-0.223	0.034					
SOILTEMP	0.795	0.568	-0.639	-0.055				
RESISTIV	-0.366	-0.012	-0.092	-0.145	-0.189			
RADON	-0.031	-0.185	-0.093	-0.178	-0.015	0.413		
SOILMOIS	0.394	-0.081	0.097	-0.010	0.189	-0.922	-0.133	
ACCUMPP	0.058	-0.106	0.091	0.226	0.113	-0.549	0.281	0.495

SITE 11

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	61.2	65.5	62.7	17.1	18.0	83.0
AIRPRES	33	2	23.41	23.47	23.43	0.22	22.84	23.77
WINDVEL	33	2	7.9	6.0	7.0	7.6	0.0	30.0
HUMIDITY	32	3	51.8	47.0	50.4	15.6	33.0	95.0
SOILTEMP	26	9	54.1	56.0	54.5	7.1	38.0	62.5
RESISTIV	26	9	308712	400000	313554	168662	1200	500000
RADON	35	0	200.3	174.5	189.1	85.6	110.9	505.6
GAMMA	2	33	10.85	10.85	10.85	0.21	10.70	11.00
SOILMOIS	26	9	2.2	1.1	1.9	2.6	1.0	10.6
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.526							
WINDVEL	-0.544	-0.324						
HUMIDITY	-0.531	-0.239	0.053					
SOILTEMP	0.843	0.616	-0.579	-0.096				
RESISTIV	-0.478	0.065	0.405	0.052	-0.344			
RADON	-0.224	-0.345	0.129	0.169	-0.235	-0.574		
SOILMOIS	0.248	-0.163	-0.125	-0.113	0.136	-0.803	0.824	
ACCUMPP	-0.038	-0.188	-0.051	0.323	0.162	-0.421	0.513	0.432

SITE 12

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	32	3	60.0	62.5	61.1	17.8	14.0	90.0
AIRPRES	33	2	23.40	23.44	23.41	0.21	22.91	23.75
WINDVEL	33	2	9.5	6.0	8.9	8.4	0.0	30.0
HUMIDITY	32	3	52.8	46.5	51.6	16.3	33.0	94.0
SOILTEMP	26	9	53.1	56.0	53.5	6.9	37.0	60.0
RESISTIV	26	9	36869	40000	36554	31389	1300	80000
RADON	35	0	395.5	383.2	380.7	159.8	168.7	933.1
GAMMA	2	33	10.15	10.15	10.15	0.49	9.80	10.50
SOILMOIS	26	9	24.0	17.5	23.7	10.3	15.2	40.0
ACCUMPP	35	0	0.29	0.15	0.24	0.37	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	SOILMOIS
AIRPRES	0.527							
WINDVEL	-0.485	-0.511						
HUMIDITY	-0.453	-0.183	0.006					
SOILTEMP	0.837	0.577	-0.574	-0.135				
RESISTIV	-0.663	-0.267	0.498	-0.017	-0.624			
RADON	0.157	0.384	-0.455	0.086	0.223	-0.159		
SOILMOIS	0.556	0.019	-0.359	-0.093	0.439	-0.889	0.115	
ACCUMPP	-0.017	-0.164	-0.039	0.333	0.134	-0.473	0.195	0.551

OVERALL

	N	N*	MEAN	MEDIAN	TRMEAN	STDEV	MIN	MAX
AIRTEMP	384	36	59.7	62.0	60.7	16.7	10.0	90.0
AIRPRES	396	24	23.36	23.40	23.37	0.22	22.55	23.80
WINDVEL	396	24	6.9	4.0	6.1	7.5	0.0	31.0
HUMIDITY	384	36	52.4	49.0	51.5	16.3	28.0	95.0
SOILTEMP	212	208	52.8	55.0	53.1	7.4	36.0	68.0
RESISTIV	212	208	507818	77500	450791	732453	600	2000000
RADON	420	0	344.5	224.4	297.6	314.0	82.0	2230.7
GAMMA	24	396	9.82	8.90	9.68	2.48	7.30	15.50
SOILMOIS	212	208	10.0	7.5	9.1	8.7	0.8	40.0
ACCUMPP	420	0	0.29	0.15	0.25	0.36	0.00	1.42

	AIRTEMP	AIRPRES	WINDVEL	HUMIDITY	SOILTEMP	RESISTIV	RADON	GAMMA	SOILMOIS
AIRPRES	0.470								
WINDVEL	-0.443	-0.271							
HUMIDITY	-0.527	-0.231	0.073						
SOILTEMP	0.812	0.588	-0.471	-0.185					
RESISTIV	-0.282	-0.245	0.101	-0.059	-0.250				
RADON	0.016	0.003	0.090	0.030	-0.022	0.221			
GAMMA	-0.255	0.132	0.183	0.223	-0.026	-0.002	0.715		
SOILMOIS	0.279	0.141	-0.045	0.014	0.218	-0.526	0.129	0.023	
ACCUMPP	0.031	-0.155	0.008	0.265	0.036	-0.236	0.109	-0.043	0.251

EXPLANATION

AIRTEMP= Air temperature in °F
AIRPRES = Barometric pressure in inches of mercury
WINDVEL= Wind speed in miles per hour
HUMIDITY= % relative humidity
SOILTEMP = Soil temperature in °F
RESISTIV = Resistivity of soil moisture cell in Ohms
RADON = Soil-gas radon concentration in pCi/L
GAMMA= Background gamma radiation in microroentgens per hour
SOILMOIS = % soil moisture
ACCUMPP = weekly accumulated precipitation (totalled for 7 days previous to sample day) in inches

N = Number of samples
N* = Number of missing samples
MEAN = Mean value of the data
MEDIAN= Median value of the data
TRMEAN= Trimmed mean - mean of data excluding the top and bottom 5%
STDEV = Standard deviation
MIN = Minimum value
MAX= Maximum value