SPECIAL REPORT 242

RADON POTENTIAL IN AMADOR, CALAVERAS AND TUOLUMNE COUNTIES, CALIFORNIA

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CALIFORNIA GEOLOGICAL SURVEY
Department of Conservation

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By

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EXECUTIVE SUMMARY

Radon is a radioactive gas formed by decay of small amounts of uranium and thorium naturally present in rock and soil. Sometimes radon gas can move from underlying soil and rock into homes and concentrate in the indoor air, posing a significant lung cancer risk for the residents. The U.S. Environmental Protection Agency (U.S. EPA, 2012) estimates indoor-radon exposure results in 21,000 lung cancer deaths annually in the United States. The U.S. EPA recommended action level for indoor radon is 4.0 picocuries per liter (pCi/L).

The California Department of Public Health (CDPH), Indoor-radon Program, surveyed 412 homes in Amador, Calaveras and Tuolumne counties for radon during February to April 2004, and December 2008 to May 2009. The surveys utilized charcoal detectors, exposed for two days. An additional 66 home measurements voluntarily reported to CDPH by radon testing companies outside of the survey periods were also available for these counties. The surveys and additional data provide indoor-radon measurements from 478 homes. These measurements range from < 0.5 pCi/L, the detection limit, to 40.4 pCi/L, for a basement measurement. In developing the radon potential map for portions of Amador, Calaveras and Tuolumne counties, the California Geological Survey (CGS) utilized these radon data, along with uranium data from soil and sediment samples and airborne gamma-ray measurements, geologic information, and soil property information.

This report documents the data and procedures used by the CGS to develop the radon potential map for Amador, Calaveras and Tuolumne Counties. Evaluating the geologic unit radon potentials involved linking indoor-radon data to individual geologic units using a geographic information system (GIS). Subsequently, each unit was assigned a preliminary radon potential based on percent of indoor-radon data at or exceeding 4.0 pCi/L as follows:

- High potential—20 percent or more
- Moderate potential—5 to 19.9 percent
- Low potential—less than 5 percent; and
- Unknown potential—insufficient data to assign a potential.

Next, National Uranium Resource Evaluation program (NURE) soil and sediment uranium data, NURE airborne equivalent uranium (eU) data, Natural Resource Conservation Service (NRCS) soil permeability and depth data were reviewed. For units with few indoor-radon data, unless the additional data review supported a different potential their preliminary potential became their final potential.

To create radon potential zone areas for the Amador, Calaveras and Tuolumne counties map, geologic units with the same assigned radon potentials were grouped together to define the radon potential zones. All high radon potential unit occurrences, collectively, define high potential zone areas, moderate potential units the moderate potential zone

areas, low potential units the low potential zone areas, and unknown potential units the unknown potential zone areas. A final map validity check involved statistical comparison of high and low potential zone radon-data populations to confirm each population was statistically distinct. The resulting map (Plate 1) shows high potential zone areas comprising about 22.0 percent of the Amador-Calaveras-Tuolumne study area, moderate potential zone areas 52.3 percent, low potential zone areas 16.9 percent, and unknown potential areas 8.8 percent.

The CGS 1:100,000-scale radon potential zone map for Amador, Calaveras and Tuolumne counties is informational, not regulatory. Its purpose is to help guide prioritization of areas for public education about radon, and for targeting additional indoor-radon testing activities. A building's location on the map does not indicate its indoor-radon concentration. Typically, all radon potential zones contain some homes with radon above 4.0 pCi/L and some below 4.0 pCi/L. The only way to identify specific homes and buildings exceeding 4.0 pCi/L is through testing.

Based on CDPH indoor-radon survey results, the CGS radon potential zone map, and 2010 U.S. Census data, an estimated 20,078 people live in residences with indoor-air radon concentrations at or exceeding 4.0 pCi/L in Amador, Calaveras and Tuolumne counties, collectively. An estimated 4,477 people live in homes that will test 10.0 pCi/L or higher, and an estimated 996 people live in homes that will test at 20.0 pCi/L or higher. Indoor-radon testing should be encouraged in Amador, Calaveras and Tuolumne counties, especially in high and moderate radon potential zone areas. In addition, testing should be encouraged within unknown potential areas and in portions of the Sierra Nevada Mountains not mapped by this project. In these areas, available data are insufficient for radon potential assignment and delineation of radon zones. Finally, radon testing should be encouraged in Amador, Calaveras and Tuolumne county homes with basements, irrespective of radon potential zone. The CDPH radon surveys of these counties found radon concentrations in some basements significantly above the 4.0 pCi/L U.S. EPA recommended action level.

Those considering building a new home may wish to consider radon resistant new construction practices, particularly at sites within high and moderate radon potential areas. Post construction radon mitigation is possible, if necessary, but is more expensive than the cost of adding radon-reducing features during home construction.

INTRODUCTION

Purpose

This report documents the data and procedures used by the California Department of Conservation, California Geological Survey (CGS) to develop the 2017 radon potential zone map for Amador, Calaveras and Tuolumne counties. CGS produced the map for the California Department of Public Health-Indoor Radon Program (CDPH-Indoor Radon Program) through an interagency agreement. The report includes radon potentials for individual geologic units and estimates of the county population exposed to 4 picocuries per liter (pCi/L) or higher indoor-radon concentrations. The report contains only minimal radon background, health and testing information. No information on radon remediation of homes and buildings is included in the report.

The following websites have information about radon, related health issues, testing, and remediation:

http://www.cdph.ca.gov/healthinfo/environhealth/Pages/Radon.aspx

http://www.epa.gov/radon/pubs/index.html.

Background Information About Radon and Health

Radon gas is a naturally occurring odorless and colorless radioactive gas. It forms from the radioactive decay of small amounts of uranium and thorium naturally present in rocks and soils. The average uranium content for the earth's continental crust is about 2.5-2.8 parts per million (ppm). Typical concentrations of uranium and thorium for many rocks and soils are a few ppm. Certain rock types, such as organic-rich shales, some granitic rocks, and silica-rich volcanic rocks may have uranium and thorium concentrations of five to several tens of ppm and occasionally higher. All buildings have some potential for elevated indoor-radon levels because radon is always present in the underlying soils and rocks. Buildings located on rocks and soils containing higher concentrations of uranium often have an increased likelihood of elevated indoor-radon levels. Breathing air with elevated radon gas abundance over long periods increases one's risk of developing lung cancer. Not everyone exposed to radon will develop lung cancer. However, the U.S. Environmental Protection Agency (U.S. EPA, 2012) estimated 21,000 people die in the United States annually from lung cancer caused by radon exposure.

Indoor-radon concentrations are reported in picocuries per liter (pCi/L) in the United States. The average indoor-radon concentration in American homes is about 1.3 pCi/L (U.S. EPA, 2012). Average outdoor air radon concentration is about 0.4 pCi/L. The U.S. EPA recommends that individuals avoid long-term exposures to radon concentrations ≥ 4.0 pCi/L (*4.0 pCi/L is the U.S. EPA recommended indoor-radon action level*). Based on long-term radon test statistics, the U.S. EPA estimates about one in 15 homes (6.7 percent) in the United States has radon levels ≥ 4.0 pCi/L.

Indoor-radon concentration is used as a guide for determining potential exposure and for identifying buildings that require remedial action. However, it is inhalation of two radon decay products, polonium-218 and polonium-214, that most likely leads to lung cancer. These polonium isotopes have very short half-lives (see Table 1). When they enter the lungs, they attach to lung tissue or trapped dust particles and quickly undergo radioactive decay, emitting high-energy alpha particles. The alpha particles are thought to damage the DNA in lung tissue cells, causing cancer (Brookins, 1990). In contrast, most longer-lived radon-222 is exhaled before undergoing radioactive decay.

Radon gas readily moves through rock and soil along micro-fractures and interconnected pore-spaces between mineral grains. Radon movement away from its site of origin is typically limited to a few feet to tens of feet because of the relatively short half-lives of radon isotopes (3.8 days for radon-222, 55.6 seconds for radon-220 and 3.96 seconds for radon-219), but movement may be hundreds of feet in some cases. Additional conditions, such as soil moisture content, also affect how far radon can move in the subsurface. Because radon-222 (a radioactive-decay product of uranium-238, see Table 1) has the longest half-life of the several radon isotopes, it is usually the predominant radon isotope in indoor air rather than shorter-lived radon-220 (a radioactive-decay product of thorium-232) or radon-219.

Radon gas moves from underlying soil into a building when air pressure inside the building is lower than air pressure in the soil, and pathways for radon entry into the building are available. Heating indoor air, using exhaust fans, and wind blowing across a building will all lower a building's internal air pressure. Pathways include cracks in slab foundations or basement walls, pores and cracks in concrete blocks, through-going floor-to-wall joints, and openings around pipes. Because radon enters buildings from the adjacent soil, indoor-radon concentrations are typically highest in basements and ground floor rooms. Radon can also enter a building in water from private wells. All ground water contains some dissolved radon gas. The travel time of water from an aquifer to a home in a private well is usually too short for much radon decay, so radon is available to be released in the house during water usage, for example through use of a bathroom shower. However, normal water usage typically adds only about 1 pCi/L of radon to indoor air per 10,000 pCi/L of radon in water (Grammer and Burkhart, 2004).

The most common indoor-radon testing methods utilize either charcoal (for 2 to 3 day short-term tests) or alpha-track type detectors (for 90 day to one-year long-term tests). These tests are simple to perform, inexpensive, and homeowners can do this testing. Homeowners expose the radon detector according to manufacturer instructions and then send it to a laboratory for analysis, which is included in the detector cost. Typical turnaround time for test results from the laboratory is one to two weeks. Alternatively, one may hire professional certified radon testers to do the testing. The CDPH Radon Program maintains lists of currently certified radon testers, mitigators and laboratories on its website:
https://www.cdph.ca.gov/HealthInfo/environhealth/Pages/RadonServiceProviders.aspx .

Nuclide (Isotope)	**Principal mode of radioactive decay**	**Half-life**
Uranium-238	Alpha	4.5×10^9 years
Thorium-234	Beta	24.1 days
Protactinium-234	Beta	1.2 minutes
Uranium-234	Alpha	2.5×10^5 years
Thorium-230	Alpha	7.5×10^4 years
Radium-226	Alpha	1,602 years
Radon-222	**Alpha**	**3.8 days**
Polonium-218	Alpha	3.1 minutes
Lead-214	Beta	26.8 minutes
Astatine-218	Alpha	1.5 seconds
Bismuth-214	Alpha	19.9 minutes
Polonium-214	Alpha	1.6×10^{-4} seconds
Thallium-210	Beta	1.3 minutes
Lead-210	Beta	22.6 years
Bismuth-210	Beta	5.0 days
Polonium-210	Alpha	138.4 days
Thallium-206	Beta	4.2 minutes
Lead-206	Stable	Stable

Table 1. The uranium-238 radioactive decay series (Generalized-does not show branching or some short-lived isotopes). Modified from Appleton, 2013, p. 241)

Long-term tests have advantages over short-term tests. Longer exposure times “average out” short-term fluctuations in radon levels, such as those caused by daily and seasonal weather changes. In addition, long-term tests utilize open-house conditions with windows and doors open or shut based on residents preferences. Short-term tests utilize closed house conditions to maximize radon concentration during the measurement period. Consequently, long-term measurements should more accurately represent a person's exposure to indoor-radon. However, short-term measurements are more common because of the shorter time required. More often than not, if a short-term indoor radon test result is several pCi/L above 4.0 pCi/L, follow-up short-term and long-term tests will also be above 4.0 pCi/L (see Appendix D).

Radon Potential Map Characteristics, Use and Limitations

Radon potential maps developed by CGS for the CDPH-Indoor Radon Program show areas where geologic conditions create higher or lower likelihoods for homes exceeding 4.0 pCi/L. Also shown are areas lacking sufficient data for radon potential determination. The number of individuals exposed to excessive radon levels for an area can be estimated using U.S. Census track data and a radon zone map.

Radon potential maps are advisory, not regulatory. Their purpose is to help guide federal, state and local government agencies and private organizations target and prioritize radon program activities and resources.

A building's location on the map does not indicate it has excessive indoor radon levels. In addition to geology, local variability in soil permeability, climatic conditions, and factors such as home design, construction, condition, and usage preferences may influence indoor radon levels. Testing is the only way to determine the radon concentration in a specific building or home accurately, regardless of the radon zone. All radon zones typically have some buildings and homes with indoor radon levels ≥ 4.0 pCi/L as well as some with radon levels < 4.0 pCi/L.

Development of the Radon Potential Map for Amador, Calaveras and Tuolumne Counties

The radon potential zone development process for Amador, Calaveras and Tuolumne counties utilized data from the following sources:

- CDPH-Radon Program 2004 and 2009-2010 indoor-radon surveys test data and additional CDPH data for a total of 478 residences in Amador, Calaveras and Tuolumne counties, and the 2010 CDPH-Radon Zip Code database (containing data from 1989-2010 data) for these counties.

- NURE Project Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) Program soil and sediment uranium data for the Sacramento, Mariposa and Walker Lake 1X2 degree quadrangles. No HSSR Program data are available for portions of Calaveras and Tuolumne counties within the San Jose 1X2 degree quadrangle.

- NURE Project Aeroradiometric Survey data for equivalent uranium (eU) for the Mariposa, Sacramento, San Jose and Walker Lake 1X2 degree quadrangles.

- An unpublished 1:100,000-scale geology digital shapefile of Amador, Calaveras and Tuolumne counties developed for this project by Pete Holland and Matt O'Neal of CGS.

- Natural Resource Conservation Service (NRCS) Soil Survey Geographic (SSURGO) databases and maps for Amador County, and portions of Calaveras and Tuolumne counties associated with the Stanislaus National Forest

- U.S. Census Bureau 2010 census block data for Amador, Calaveras and Tuolumne counties, California

The radon potential map development steps were:

1) Group indoor-radon survey data by geologic unit using a geographic information system (GIS)

2) Preliminarily assign geologic units to one of four radon potential categories based on the percentage of indoor-radon measurements at, or exceeding, 4.0 pCi/L (see step 7 for categories), the number and magnitude of indoor-radon measurements per unit exceeding 10.0 pCi/L, and the total number of measurements.

3) Group NURE project uranium soil and sediment data and airborne equivalent uranium (eU) data by geologic unit using GIS.

4) Rate geologic units as to their likelihood of having problem radon homes based on the percentage of NURE eU data exceeding 5.0-ppm uranium (twice the average crustal uranium abundance of 2.5 ppm).

5) Group indoor-radon survey data fby NRCS soil unit using GIS.

6) Review soil permeability, shrink-swell character, hydrologic soil group information for soil units and indoor-radon data to see if these soil characteristics relate to higher or lower indoor-radon concentration homes.

7) Assign final radon potentials to all 1:100,000-scale geologic units in the Amador, Calaveras and Tuolumne county study area using information from steps 2, 4, 6 and 7. Radon potential categories are defined by percentages of short-term tests likely to exceed 4.0 pCi/L as follows:

    - High—20.0 percent or more ≥ 4.0 pCi/L indoor measurements
    - Moderate—5 to 19.9 percent ≥ 4.0 pCi/L indoor measurements

- Low—0 to 4.9 percent ≥ 4.0 pCi/L indoor measurements
- Unknown—units with insufficient data for estimating the percent of ≥ 4.0 pCi/L indoor measurements

8) Group unit areas with similar radon potentials to form radon potential zones using GIS.

9) Statistically compare indoor-radon data populations for the high, moderate and low radon potential zones to confirm that each zone represents a distinct indoor-radon data population.

10) Estimate the number of people living in each radon zone by using GIS to compare the census tract data to the radon zones and estimate the number of people residing in homes at or above 4.0 pCi/L.

Following sections of this report provide more details on data used and the results of these steps.

Portions of radon potential zones with faults and shear zones often have increased potential for elevated indoor-radon concentrations because such features provide pathways for radon flow. However, the 1:100,000 scale Amador, Calaveras and Tuolumne counties radon potential zone map does not show fault and shear zone locations. Fractures less than an inch wide can be significant radon pathways. Accurate representation of such fractures on a 1:100,000-scale map is not possible. A feature must be at least 100-200 square feet in size to show on a map at this scale and the accuracy of that feature's location is commonly +/- tens to hundreds of feet. Additionally, soil and alluvium may obscure faults and shear zones, especially smaller ones, or prevent their precise location. Consequently, at 1:100,000-scale mapping, it is better to base radon testing priorities on zone designation rather than attempt to target fault and shear zone locations. Detailed investigations of indoor-radon and fault or shear zone relationships require use or development of 1:24,000 or more detailed scale geologic maps.

Amador, Calaveras and Tuolumne Counties Geology Digital Layer

CGS radon potential map development requires appropriate geologic maps at 1:100,000-scale or more detailed scales. Geologic maps at smaller scales (less detail) typically do not work well for radon mapping. This is because geologic units from smaller-scale maps are more likely to be a composite of multiple rock types, and each lithology may have a distinctly different radon potential. Ideal geologic maps for radon potential map development are those with geologic units having a dominant lithology with relatively narrow ranges of variation in chemical and physical properties.

No published geologic maps currently exist showing geologic units at 1:100,000-scale or more detailed scales for the Amador, Calaveras and Tuolumne county area. Consequently, part of the radon potential map development for Amador, Calaveras and Tuolumne counties required compilation of a geologic unit digital layer at 1:100,000-

scale. Pete Holland and Matt O'Neal of the CGS Regional Mapping Program developed such a digital layer for this radon-mapping project using GIS and information from the references listed in Appendix E.

AMADOR, CALAVERAS AND TUOLUMNE COUNTIES SHORT-TERM INDOOR-RADON SURVEYS AND OTHER INDOOR-RADON DATA

Overview

The CDPH-Radon Program conducted radon surveys of indoor radon in homes in Amador, Calaveras and Tuolumne counties between February and April 2004 and December 2008 and May 2009. Each survey participant received a free charcoal detector with instructions for placement and exposure. After exposure, participants mailed their detector to the Radon Program contract lab for measurement. The contract lab provided test results directly to survey participants within several weeks of detector receipt. CDPH conducted the 2008-2009 survey because the 2004 survey did not produced enough home measurements to allow radon potential map development. This happened in part because the 2004 survey contract lab measured a number of the exposed charcoal devices more than six days after the end of exposure and accuracy of these results was questionable. Six days is the protocol limit for activated charcoal radon measurements (WRRTC, 2004). In spite of a mathematical correction applied to the greater than six-day measurement data by the lab, the six-day or less data and the greater than six-day data are significantly different statistically (by the Mann-Whitney rank sum test). The greater than six days tests were consistently higher in radon concentration than the six days or less tests for the same geologic units which is suspected to be an error introduced by the mathematical correction. Consequently, the radon data set used to develop the radon potential map for Amador, Calaveras and Tuolumne counties exclude radon data measured more than six days after exposure. Ultimately, the 2004 survey and the 2008-2009 survey generated useable indoor-radon data for 412 homes in the three counties. The CDPH-Radon Program had an additional 66 voluntary indoor radon measurements for these counties in their records, mostly dating between November 2009 and May 2010, which were suitable for use and included in this study. The finalized database contains 478 home radon measurements.

The primary goal of the surveys was to obtain sufficient indoor-radon data for homes located on specific geologic units to evaluate unit radon potentials. The percentage of homes exceeding the 4.0 pCi/L U.S. EPA recommended radon action level was used to evaluate geologic unit radon potential.

Figure 1 shows the geographic distribution of homes with radon measurements in Amador, Calaveras and Tuolumne counties used in this study. Areas of high and low survey sample densities reflect areas of high and low population densities in the county. Figure 2 shows the geographic distribution of the 70 survey homes testing ≥ 4.0 pCi/L and homes testing < 4.0 pCi/L.

The CDPH radon survey concentrations range from < 0.5 pCi/L, the reported detection limit, to 40.4 pCi/L, the latter for a basement measurement in a home in Jackson. Table 2 provides foundation type, test floor and test room information, and the name of the associated geologic unit for those homes with radon survey measurements of 10.0 pCi/L or above.

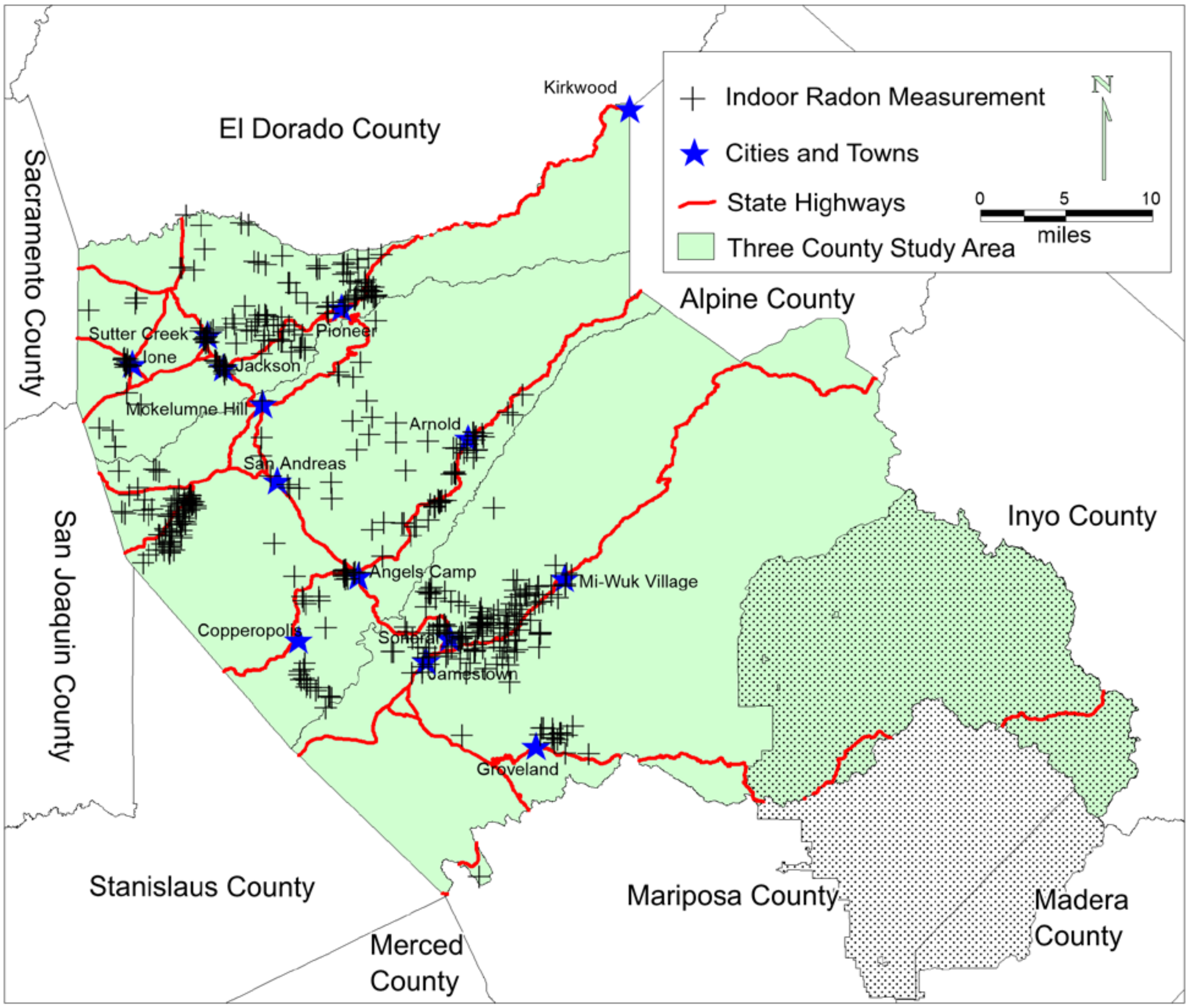

Figure 1. CDPH Amador, Calaveras and Tuolumne counties home radon test locations (The stippled area is Yosemite National Park)

Tables 3, 4 and 5 summarize Amador, Calaveras and Tuolumne county indoor-radon measurements used in this study by Zip Code zone and City/Region. For comparison, Tables 6, 7 and 8 summarize all CDPH on-line Zip Code radon database data for the Amador, Calaveras and Tuolumne county Zip Code zones accumulated by CDPH since 1989 (excluding 2003-2004 data exceeding 6 days between exposure and lab measurement, as previously discussed). Using definitions of high, moderate and low radon potentials previously stated, the data in Tables 3 and 4 suggest many parts of Amador, Calaveras and Tuolumne counties have moderate to high radon potentials.

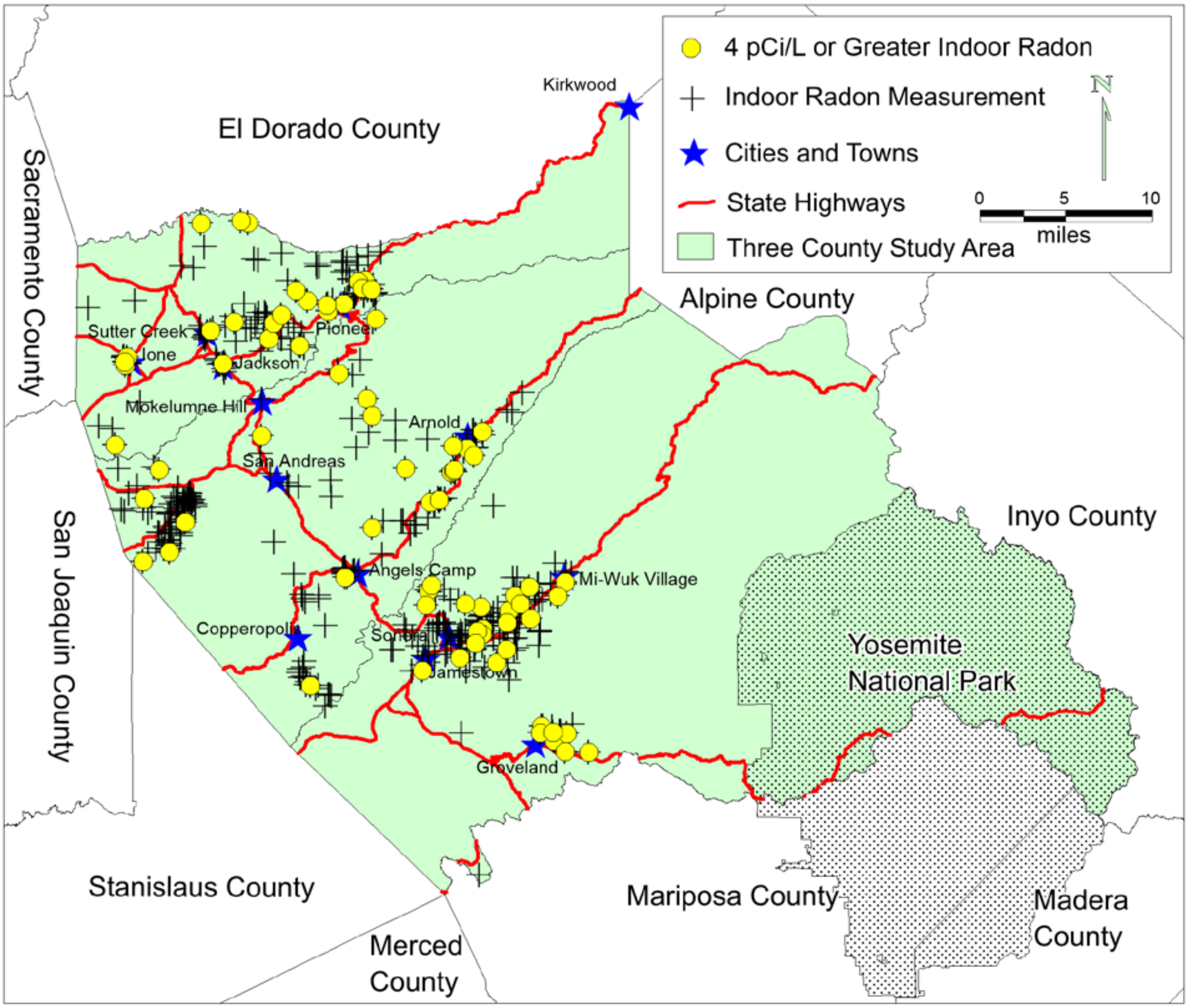

Figure 2. CDPH Amador, Calaveras and Tuolumne counties home radon test locations with 4.0 pCi/L or greater sites (shown as yellow circles)

The 1989-2010 CDPH data, summarized in Tables 6, 7 and 8 cannot be used for evaluating the radon potential of particular geologic units because the only location information for many of the data is Zip Code. More precise test location information is required for geologic unit evaluation. Another complication with the CDPH 1989-2010 database is that it likely includes multiple measurements for some homes not documented as such. Examples of these measurements include follow-up measurements after initial tests, measurements from simultaneous measurements in multiple rooms, multiple measurements from apartment or condominium complexes, and even a few measurements made after radon mitigation projects.

Home	Radon pCi/L	Zip Code	Floor*	Location*	Geologic Unit
Amador County					
1	40.4	95642	Basement	--	granitic rocks, undifferentiated
2	38.8	95669	--	--	Calaveras Complex, undifferentiated
3	29.4	95666	First Floor	Family Room	Mehrten Formation
4	16.7	95685	Basement	--	Logtown Ridge Formation
5	12.5	95689	Basement	Office	Calaveras Complex, undifferentiated
6	11.5	95675	First Floor	--	granitic rocks, undifferentiated
7	10.2	95675	Basement	--	granitic rocks, undifferentiated
Calaveras County					
8	13.1	95255	--	--	mafic plutonic rocks, undifferentiated
9	12.3	95248	First Floor	--	Calaveras Complex, undifferentiated
10	12.0	95222	First Floor	--	Don Pedro Terrane, phyllite and schist of Clark
11	10.1	95252	--	--	dredge or mine tailings
Tuolumne County					
12	15.0	95370	First Floor	Living Room	granitic rocks, undifferentiated
13	11.3	95321	First Floor	--	Calaveras Complex, undifferentiated
14	10.1	95327	--	--	Sullivan Creek terrane, phyllite belt

*-- not provided by homeowner

Table 2. CDPH survey indoor-radon measurements ≥ 10.0 pCi/L by Zip Code, floor, room, and geologic unit for Amador, Calaveras and Tuolumne Counties

Zip Code	City/Region	Number of Tests	Tests ≥ 4.0 pCi/L	% Tests ≥ 4.0 pCi/L	High pCi/L
95629	Fiddletown	3	0	0	2.6 (First Floor)
95640	Ione	18	4	22.2	4.7 (First Floor)
95642	Jackson	20	2	10.0	40.4 (Basement)
95665	Pine Grove	13	4	30.8	7.5 (Basement)
95666	Pioneer	38	5	13.2	29.4 (First Floor)
95669	Plymouth	5	0	0	2.9 (First Floor)
95675	River Pines	2	2	100	11.5 (First Floor)
95685	Sutter Creek	20	2	10.0	16.7 (Basement)
95689	Volcano	9	1	11.1	12.5 (Basement)
	Total	128	20	15.6	40.4 (Basement)

Table 3. Indoor-Radon Short-Term Test Results for the CDPH 2004 and 2008-2009 Amador County Survey--by Zip Code Zone (This table excludes all data with laboratory analysis occurring more than 6 days after detector exposure)

Zip Code	City/Region	Number of Tests	Tests ≥ 4.0 pCi/L	% Tests ≥ 4.0 pCi/L	High pCi/L
95221	Altaville	2	0	0	0.8 (? Floor)
95222	Angles Camp	20	0	0	2.7 (Basement)
95223	Arnold (inc.1= Camp Connell)	19	4	21.1	8.2 (First Floor)
95224	Avery	5	3	60.0	39.5 (Basement)
95225	Burson	4	1	25.0	5.4 (First Floor)
95228	Copperopolis	15	1	6.7	4.3 (First Floor)
95232	Glencoe	2	1	50.0	7.6 (First Floor)
95245	Mokelumne Hill	4	2	50.0	8.7 (First Floor)
95246	Mountain Ranch	5	1	20.0	4.3 (First Floor)
95247	Murphys	19	5	26.3	8.2 (First Floor)
95248	Rail Road Flat	3	1	33.3	12.3 (First Floor)
95249	San Andreas	7	0	0	1.1 (First Floor)
95250	Sheep Ranch	1	0	0	2.1 (? Floor)
95251	Vallecito	1	0	0	0.9 (First Floor)
95252	Valley Springs	74	4	5.4	10.1 (? Floor)
95254	Wallace	1	0	0	1.9 (Basement)
95255	West Point	1	1	100.0	13.1 (? Floor)
	Totals	183	24	13.1	39.5 (Basement)

Table 4. Indoor-Radon Short-Term Test Results for the CDPH 2004 and 2008-2009 Calaveras County Survey—by Zip Code Zone (This table excludes all data with laboratory analysis occurring more than 6 days after detector exposure)

Zip Code	City/Region	Number of Tests	Tests ≥ 4.0 pCi/L	% Tests ≥ 4.0 pCi/L	High pCi/L
95310	Columbia	9	2	25.0	6.8 (Basement)
95321	Groveland	16	6	37.5	11.3 (First Floor)
95327	Jamestown	14	1	7.1	10.1 (? Floor)
95329	La Grange	1	0	0	2.3 (? Floor)
95346	Mi Wuk Village	5	1	20.0	9.4 (First Floor)
95370	Sonora	97	10	10.3	15.0 (First Floor)
95372	Soulsbyville	3	0	0	2.7 (First Floor)
95379	Tuolumne	6	1	16.7	6.8 (First Floor)
95383	Twain Harte	16	1	6.2	4.5 (Basement)
	Totals	167	22	13.2	15.0 (First Floor)

Table 5. Indoor-Radon Short-Term Test Results for the CDPH 2004 and 2008-2009 Tuolumne County Surveys—by Zip Code Zone. (This table excludes all data with laboratory analysis occurring more than 6 days after detector exposure.)

Zip Code	City/Region	Number of Tests	Tests ≥ 4.0 pCi/L	% Tests ≥ 4.0 pCi/L	High pCi/L
95601	Amador City	3	1	33.3	4.2
95629	Fiddletown	6	1	16.7	6.7
95640	Ione	58	8	13.8	4.7
95642	Jackson	49	6	12.2	40.4
95665	Pine Grove	42	11	26.2	18.2
95666	Pioneer	73	8	11.0	6.1
95669	Plymouth	19	2	10.5	38.8
95685	River Pines	6	5	83.3	11.5
95685	Sutter Creek	64	10	15.6	16.7
95689	Volcano	23	3	13.0	12.5
	Total	343	55	16.0	40.4

Table 6. Radon test results for Amador County Zip Code Zones from the CDPH on-line Zip Code Database for California (1989-2010). (This table excludes data with laboratory analysis occurring more than 6 days after detector exposure and “0” data.)

Zip Code	City/Region	Number of Tests	Tests ≥ 4.0 pCi/L	% Tests ≥ 4.0 pCi/L	High pCi/L
95221	Altaville	6	0	0	1.0
95222	Angels Camp	45	0	0	2.9
95223	Arnold	70	15	21.4	9.2
95224	Avery	14	10	71.4	39.5
95225	Burson	4	1	25.0	5.4
95228	Copperopolis	23	1	4.3	4.3
95232	Glencoe	7	4	57.1	12.1
95233	Hathaway Pines	10	4	40.0	6.1
95245	Mokelumne Hill	43	5	11.6	8.7
95246	Mountain Ranch	23	4	17.4	7.9
95247	Murphys	71	8	11.3	9.8
95248	Railroad Flat	6	3	50.0	12.3
95249	San Andreas	33	1	3.0	9.1
95250	Sheep Ranch	1	0	0	2.1
95251	Vallecito	6	1	16.7	5.6
95252	Valley Springs	104	9	11.6	10.1
95254	Wallace	4	0	0	2.4
95255	West Point	15	4	26.7	18.1
	Total	485	70	14.4	39.5

Table 7. Radon test results for Calaveras County Zip Code Zones from the CDPH online Zip Code Database for California (1989-2010) (This table excludes data with laboratory analysis occurring more than 6 days after detector exposure and “0” data.)

Zip Code	City/Region	Number of Tests	Tests ≥ 4.0 pCi/L	% Tests ≥ 4.0 pCi/L	High pCi/L
95305	Big Oak Flat	3	0	0	3.0
95309	Chinese Camp	1	0	0	1.0
95310	Columbia	29	2	6.9	6.8
95321	Groveland	74	17	23.0	45.5
95327	Jamestown	34	3	8.8	10.1
95335	Long Barn	8	1	12.5	10.3
95346	Mi Wuk Village	13	3	23.1	13.2
95364	Pinecrest	7	0	0	3.6
95370	Sonora	326	35	10.7	15.3
95372	Soulsbyville	17	0	0	3.3
95373	Standard	1	0	0	1.6
95375	Strawberry	2	0	0	1.9
95379	Tuolumne	38	14	36.8	62.3
95383	Twain Harte	67	9	13.4	12.0
	Total	620	75	12.1	62.3

Table 8. Radon test results for Tuolumne County Zip Code Zones from the CDPH online Zip Code Database for California (1989-2010). (This table excludes data with laboratory analysis occurring more than 6 days after detector exposure and “0” data.)

Radon Survey Data—Exposure Duration and Data Quality

Most Amador, Calaveras and Tuolumne county CDPH radon survey participants exposed their radon tests for two days as instructed, but some exposed them for three or more days. Differences between two-day, three-day or longer test results should be negligible. Appendix A lists results for 14 concurrent (duplicate) tests made during the survey. Table 9 summarizes these test results and shows consistency between the less than 4.0 pCi/L test results. The variability in the 6.0 pCi/L and greater data in Table 9 relate to charcoal detectors placed at three different locations in a basement of one house. The differences of pairs of results in two other houses are 0.5 and 0.7 pCi/L.

High Measurement Group Range pCi/L	Associated Concurrent Group Measurement Ranges pCi/L	Differences pCi/L
6.0-12.5	4.1-9.2	0.5-8.4
1.0-3.5	0.9-2.5	0.2-3.4
>1.0	>1.0	0.0-<0.5

Table 9. Summary of concurrent indoor-radon test data from the Amador, Calaveras and Tuolumne 2008-2009 CDPH survey

Appendices B and C show the analytical results for three field blank radon detectors (i.e., not exposed to radon) and ten spiked radon detectors (exposed to a known concentration of radon). The three detector blanks all measured below the reported lab detection limit of 0.5 pCi/L. Eight of the ten laboratory spike samples differed by between 0.3 and 3.4 pCi/L from the mean chamber radon concentration of 18.2 pCi/L. One spiked sample measured 4.8 pCi/L above and another measured 11.8 pCi/L above the chamber's average radon concentration. All detectors exposed to air averaging 18.2 pCi/L radon measured above 4.0 pCi/L, the U.S. EPA recommended action level.

In summary, duplicate, blank and spiked sample test results support the validity of the CDPH-Indoor Radon Program Amador, Calaveras and Tuolumne counties radon survey data.

Follow-up Radon Testing Results

Appendix D compares 21 follow-up radon measurements with initial survey measurements for 12 different homes in the three county study area. The time between original and follow-up measurements range from 4 to 1,788 days (4 years, 10 months, 23 days). The highest measurement in Appendix D, a basement measurement of 40.4 pCi/L, tested 35 days later at 36.5 pCi/L. This confirms the magnitude of the first test and shows elevated radon concentration likely exists over significant periods in this basement. Two groups of three basement measurements (superscript 1 in Appendix D) in a home were made in April and June 2009, 78 days apart. The April tests all exceed 4.0 pCi/L while all the June tests are 1.1 pCi/L or less. It is unknown if these differences are seasonal or if radon mitigation activity occurred between the two test periods.

Overall, the follow-up tests in Appendix D made between 249 days and more than 4 years apart are relatively similar in magnitude, with differences varying between 0.5 and 2.0 pCi/L. Two test pairs 4 days and 20 days apart show greater differences, 3.3 pCi/L and 4.0 pCi/L. This suggests indoor-radon concentrations have more short-term variability in some homes than in others. Appendix D measurements also show that short-term tests can be consistently above or consistently below 4.0 pCi/L in some homes for long periods.

AMADOR, CALAVERAS AND TUOLUMNE COUNTIES GEOLOGIC UNIT PRELIMINARY RADON POTENTIALS

Introduction

The first step in developing the radon potential map for Amador, Calaveras and Tuolumne counties was determining preliminary radon potentials for the geologic units. Using a GIS, this involved comparing CDPH survey test locations with the geologic map digital layer prepared by CGS Regional Mapping staff to determine the geologic unit present at each test location. Appendix F lists the 100 geologic units within the Amador, Calaveras and Tuolumne county and the associated radon measurement data for each unit. Thirty-five units have one or more home radon measurements. Geologic units were assigned preliminary radon potentials based on radon data in Appendix F and radon potential definitions in step 7 (page 6). Table 10 lists high potential units, Table 11 moderate potential units, and Table 12 low potential units. Appendix G lists units categorized as having unknown radon potential because they have few or no indoor-radon measurements. Some unit radon potentials listed in Tables 11 and 12 are provisional—less certain because they have significantly less than 25 indoor-radon measurements. A "(P)" indicates the radon potential status is provisional (less certain) in Tables 11 and 12.

Geologic Unit	Indoor-Radon Data	Radon Potential Designation
DSof (Shoo Fly Complex)	R* = 30.0% n = 40 n ≥ 4.0 pCi/L = 12 Maximum = 8.2 pCi/L	High R* ≥ 20%
MzPzcc (Calaveras Complex, undifferentiated)	R = 25.7% n = 70 n ≥ 4.0 pCi/L = 18 Maximum = 38.8 pCi/L	High R ≥ 20%

*R=the percent of indoor-radon data ≥ 4.0 pCi/L

Table 10. Amador, Calaveras and Tuolumne Counties geologic units assigned preliminary high radon potential status based on 2008-2009 CDPH indoor radon survey data

Geologic Unit	*Indoor-Radon Data*	*Radon Potential Designation*
Ei (Ione Fm.)	R* = 14.3% n = 14 n ≥ 4.0 pCi/L = 2 Maximum = 4.4 pCi/L	Moderate (P*) 5 to 19.9 %
Jgo (Gopher Ridge Fm., undifferentiated)	R = 12.5% n = 16 n ≥ 4.0 pCi/L = 2 Maximum = 5.4 pCi/L	Moderate (P) 5 to 19.9 %
Jlr and Jvl (Logtown Ridge Fm.)	R = 10.0% n = 10 n ≥ 4.0 pCi/L = 1 Maximum = 16.7pCi/L	Moderate (P) 5 to 19.9 %
MPm (Mehrten Fm.)	R = 8.5% n = 47 n ≥ 4.0 pCi/L = 4 Maximum = 39.5 pCi/L	Moderate 5 to 19.9 %
Mzg (granitic rocks, undifferentiated)	R = 17.2% n = 93 n ≥ 4.0 pCi/L = 16 Maximum = 40.4 pCi/L	Moderate 5 to 19.9 %
Mzpm (Mafic plutonic rocks, undifferentiated—diorite to gabbro; locally pyroxenite and hornblendite)	R = 10.3% n = 29 n ≥ 4.0 pCi/L = 3 Maximum = 15.0 pCi/L	Moderate 5 to 19.9 %
OMvs (Valley Springs Fm.)	R = 6.7% n = 30 n ≥ 4.0 pCi/L = 2 Maximum = 4.7 pCi/L	Moderate 5 to 19.9 %
Pzcm (Calaveras Complex, marble) in Tuolumne County	R = 9.1% n = 11 n ≥ 4.0 pCi/L = 1 Maximum = 4.6 pCi/L	Moderate (P) 5 to 19.9 %

*R=the percent of indoor-radon data ≥ 4.0 pCi/L; **(P)=Unit radon potential is provisional (less certain) because unit has significantly less than 25 tests

Table 11. Amador, Calaveras and Tuolumne Counties geologic units assigned preliminary moderate radon potential status based on 2008-2009 CDPH indoor radon survey data

Geologic Unit	Indoor-Radon Data	Radon Potential Designation
Jch and Jvc (Copper Hill Volcanics)	R* = 0.0% n = 9 n ≥ 4.0 pCi/L = 0 Maximum = 2.5pCi/L	Low (P*) R < 5%
Jdpv (Don Pedro Terrane, greenschist metavolcanic) of Clark	R = 0.0% n = 15 n ≥ 4.0 pCi/L = 0 Maximum = 1.1 pCi/L	Low (P) R < 5%
Jgoqp (Gopher Ridge Fm., quartz porphyry)	R = 0.0% n = 9 n ≥ 4.0 pCi/L = 0 Maximum = 1.7pCi/L	Low (P) R < 5%
Jsg (Sullivan Creek terrane, greenschist belt)	R = 0.0% n = 13 n ≥ 4.0 pCi/L = 0 Maximum = 3.1 pCi/L	Low (P) R < 5%
Jss (Salt Springs Slate, with some Mariposa Fm.)	R = 4.5% n = 22 n ≥ 4.0 pCi/L = 1 Maximum = 4.3 pCi/L	Low R < 5%

R=the percent of indoor-radon data ≥ 4.0 pCi/L; (P)=Unit radon potential is provisional (less certain) because unit has significantly less than 25 tests

Table 12. Amador, Calaveras and Tuolumne Counties geologic units assigned preliminary low radon potential status based on 2008-2009 CDPH indoor radon survey data

Indoor-Radon Data and Elevation (Climate and Weather Impacts)

The CDPH radon survey data are from homes along the western Sierra Nevada foothills that range in elevation from less than 500 feet to about 5,200 feet above sea level. Outdoor temperatures and annual precipitation amounts vary with elevation in the Sierra Nevada foothills. Because weather and climate influence indoor-radon concentrations, data for several geologic units were grouped by elevation and the resulting data populations were compared to check for trends related to elevation and climate. The data checked were associated with the following geologic units: granitic rocks (Mzg), the Shoo Fly Formation (DOsf) and the Calaveras Complex (MzPzcc). The elevation groups were less than 1,000 feet, 1,000 to 2,000 feet, 2000 to 3,000 feet, and 3,000 to 4,000 feet. Few test results for homes above 4,000 elevation are available. No significant differences related to elevation were found for these geologic unit radon populations. Consequently, weather and climate differences over several thousand feet of elevation apparently do not cause consistent differences in indoor-radon concentrations in homes on these three geologic units in Amador, Calaveras and Tuolumne counties.

Use of Additional Data in Determining Geologic Unit Radon Potential

Besides indoor-radon data, other data useful to consider when assessing unit radon potentials are available for Amador, Calaveras and Tuolumne counties. These are soil and sediment uranium data, airborne radiometric uranium data, and soil permeability data. For geologic units without indoor-radon measurements, uranium and soil permeability data may be sufficient to allow assignment of a radon potential. The next two report sections describe these data, indicate their degree of support for unit preliminary radon potentials based on indoor-radon data, and suggest radon potentials for units without indoor-radon data.

NURE PROJECT URANIUM DATA

Background

Because radon is a radioactive decay product of uranium, areas with higher natural background amounts of uranium are more likely to have higher quantities of radon in the subsurface. Buildings in such areas have a greater potential for indoor-radon problems. Consequently, background uranium data for rock units, soils and sediments are valuable for radon-potential mapping projects, particularly for assessing radon potential where indoor-radon measurements are sparse or absent.

Between 1975 and 1983, the United States government funded the National Uranium Resource Evaluation (NURE) project. The goal of NURE was to identify new domestic sources (ore deposits) of uranium for energy production and national defense. NURE uranium exploration activities included airborne gamma-ray spectral surveys that estimated the uranium content of soils and rocks at points along a grid of flight lines. Locations with unusually high uranium abundance were targets for additional work to determine whether economically recoverable uranium deposits were present. In parts of California, NURE project contractors collected soil and stream sediment samples for uranium determinations at various U.S. government laboratories. These data are available from the U.S. Geological Survey at: http://mrdata.usgs.gov/geophysics/nurequads.html and http://mrdata.usgs.gov/nuresed/. Within the Amador, Calaveras and Tuolumne county study area, NURE sediment and soil analyses are available for portions of these counties within the Mariposa, Sacramento and Walker Lake 1X2 degree quadrangles. The NURE project ended before soil and sediment sample collection and analysis for the San Jose 1X2 degree quadrangle was completed. Consequently, no NURE soil and sediment data are available for these parts of Calaveras and Tuolumne counties. The NURE project did not collect soil and sediment samples or airborne radiometric data within Yosemite National Park.

Uranium in Soil and Sediment Samples

NURE project sub-contractors collected 883 soil and sediment samples in Amador, Calaveras and Tuolumne counties. Figure 3 shows the sample distribution within these counties. Small open black squares in Figure 3 show NURE sediment or soil sample locations. The larger red squares are those locations with uranium concentrations at or exceeding 5.0 ppm (i.e., approximately twice the average uranium content of the earth's crust). Sample spacing typically ranges from 0.9 to 2.0 miles. Gaps in sample coverage of several miles relate to land access issues. The area from Copperopolis and Sonora south that includes Jamestown and Groveland does not have NURE sediment and soil uranium data available because it is within the San Jose 1X2 degree quadrangle as previously noted. Table 13 lists the numbers of NURE soil and stream sediment samples for each county.

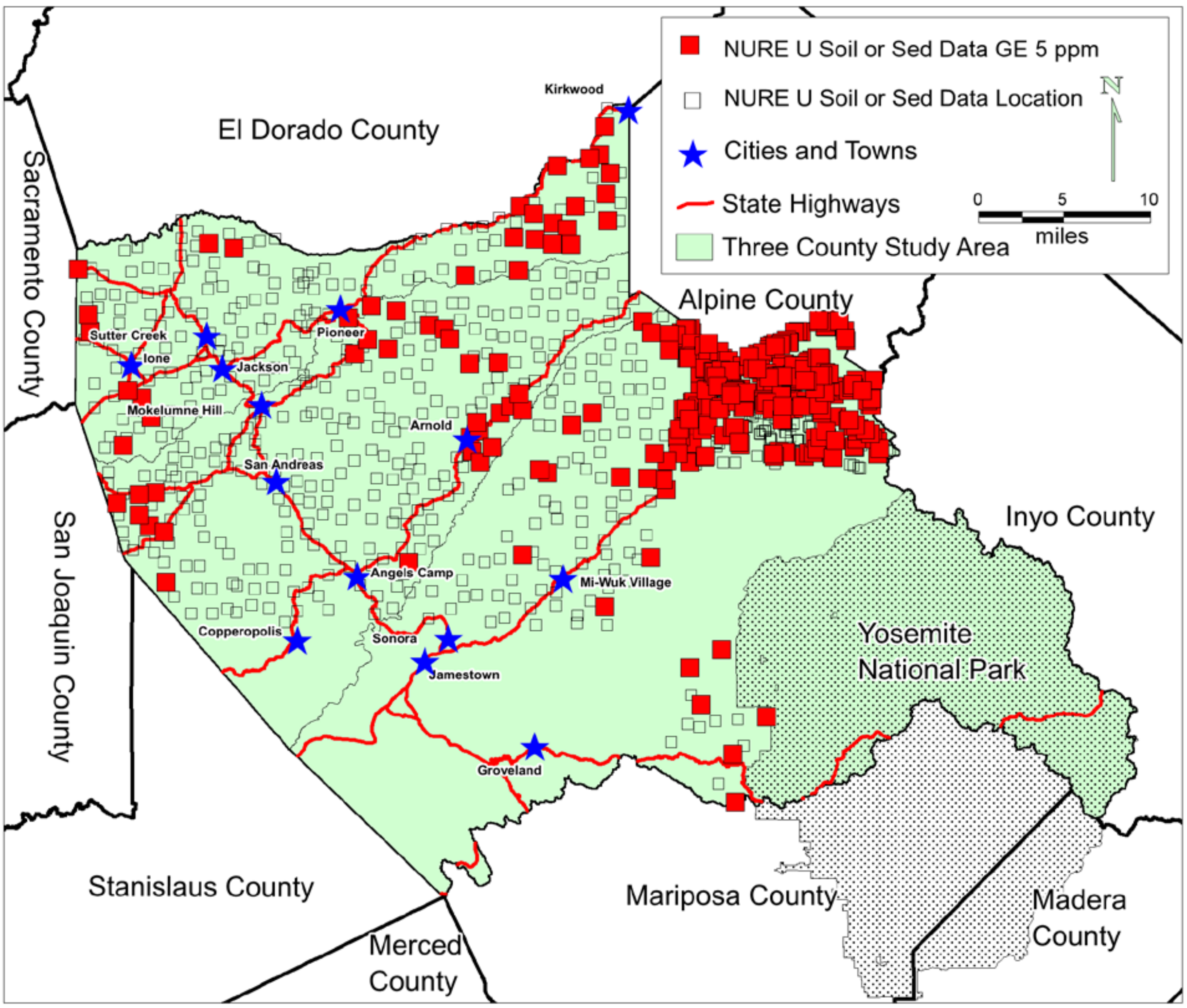

Figure 3. NURE project soil and stream-sediment uranium data for Amador, Calaveras and Tuolumne counties

County-Quadrangle	Number of soil samples	Number of stream sediment samples
Amador-SAC Quad	63	104
Calaveras-SAC Quad	115	132
Tuolumne-SAC Quad	31	70
Tuolumne-MAR Quad	8	4
Tuolumne-WL Quad	52	383

Table 13. NURE project soil and stream-sediment samples within Amador, Calaveras and Tuolumne counties

The cluster of 5.0-ppm and higher uranium data in northeastern Tuolumne County is just west of Sonora Pass and southeast of The Dardanelles. Uranium deposits were first discovered in this area about 1955. Between 1956 and 1966, the Juniper Mine in this area produced a total of about 45,000 pounds of uranium oxide (U_3O_8) (Rapp and Short, 1981; Rapp, 1978). The Juniper Mine U.S. Geological Survey Mineral Resource Data System (MRDS) deposit ID is 10037763 and its geographic coordinates are -119.79766, 38.29797 (WGS84) (USGS, 2016). It produced more uranium than any other mine in California, but its total production is very small compared to other national and foreign uranium mines. The U.S. Forest Service reclaimed the mine site during 2011-2013.

The Juniper Mine is a “secondary” uranium mineral deposit. This deposit type forms when uranium is leached from source rocks by weathering (under oxidizing conditions) and transported by ground water to sites with reducing (low oxygen) chemical environments. The reducing conditions cause the uranium to precipitate from the ground water, or adsorbed by organic matter if present, and thus concentrate at the site.

Uranium mineralization at the Juniper Mine is restricted to the Relief Peak Formation with uranium present as coffinite, uraninite and unidentified uranium minerals (Rapp and Short, 1980). The Relief Peak Formation is largely composed of discontinuous beds of andesitic conglomerate and lahars. Ore is closely associated with coalified material, hosted in thin-bedded, carbonaceous, tuffaceous sandstone in channels incised into granodiorite and rhyolitic tuff (Dahlkamp, 2010). Rapp and Short (1980) reviewed the following geologic units for potential as host-rocks or uranium sources for secondary uranium deposits in the Sonora Pass area and their conclusions, summarized here, are:

- Granitic rocks are not favorable host rocks for secondary uranium mineralization. They contain 3 to 6 ppm uranium and no major radiometric anomalies are known within Sonora Pass area granitic rocks.

- Valley Springs Formation, consisting of air-fall and ash-flow rhyodacite tuff, has been highly weathered in the Sonora Pass area. This weathering converted feldspathic glass and feldspar to clay reducing the permeability of these beds and lowering the likelihood of these beds as uranium-deposit host rocks. At lower elevations further west, where pebble conglomerate and sandstone beds are more permeable and where associated with Ione Formation, conditions for secondary uranium mineralization may be more favorable. Rapp and Short do not report any uranium analyses for Valley Springs Formation samples.

- Relief Peak Formation, consisting of a heterogeneous assemblage of andesitic lahar and conglomerate beds, is the most important potential uranium host formation in the Sonora Pass region. Uranium mineralization is present in conglomerate, coarse- and fine-grained sandstone, siltstone and lithic wacke. Most, but not all (e.g., the Juniper Mine), uranium concentrations in the Relief Peak formation are within zones containing carbonaceous matter or carbonized wood chips.

- Late Miocene latite flows, the Table Mountain Latite and Eureka Valley Tuff, contain 10 to 14 ppm uranium in the Sonora Pass area but occur in topographically high areas more likely to be leached of uranium than enriched in uranium by ground water. Consequently, they are not good uranium-deposit host rocks.

- Pleistocene basalt flows are dense, limited in distribution and their chemistry makes them unlikely uranium-deposit host rocks.

- Eureka Valley Tuff is the most likely source of uranium for deposits in the Sonora Pass area. Non-hydrated glass specimens contain 12 to 14 ppm uranium. Its beds are not well cemented or welded in many places so it is relatively permeable, and it overlies the Relief Peak Formation, the principal uranium-deposit host formation.

- Uraniferous pegmatite complexes can be present in the granitic rocks but they are small and probably not significant sources of uranium for secondary-uranium deposits in the Sonora Pass area.

The information from Rapp and Short (1980) has the following implications for indoor-radon potential for Amador, Calaveras and Tuolumne Counties:

- Uranium contents of 3 to 6 ppm for granitic rocks in the Sonora Pass area suggest they are mostly low to moderate in radon potential.

- Portions of the Valley Springs Formation may become secondarily enriched in uranium and have increased radon potential when in association with the Ione Formation in the lower elevation western parts of the Amador, Calaveras and Tuolumne area.

- Secondary uranium mineralization occurrences in the Relief Peak Formation and 10 to 14 ppm uranium contents for the Table Mountain Latite and Eureka Tuff suggest significant portions of these geologic units have high radon potential.

- Basalt flows in the Sonora Pass area have low radon potential.

Although radon potential is likely high near the Juniper mine and at locations in the Sonora Pass area where Relief Peak Formation and Eureka Valley Tuff are present, few or no individuals reside in these areas.

Regional Trends in Background Uranium in the Amador, Calaveras and Tuolumne County Area Using NURE Data

Dodge (1972) found background uranium concentrations increased in granitic rocks from west to east across the central Sierra Nevada batholith. However, looking for regional uranium trends in a database of mixed soil and stream sediment samples can be problematic. Soil data commonly represent the local bedrock background-uranium concentrations better than local stream sediment data, provided weathering has not removed significant amounts of uranium from the soil. Local sediment uranium abundance can deviate from local soil uranium abundance due to mixing with significant quantities of higher or lower uranium sediment from upstream sources. The first possibility is likely in Tuolumne County for stream sediments within watersheds that include parts of the Sonora Pass area. To check this possibility NURE stream sediment and soil data for Amador, Calaveras and Tuolumne counties were compared for five geologic units with sufficient data for evaluation using the Mann-Whitney rank sum statistical test (a non-parametric test). Appendix I lists the summarized results of this comparison. Note that geologic units not included as bullets below have too few soil and/or stream-sediment uranium data for statistical evaluation.

Geologic units and locations where associated soil and stream-sediment uranium data <u>are not</u> significantly different in uranium content:

- Shoo Fly Formation (DOsf)—Calaveras County—Sacramento quadrangle

- Mehrten Formation (MPm)—Calaveras and Tuolumne counties—Sacramento and Walker Lake quadrangles

- Granitic rocks (Mzg)—Calaveras and Tuolumne counties—Sacramento Quadrangle

- Calaveras Complex, undifferentiated rocks (MzPzcc)—Calaveras County—Sacramento quadrangle

Conclusion—local stream sediment associated with these rock units and areas appear not to contain large quantities of sediment from upstream source areas with either higher or lower uranium contents than typical for these geologic units.

Geologic units and locations where associated soil and stream-sediment uranium data are significantly different in uranium content:

- Calaveras Complex, undifferentiated rocks (MzPzcc)—Amador County—Sacramento quadrangle; higher background uranium in soil
- Don Pedro Terrane, greenschist (metavolcanic) of Clark (Jdpv)—Calaveras County—Sacramento quadrangle; higher background uranium in stream sediments
- Valley Springs Formation (OMvs)—Calaveras County—Sacramento quadrangle; higher background uranium in soil
- Granitic rocks in Tuolumne County (Mzg)—Walker Lake Quadrangle; higher background uranium in stream sediments

Conclusion—local stream sediment associated with the Don Pedro Terrane, Calaveras County, and Granitic rock in Tuolumne County—Walker Lake Quadrangle units and areas appear to contain a component of upstream sediment from source areas with higher uranium than typical for these geologic units. The elevated uranium source for stream sediment within the Don Pedro Terrane area is uncertain. The elevated uranium source for stream sediment within granitic rock areas in Tuolumne County is most likely Eureka Valley Tuff, Relief Peak Formation and/or Table Mountain Latite. Local stream sediment associated with Calaveras Complex rocks in Amador County and the Valley Springs Formation in Calaveras County may contain a component of sediment derived from upstream areas with lower background uranium.

These soil-stream sediment uranium variations support the use of only NURE soil uranium data for evaluating overall radon potential and radon potential variability within geologic units in the Amador-Calaveras-Tuolumne county area.

Variability of Background Uranium Abundance Within Geologic Units and Across the Amador-Calaveras-Tuolumne Study Area

Comparison of soil background-uranium data from different locations within the boundaries of an underlying bedrock unit may indicate spatial variability in radon potential for that unit. Figure 4 shows soil uranium data locations. Red squares indicate locations where these data contain 5 ppm or more uranium. Table 14 shows the comparison results for radon data in different counties for the Shoo Fly Formation, Mehrten Formation, undifferentiated granitic rocks and undifferentiated Calaveras Formation areas. Comparisons were made using the Mann-Whitney Rank Sum non-parametric test. Soil-uranium population differences were not statistically significant for:

- Shoo Fly Formation areas in Amador and Calaveras counties

- Mehrten Formation areas in Amador and Tuolumne counties, Calaveras and Tuolumne counties, and portions of Tuolumne County with the Sacramento and Walker Lake quadrangles

- Granitic rock areas in Amador and Tuolumne counties (in the Sacramento, Mariposa and Walker Lake Quadrangles)

- Calaveras Complex areas in Amador and Calaveras counties.

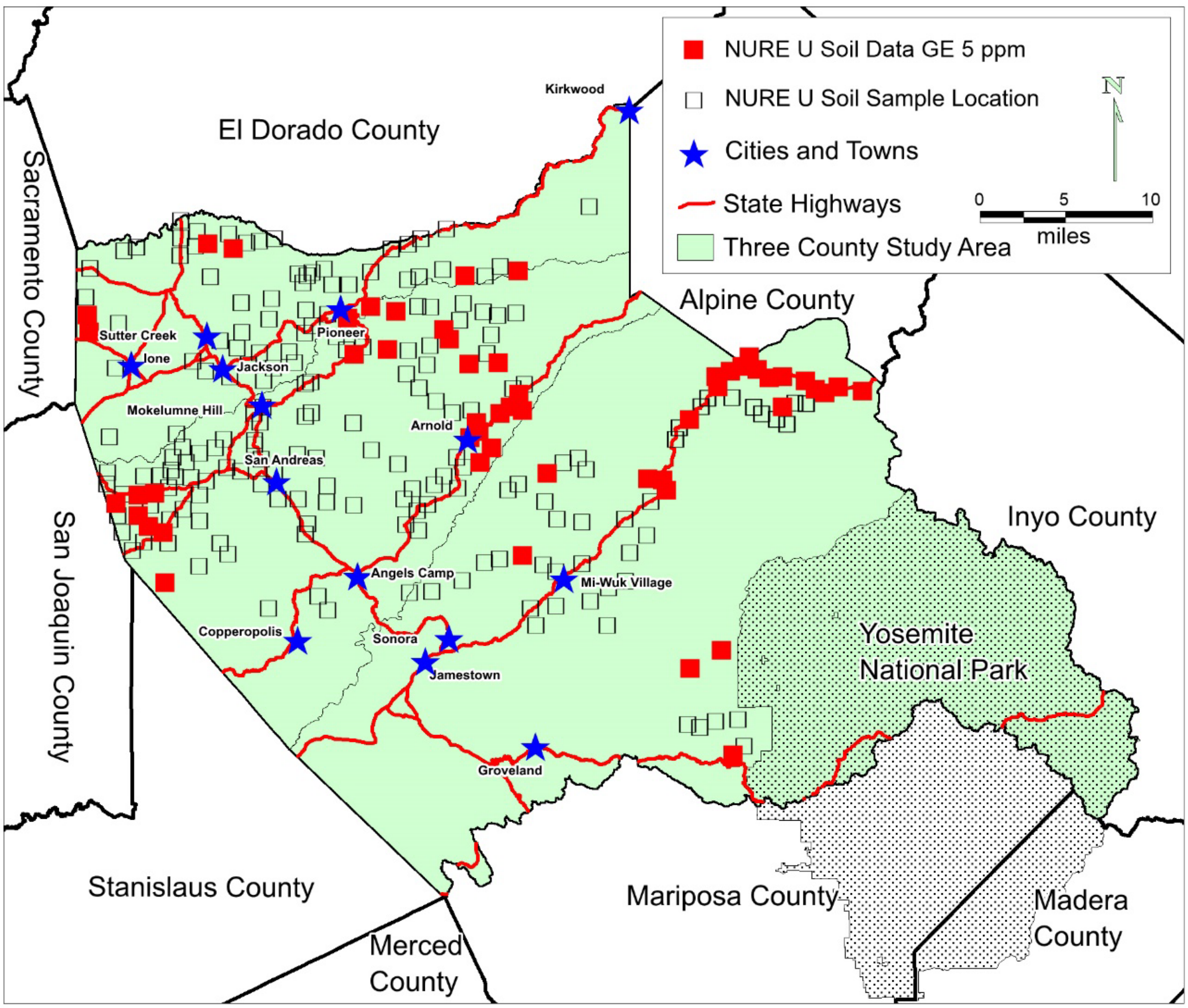

Figure 4. NURE soil uranium data for Amador, Calaveras and Tuolumne counties

Unit Symbol	Unit Name	Counties	1X2 Deg. Quadrangles	N 1st Soil	N 2nd Soil	Statistical Comparison
DOsf	Shoo Fly Fm.	Amador/ Calaveras	Sacramento/ Sacramento	5	15	NSD P=0.631
MPm	Mehrten Fm.	Amador/ Calaveras	Sacramento/ Sacramento	9	17	SD P=0.043 Cal.SAC med. 3.70 ppm; Am. SAC med 2.50 ppm
MPm	Mehrten Fm.	Amador/ Tuolumne	Sacramento/ Sacramento	9	11	NSD P=0.647
MPm	Mehrten Fm.	Amador/ Tuolumne	Sacramento/ Walker Lake	9	12	SD P=0.027 Tuol.WL med. 3.55 ppm; Am. SAC med. 2.50 ppm
MPm	Mehrten Fm.	Calaveras-Tuolumne	Sacramento/ Sacramento	17	11	NSD P=0.126
MPm	Mehrten Fm.	Calaveras-Tuolumne	Sacramento-Walker Lake	17	12	NSD P=0.929
MPm	Mehrten Fm.	Tuolumne/ Tuolumne	Sacramento/ Walker Lake	11	12	NSD P=0.090
Mzg	granitic rocks, undif.	Amador/ Calaveras	Sacramento/ Sacramento	9	11	SD P=0.030 Cal.SAC med. 6.5 ppm; Am. SAC med. 2.7 ppm
Mzg	granitic rocks, undif.	Amador/ Tuolumne	Sacramento/ Sacramento	9	12	NSD P=0.831
Mzg	granitic rocks, undif.	Amador/ Tuolumne	Sacramento/ Mariposa	9	7	NSD P=0.397
Mzg	granitic rocks, undif.	Amador/ Tuolumne	Sacramento/ Walker Lake	9	36	NSD P=0.327
Mzg	granitic rocks, undif.	Calaveras/ Tuolumne	Sacramento/ Sacramento	11	12	SD P=0.015 Cal.SAC med. 6.5 ppm; Tuol. SAC med. 3.85 ppm
Mzg	granitic rocks, undif.	Calaveras/ Tuolumne	Sacramento/ Mariposa	11	7	NSD P=0.094
Mzg	granitic rocks, undif.	Calaveras/ Tuolumne	Sacramento/ Walker Lake	11	36	NSD P=0.056
Mzg	granitic rocks, undif.	Tuolumne/ Tuolumne	Sacramento/ Mariposa	12	7	NSD P=0.271
Mzg	granitic rocks, undif.	Tuolumne/ Tuolumne	Sacramento/ Walker Lake	12	36	NSD P=0.441
Mzg	granitic rocks, undif.	Tuolumne/ Tuolumne	Mariposa/ Walker Lake	7	36	NSD P=0.489
MzPzcc	Calaveras Complex, undif.	Amador/ Calaveras	Sacramento/ Sacramento	18	13	NSD P=0.888

Abbreviations: SD=statistically significant difference; NSD=no statistically significant difference; P=P-value statistic; med=median; undif.=undifferentiated, N=number of samples

Table 14. Statistical comparison of NURE soil uranium data in different counties and quadrangles by bedrock association using the Mann-Whitney Rank Sum Test.

Statistically significant differences in soil uranium populations exist for:

- Mehrten Formation areas in Amador and Calaveras counties, Sacramento Quadrangle. Median uranium values for these areas are 2.50 ppm and 3.70 ppm respectively.

- Mehrten Formation areas in Amador County, Sacramento Quadrangle, and Tuolumne County, Walker Lake Quadrangle. Median uranium values for these areas are 2.50 ppm and 3.55 ppm respectively.

- Granitic rock areas in Amador and Calaveras counties, Sacramento Quadrangle. Median uranium values for these areas are 2.7 ppm and 6.5 ppm respectively.

- Granitic rock areas in Calaveras and Tuolumne counties, Sacramento Quadrangle. Median uranium values for these areas are 6.5 ppm and 3.85 ppm respectively.

The implications of these statistical comparisons for geologic unit radon potentials are:

- Radon potential may be slightly higher for Mehrten Formation areas in Calaveras County and in Tuolumne County, Walker Lake Quadrangle, than elsewhere.

- Radon potentials are probably similar for Mehrten Formation areas in Amador and Tuolumne county areas in the Sacramento Quadrangle, and Calaveras and Tuolumne county areas in the Sacramento Quadrangle, and Tuolumne County areas in the Walker Lake Quadrangle.

- Radon potential may be significantly higher for granitic rock areas in parts of Calaveras County than in Amador or Tuolumne counties, within the Sacramento Quadrangle. However, at this point the range of variation and number of data is not sufficient to justify changing portions of granitic rock areas in Calaveras County to high potential. Future studies may wish to investigate this further.

- Radon potentials are probably similar for granitic rock areas in Amador and Tuolumne counties, Sacramento Quadrangle and the Tuolumne County portion of the Walker Lake Quadrangle.

- Radon potentials are probably similar for Shoo Fly Formation areas in Amador and Calaveras counties, Sacramento Quadrangle.

- Radon potentials are probably similar for Calaveras Complex areas in Amador and Calaveras counties.

Insufficient soil uranium data prevent statistical evaluation of geographic uranium variability and within the geologic units not listed above. Consequently, relatively uniform uranium distribution and uniform radon potential are assumed for these units in Amador, Calaveras and Tuolumne counties.

Figure 5 shows NURE stream-sediment sample locations for Amador, Calaveras and Tuolumne counties. Red diamonds indicate where samples contain 5 ppm or more uranium. Comparison of Figures 4 and 5 show differences in the distribution of 5 ppm or higher soil samples and 5 ppm or higher stream sediment samples. Note that there are differences in the locations of 5 ppm or greater uranium soil and stream sediment samples in Amador and Calaveras Counties not just resulting from differences in sample density (e.g., between Pioneer and Arnold).

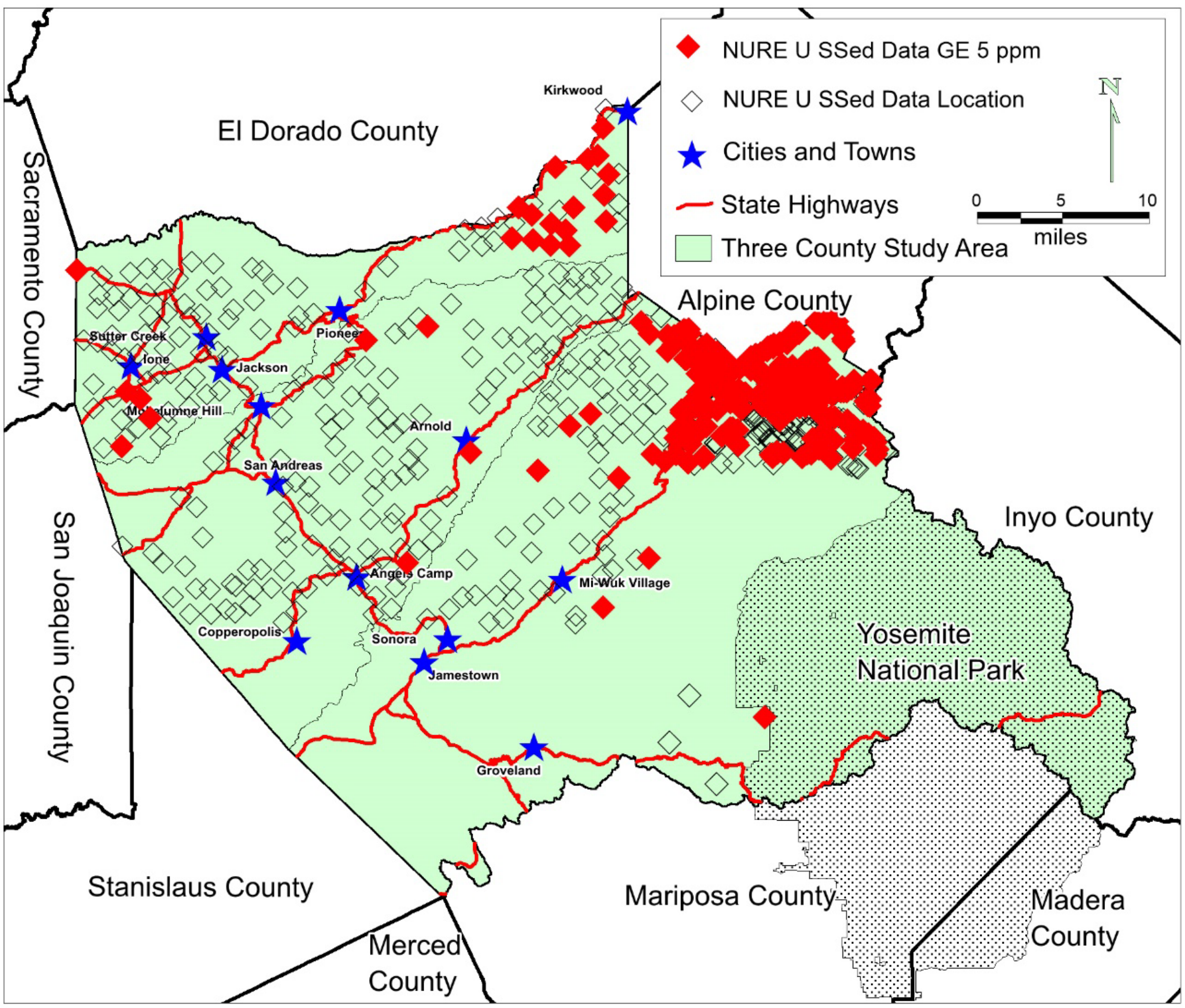

Figure 5. NURE project stream-sediment uranium data for Amador, Calaveras and Tuolumne counties

Table 15 shows results of comparing stream sediment samples associated with portions of the Mehrten Formation, granitic rocks, Calaveras Formation and Valley Springs

Formation from different counties and 1X2 degree quadrangles. In all comparisons in Table 15 involving Tuolumne County Walker Lake Quadrangle stream sediment, it has the higher background uranium content. Consequently, there must be a significant source area with elevated background uranium concentrations within the Tuolumne County portion of the Walker Lake Quadrangle and/or in adjacent areas east of Tuolumne County. This fits with one or more of the elevated uranium Formations in the Walker Lake quadrangle listed above—Relief Peak Formation, Table Mountain Latite, and Eureka Valley Tuff—supplying significant quantities of sediment to downstream locations. Although sediments derived from these geologic units may have elevated radon potential, there may not be any homes or buildings associated with them except where they form terrace or alluvial fan deposits. Elevated uranium geologic units do not appear to impact stream-sediment uranium concentrations in Mehrten Formation or granitic rock areas in the portions of Calaveras or Tuolumne counties within the Sacramento quadrangle.

Unit Symbol	Unit Name	Counties	1X2 Deg. Quadrangles	N 1st Sed.*	N 2nd Sed.**	Statistical Comparison+
MPm	Mehrten Fm.	Calaveras/ Tuolumne	Sacramento/ Sacramento	8	16	NSD P=0.091
MPm	Mehrten Fm.	Calaveras/ Tuolumne	Sacramento/ Walker Lake	8	82	SD P=0.003 Walker Lake med. higher
MPm	Mehrten Fm.	Tuolumne/ Tuolumne	Sacramento/ Walker Lake	16	82	SD P=0.019 Walker Lake med. higher
Mzg	granitic rocks, undifferentiated	Calaveras/ Tuolumne	Sacramento/ Sacramento	7	41	NSD P=0.804
Mzg	granitic rocks, undifferentiated	Calaveras/ Tuolumne	Sacramento/ Walker Lake	7	285	SD P= 0.003 Walker Lake med. Higher
Mzg	granitic rocks, undifferentiated	Tuolumne/ Tuolumne	Sacramento/ Walker Lake	41	285	SD P<0.001 Walker Lake med. higher
MzPzcc	Calaveras Complex, undifferentiated	Amador/ Calaveras	Sacramento/ Sacramento	14	17	NSD P=0.125
OMvs	Valley Springs Formation	Amador/ Tuolumne	Sacramento/ Walker Lake	16	8	SD P=0.043 Walker Lake med. higher

* 1st Sed. = sediment from first listed county and first listed quadrangle
**2nd Sed. = sediment from second listed county and second listed quadrangle
+Statistical Comparison: NSD = not statistically different; SD = statistically different; P = P value

Table 15. Statistical comparison of NURE stream-sediment uranium data in different counties and quadrangles by bedrock association using the Mann-Whitney Rank Sum Test

Considering the above NURE soil and sediment U information and characteristics, the data tabulation in Appendix H, and the number of related soil U data, the following radon potentials are supported by NURE soil and sediment uranium data for geologic units with sufficient data:

High radon potential

- DOsf-Shoo-Fly Complex, in Amador, Calaveras and Tuolumne counties, in the Sacramento quadrangle

- Ei-Ione Formation, in Amador and Calaveras counties, in the Sacramento quadrangle

- Mzg-granitic rocks, undifferentiated, in Amador, Calaveras and Tuolumne counties, in the Sacramento quadrangle; and in Tuolumne County, in the Mariposa and Walker Lake quadrangles

- OMvs-Valley Springs Formation, in Amador and Calaveras counties in the Sacramento quadrangle

Moderate radon potential

- MPm-Mehrten Formation, in Tuolumne County, in the Walker Lake quadrangle

- Mzd-diorite, in Calaveras County, in the Sacramento quadrangle

Low to moderate radon potential

- MPm-Mehrten Formation, in Amador, Calaveras and Tuolumne counties, in the Sacramento quadrangle

Low radon potential

- MzPzcc-Calaveras Complex, undifferented, in Amador, Calaveras and Tuolumne counties, in the Sacramento quadrangle

Geologic units not listed have insufficient soil and sediment uranium data to estimate a radon potential.

Airborne Radiometric Data

Another approach used by the NURE project to obtain uranium data for soil, sediments and rocks involved airborne radiometric surveys. These surveys utilized helicopters equipped with gamma-ray spectrometers to make measurements along a grid of flight lines within 1X2 degree quadrangles throughout the U.S. The spectrometers detect trace amounts of gamma radiation characteristic of several radioactive isotopes including bismuth-214. Because this isotope is a member of the uranium-238 radioactive decay chain (see Table 1), its gamma-ray data can be used to estimate uranium contents of the soils, sediments and rocks along the helicopter's flight paths. Such estimated uranium concentrations, in ppm, are referred to as "equivalent uranium" (eU) data, to distinguish them from uranium (U) data obtained by analyzing soil, sediment or rock samples by various methods in a laboratory . Uranium exploration studies view locations with anomalously high eU concentrations as targets for follow-up investigations to determine if economically viable uranium deposits are present. NURE airborne radiometric data used for developing the Amador, Calaveras and Tuolumne counties radon potential map are from a compilation by Duval (2000). The NURE radiometric surveys covering these counties are the Mariposa, Sacramento, San Joaquin, and Walker Lake 1X2 degree quadrangle surveys.

The radon isotope most often responsible for elevated indoor-radon concentrations is radon-222. It a member of the uranium-238 decay chain, in a position between radium-226 and bismuth-214. Because bismuth-214 forms just a few minutes after radon-222 decays (see Table 1), it can be a good indicator of radon abundance within the interval of soil or rock from the surface to about 18 inches deep. However, soil moisture (Grasty, 1977) topography, atmospheric inversion and other local conditions can negatively affect airborne eU data accuracy. Radon entering buildings typically originates within several 10s of feet below the building but sometimes deeper. However, eU estimates are averages for only the uppermost 18 inches of the subsurface (High Life Helicopters 1980a and 1980b; U.S. DOE, 1980) eU measurements. Consequently, while generally helpful, eU measurements are not always good indicators of local subsurface radon availability. For these reasons, CGS radon mapping studies do not treat NURE airborne eU data as quantitative in defining anomalous radon areas as they do NURE laboratory uranium analyses of soil, sediment and rock samples. Instead, CGS studies treat airborne eU data as qualitatively suggestive of areas with higher or lower radon potentials.

Airborne radiometric data collection for Amador, Calaveras and Tuolumne counties occurred at average elevations above ground surface of about 400 feet at a flight speed of about 75 to 95 miles per hour. Under such conditions, each measurement approximately represents the average uranium content within the upper 18 inches of surficial material over an area of approximately 48,000 square feet (or 1.1 acres; see High-Life Helicopters, 1980a and U.S. Department of Energy, 1980). Flight-line grid patterns for Amador, Calaveras and Tuolumne counties consist of east-west flight lines, mostly 2 to 4 miles apart, and north-south flight lines, generally 10 to 15 miles apart. While helpful in the search for anomalous eU areas, this spacing may miss even moderate to relatively large anomalous eU areas.

Figure 6 shows the location of the approximately 1,371 miles of NURE project flight lines within Amador, Calaveras and Tuolumne counties (266 miles in Amador County; 439 miles in Calaveras County; and 666 miles in Tuolumne County). All Amador County data are within the Sacramento 1X2 degree quadrangle survey. Calaveras County data are contained in the Sacramento and San Jose 1X2 degree quadrangle surveys. Tuolumne County data are contained within the Sacramento, San Jose, Mariposa and Walker Lake 1x2 degree quadrangle surveys. Gamma-ray spectral measurements were recorded at 60,653 locations along these flight lines (Amador County, 11,217; Calaveras County, 18,348, and Tuolumne County, 31,088).

Figure 6 also shows the location of the highest two percent of eU concentrations within each 1X2 degree quadrangle. These data appear to cluster in several areas: near Ione, southwest of San Andreas, south of Arnold and northeast of Angles Camp, south of Kirkwood, north of Yosemite National Park and south of Mi-Wuk Village. Within Tuolumne County in the San Jose quadrangle area, higher eU data are more common southwest of Jamestown and along an east-west flight line from southwest of Jamestown eastward to the edge of the quadrangle. However, there are problems with the eU data for the San Jose quadrangle.

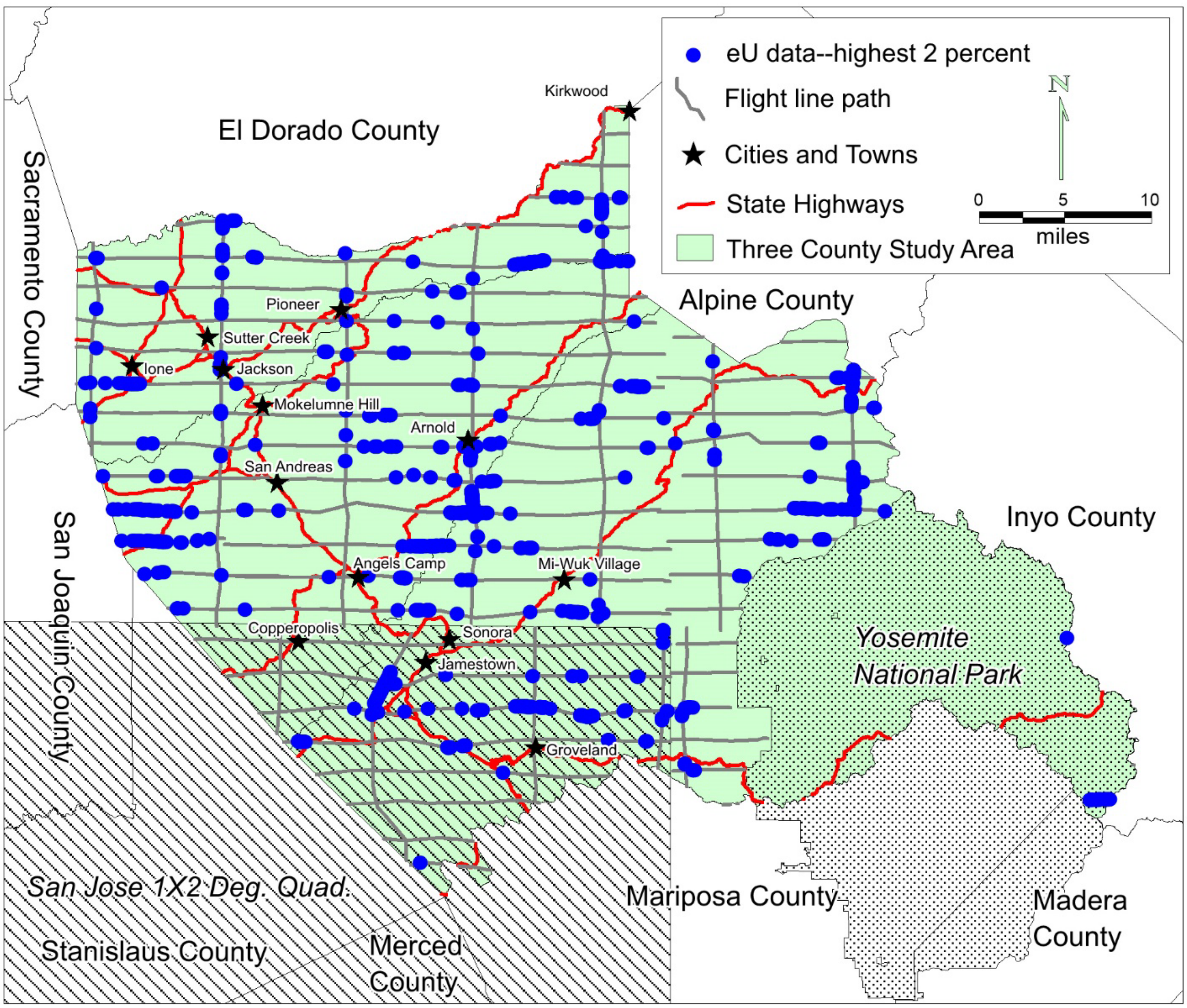

Figure 6. NURE project airborne radiometric survey flight-line paths and the highest 2 percent eU data within each 1X2 degree quadrangle

Appendix J contains the eU data tabulated by geologic unit and quadrangle. Note that the eU data within the San Jose quadrangle are usually higher in concentration, often much higher, than eU data for the same unit in the Sacramento, Mariposa and Walker Lake quadrangles. There is not an obvious geologic reason that explains this discrepancy. Wollenberg and Revzan (1990) also noticed a significant discrepancy between aeroradiometric and lithologic-estimated radium (Ra) in central California (The same Bi-214 gamma ray data may be used to calculate either eU concentrations or eRa concentrations). They investigated the anomalously high radium in the San Jose quadrangle and found strong east-west oriented zone of high concentrations near the northern quadrangle border and in the southern part of the quadrangle. These zones are oriented differently than from the geologic unit orientations and do not match distribution patterns for thorium (eTh) collected at the same time. The Sacramento 1X2 degree quadrangle immediately to the north does not have an eU east-west pattern similar to that in the northern San Jose quadrangle. Wollenberg and Revzan (1990) report that a ground-level gamma-spectral measurement and sampling traverse was conducted across the anomalous areas on the west side of the San Joaquin Valley in open fallow fields with sampling sites based 2 to 3 miles apart. These ground level survey radium measurements showed no correlation with the aeroradiometrically-determined radium concentrations. Wollenberg and Revzan (1990) suspect the aeroradiometrically determined eRa values are artificially high, possibly because of an autumn period atmospheric inversion during which radon (Rn-222) concentrated near the ground surface below the survey aircraft. Such inversion conditions would also account for artificially elevated eU concentrations. Alternative possibilities not discussed by Wollenberg and Revzan (1990) are calibration problems or equipment malfunction for the airborne analytical equipment. Consequently, the accuracy of the San Jose quadrangle eU data is sufficiently questionable that they cannot be used to assess geologic unit radon potentials. Therefore, geologic units within the Calaveras and Tuolumne county portions the San Jose quad will be assumed to have similar eU characteristics as portions of those units within the Sacramento, Mariposa and Walker Lake quadrangles.

NURE airborne eU data in Appendix J for geologic units in Amador, Calaveras and Tuolumne counties, exclusive of those portions of Calaveras and Tuolumne counties within the San Jose 1x2 degree quadrangle, suggest the following geologic units are more likely to have **moderate to high radon potentials**:

- DOsf-Shoo Fly Complex, in the Sacramento and Mariposa quadrangles
- Ei-Ione Formation, in the Sacramento quadrangle
- Mzg-granitic rocks, undifferentiated, in the Walker Lake quadrangle
- MzPzcls-Calaveras Complex, limestone, in the Sacramento quadrangle
- OMvs-Valley Springs Formation, in the Sacramento quadrangle
- pCC-marine metasedimentary rock, in the Walker Lake quadrangle
- Pzsg-Shoo Fly Complex, gneiss, in the Sacramento quadrangle
- Qa-alluvium, in the Sacramento quadrangle
- Qm-Modesto Formation, in the Sacramento quadrangle

- Qr3?-Riverbank Formation, unit 3, queried, in the Sacramento quadrangle
- Tml-Table Mountain Latite, in the Sacramento quadrangle

Airborne eU data in Appendix J suggest the following units have **low to moderate radon potentials**:

- Jss-Salt Springs Slate (with some Mariposa Formation), in the Sacramento quadrangle
- MPm-Mehrten Formation, in the Walker Lake quadrangle
- Mzd-diorite, in the Sacramento quadrangle
- Mzg-granitic rocks, undifferentiated, in the Sacramento quadrangle
- Pl-Laguna Formation, in the Sacramento quadrangle
- Tg-Tertiary auriferous gravels, in the Sacramento quadrangle

Airborne eU data in Appendix J also suggest the following geologic units are more likely to have **low radon potentials**:

- gb-gabbro, in the Sacramento quadrangle
- Jch-Copper Hill Volcanics, in the Sacramento quadrangle
- Jcha-Copper Hill Volcanics, amphibolite, in the Sacramento quadrangle
- Jchl-Copper Hill Volcanics, amygdaloidal mafic lava, in the Sacramento quadrangle
- Jchqp-Copper Hill Volcanics, quartz porphyry, in the Sacramento quadrangle
- Jdpv-Don Pedro Terrane, greenschist (metavolcanic) of Clark, in the Sacramento quadrangle
- Jgo-Gopher Ridge Formation, undifferentiated, in the Sacramento quadrangle
- Jgoa-Gopher Ridge Formation, amphibolite facies, in the Sacramento quadrangle
- Jgoqp-Gopher Ridge Formation, quartz porphyry, in the Sacramento quadrangle
- Jlr-Logtown Ridge Formation, in the Sacramento quadrangle
- Jm-Mariposa Formation, in the Sacramento quadrangle
- Jmb-Metavolcanic Unit, possibly Mariposa Formation, Brower Creek Member, in the Sacramento quadrangle
- ls-limestone or marble, in the Sacramento quadrangle
- MPm-Mehrten Formation, in the Sacramento quadrangle
- ms-metasedimentary rocks, in the Sacramento quadrangle
- mv-metavolcanic rocks (includes some metasedimentary rocks) in the Sacramento quadrangle
- Mzg-granitic rocks, undifferentiated, in the Mariposa quadrangle
- Mzpm-mafic plutonic rocks, undifferentiated (diorite to gabbro; locally pyroxenite and hornblendite), in the Sacramento, Mariposa and Walker Lake quadrangles
- MzPzcc-Calaveras Complex, undifferentiated, in the Sacramento and Mariposa quadrangles
- OMvs-Valley Springs Formation, in the Walker Lake quadrangle

- Pzcm-Calaveras Complex, marble, in the Sacramento quadrangle
- Qa-alluvium, in the Walker Lake quadrangle
- Qc-colluvium, in the Sacramento quadrangle
- Qm2-Modesto Formation, unit 2, in the Sacramento quadrangle
- sp-serpentinite, in the Sacramento quadrangle
- t-dredge or mine tailings, in the Sacramento quadrangle

Note the possible geographic variability in radon potentials for the following units:

- MPm-Mehrten Formation, low to moderate potential-Walker Lake quadrangle; low potential-Sacramento quadrangle
- Mzg-granitic rocks, undifferentiated, moderate or high potential-Walker Lake quadrangle; low-moderate potential Sacramento quadrangle, low potential-Mariposa quadrangle
- OMvs-Valley Springs Formation, moderate or high potential-Sacramento quadrangle; low potential-Walker Lake quadrangle
- Qa-alluvium, moderate or high potential-Sacramento quadrangle; low potential-Walker Lake quadrangle

For MPm (Mehrten Formation), NURE soil data suggest no radon potential difference between quadrangles but eU data suggests a small difference between the Walker Lake and Sacramento quadrangles. For Mzg (granitic rocks, undifferentiated), the eU results differ from the NURE soil uranium data; the latter suggest little difference in radon potentials between the Sacramento and Walker Lake quadrangles. The former suggest significant differences in radon potentials between Mzg Sacramento, Mariposa and Walker Lake quadrangles. Geologic units not in the above lists have insufficient eU data to estimate a radon potential or no eU data.

NRCS SOIL DATA

Background

Natural Resource Conservation Service (NRCS) soil data are sometimes useful in identifying areas with higher radon potential. Higher permeability soils facilitate radon release from host minerals and migration in the subsurface. Radon release and migration can be significantly restricted in soils with low permeability. Soil moisture also influences radon availability and migration in the subsurface. Soils exhibiting moderate to high shrink-swell character may be associated with indoor-radon problems. Such soils change permeability because they contain clays that expand or contract in relation to soil moisture content. They exhibit low permeability during periods of precipitation and high permeability (cracks) during dry periods. High shrink-swell soils also stress and sometimes crack foundations, creating radon entry pathways into homes. Radon is more readily released from its point of origin and may migrate further in dry soils than wet soils because it is captured (dissolved) and held in water (Brookins, 1990).

Soil Properties in Amador, Calaveras and Tuolumne Counties

Appendix K provides information on soil properties and the relationships between soil units, geologic units and indoor-radon data in Amador, Calaveras and Tuolumne counties. Unfortunately, several factors limit the usefulness of NRCS soil data for radon potential mapping. Soil data represent soil properties at a type location and properties at other locations for that soil may be somewhat different. Typically, soil properties are only described from the surface to depths of five to seven feet in NRCS reports. Only part of the radon entering buildings originates within this interval and the rest originates deeper where soil property information, such as permeability, is not available. Although radon potential mapping projects routinely consider soil water permeabilities, these permeabilities are not always good substitutes for soil gas permeabilities. Lastly, the uncertainty about how to interpret vertical radon permeability when vertical soil intervals have multiple horizons with significant permeability differences is problematic. One approach to this multiple-horizon problem is to use hydrologic soil groups (HSG) to proxy for the soil permeability intervals. The relationship between soil permeability and HSG is defined as follows. The HSG for a soil type is determined by the water transmitting soil layer with the lowest saturated hydraulic conductivity and the depth to any layer that is water impermeable (e.g., fragipan or duripan), or depth to a water table if present (NRCS, 2009). The least transmissive layer is any soil horizon that transmits water at a slower rate relative to horizons above or below it. For simplicity in HSG assessment, an impermeable horizon is one with a saturated hydrologic conductivity of 0.0 to 0.1 inches per hour (or 0 micrometers per second to 0.9 micrometers per second). Table 16 shows the NRCS HSG definitions with HSG group A having the highest permeability and HSG group D the lowest permeability. In spite of these generalizations, soil permeabilities do sometimes correlate with areas of higher or lower radon potential.

Soil Property	**NRCS Hydrologic Soil Group**			
	A	B	C	D
Saturated hydraulic conductivity of the least transmissive layer	>1.42 in/h (>10.0 μm/s)	≤1.42 to >0.57 in/h (≤10.0 to >4.0 μm/s)	≤0.58 to >0.06 in/h (≤4.0 to >0.40 μm/s)	≤0.06 in/h (≤0.40 μm/s)
Old permeability classification	Very high to moderate permeability	Moderate to moderately slow permeability	Moderately slow to slow permeability	Very slow permeability

Table 16. Definitions of Hydrologic Soil Groups (Modified from NRCS, 2007)

With regard to the Amador, Calaveras and Tuolumne counties area, NRCS soil data availability are limited. NRCS survey CA626 (NRCS, 2014a) provides soil data for

Amador County. NRCS survey CA731 (NRCS, 2014b) provides soil data for parts of the Stanislaus National Forest. Currently there are no NRCS soil data available for western Calaveras and Tuolumne counties where the majority of these counties' citizens reside (see Figure 7 and NRCS, 2013). Consequently, only 157 (32.9%) of the 478 CDPH radon survey homes have soil data available and 81.5 percent of those homes are in Amador County. Whenever NRCS completes a new soil map for western Calaveras and Tuolumne counties a comparison of radon data and soil data, especially HSG data, may yield important insights into the indoor-radon potential for these counties. Note that some of the NRCS HSG map units in Figure 7 contain multiple HSG units (e.g., A+B or B+C and sometimes three different HSG units) of individual HSG

With limited NRCS data available, radon and HSG comparison was only possible for Amador County and small portions of Calaveras and Tuolumne counties. Note that radon survey data are only available for the westernmost portions of the CA731 survey area in the latter two counties (see Figure 8).

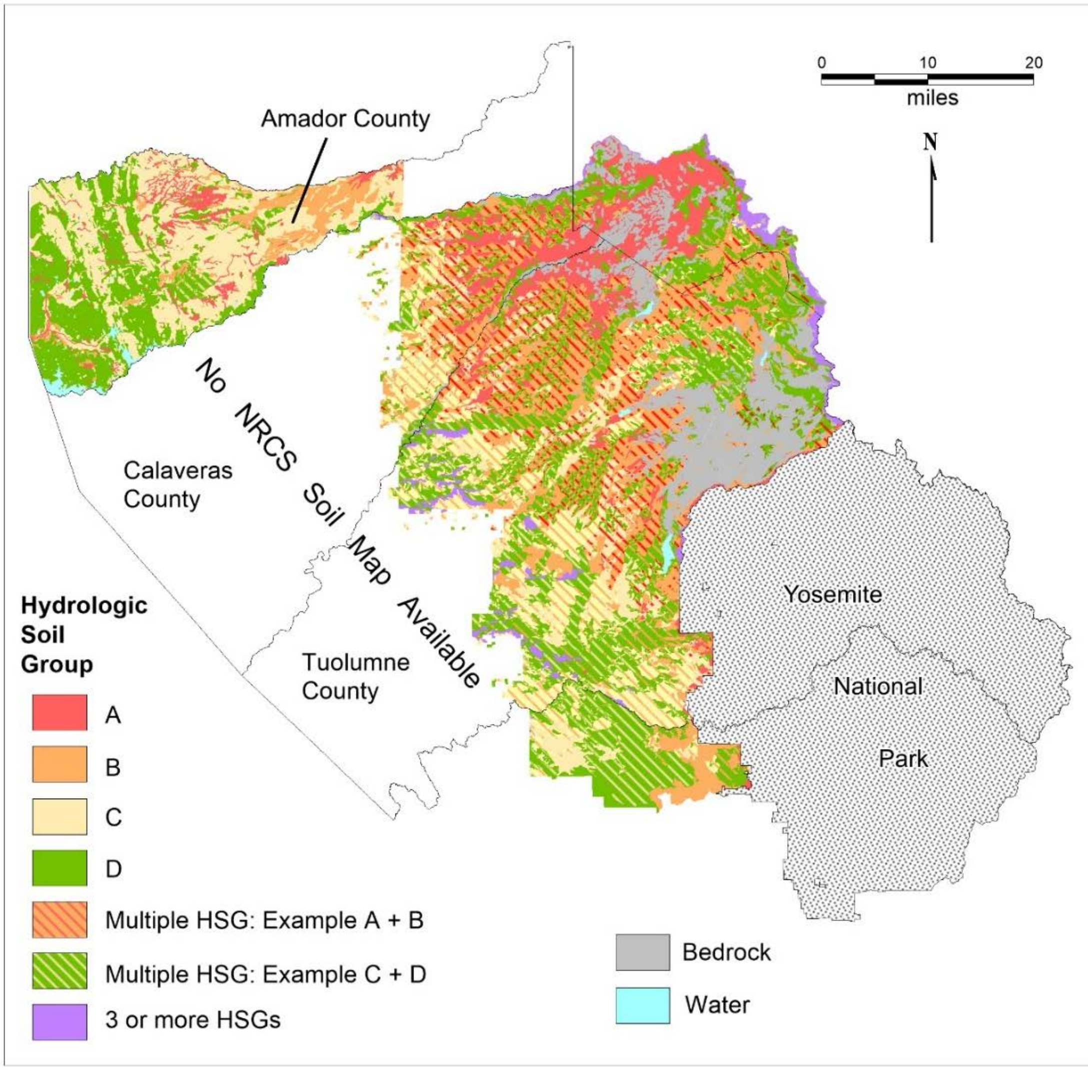

Figure 7. NRCS Hydrologic Soil Groups (HGS) for Amador County and the eastern portions of Calaveras and Tuolumne Counties

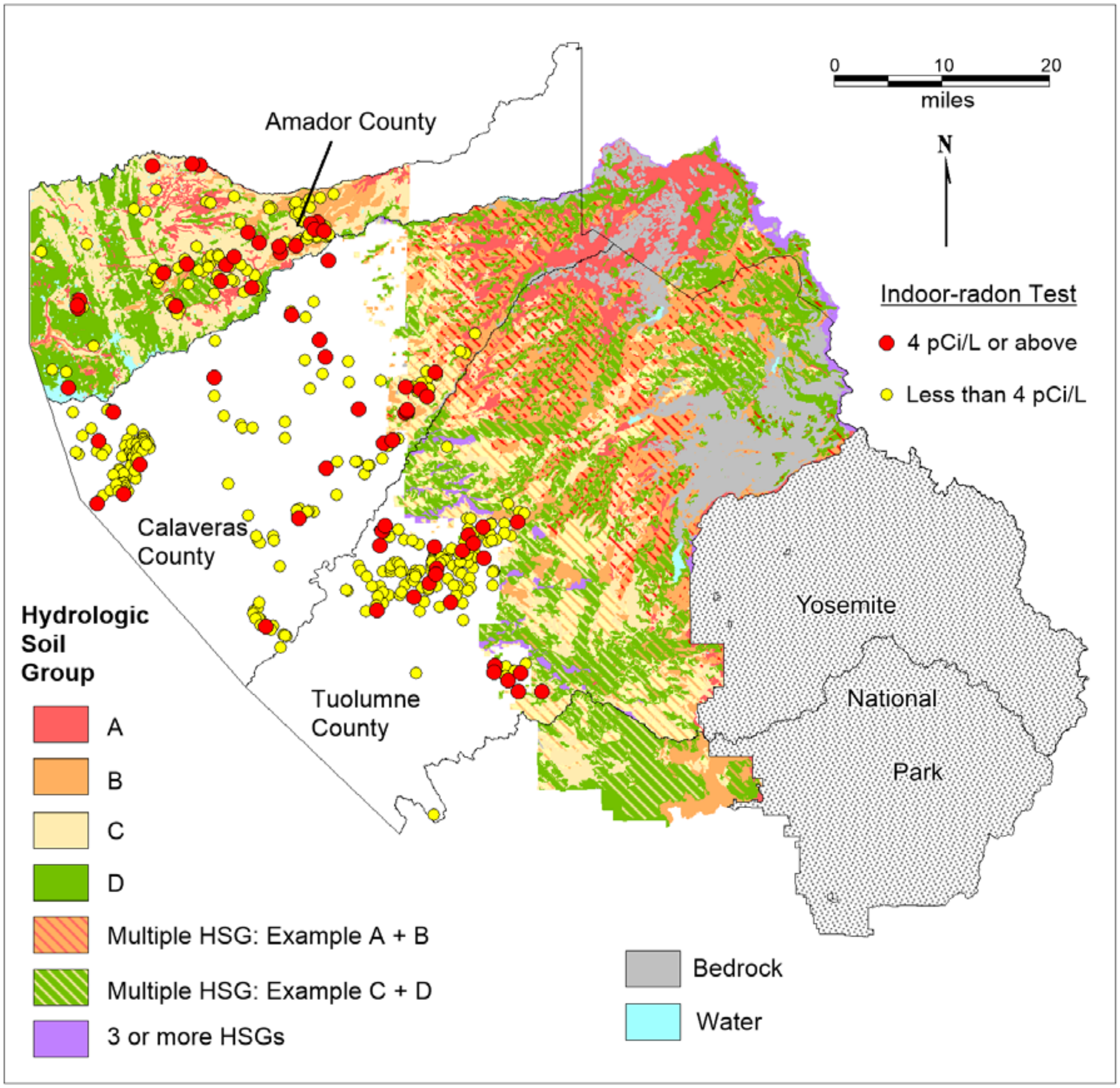

Figure 8. NRCS Hydrologic Soil Groups and indoor-radon survey data for Amador, Calaveras and Tuolumne Counties

Table 17 shows the median and maximum radon concentrations and the percentage of 4.0 pCi/L or higher radon data for HSG groups for the portions of Amador, Calaveras and Tuolumne counties with soil data available. Table 17 suggests significant differences exist between the radon populations for different HSG groups but no statistically significant differences were found based on comparisons by the Mann-Whitney rank sum test. A more useful investigation of HSG and indoor radon relationships would be to look at them by geologic unit, but there are insufficient radon data available for that evaluation. Visual inspection of Figure 7 reveals that higher permeability HSG groups are more prevalent in the eastern parts of the counties and lower permeability HSG groups are more prevalent in the western part of Amador county. Likely western Calaveras and Tuolumne counties are similar to Amador County in the distribution of HSG groups. Eastward increasing soil permeabilities suggest that radon potentials may increase eastward in Amador, Calaveras and Tuolumne counties.

HSG*	N Rn Data	Rn Median pCi/L	Rn Maximum pCi/L	% Rn ≥ 4.0 pCi/L
A	6	3.7	12.5	50.0
B	37	1.9	29.4	10.8
C	54	2.1	40.4	25.9
D	30	2.1	6.7	13.3

Table 17. Comparison of Indoor-radon data by hydrologic soil group (*Hydrologic soil group)

In addition to the HSG and indoor-radon relationships, relationships between HSG and soil uranium abundance were investigated. To do this NURE soil uranium data were grouped by HSG and the groups compared using the Mann-Whitney rank sum test. A complication in making comparisons between CA 731 and CA626 areas is that the former extensively uses soil map units that are combinations of two or more soil types belonging to different HSG types. The multiple HSG soil units make it difficult to evaluate HSG and soil uranium relationships because it is impossible to determine which HSG group is present at a particular soil sample location. Only three geologic units had sufficient associated uranium data to evaluate HSG-indoor radon relationships. These units are the Mehrten Formation, undifferentiated granitic rock, and undifferentiated Calaveras Complex.

Mehrten Formation associated soil units within Amador, Calaveras and Tuolumne counties primarily belong to HSG groups A, B, C and D. Only soil map units consisting of multiple HSG groups A+B, B+C, and C+D have sufficient soil uranium data to allow statistical comparisons. Mehrten Formation soil HSG groups A+B and C+D uranium populations are statistically different, with group A+B (the higher permeability soil) significantly higher in background uranium abundance than group C+D. Similarly, Mehrten Formation multiple HSG units B+C and C+D uranium populations are significantly different, with group B+C (the higher permeability soil) being higher in background uranium content than group C+D (the lower permeability soil). Mehrten Formation groups A+B and B+C are not significantly different in their soil uranium contents. If these uranium differences reflect differences in the underlying Mehrten Formation then they suggest radon potential may be higher in the more permeable (eastern) portions of the Mehrten Formation. If the uranium variations are just within the associated soils (e.g., due to uranium leaching variability) and not reflective of the underlying bedrock then soil uranium variations may not be representative of radon potential trends within Mehrten areas. Lack of Mehrten Formation uranium data below the soil horizon prevents these possibilities from being further evaluated at this time.

Granitic rock associated soil units in the Amador, Calaveras and Tuolumne county area belong to HSG groups A, B, C and D but some map units are combination of two or more groups. Only granitic rock associated with soil units consisting of HSG groups A, B, A+B and B+C have sufficient soil uranium data to allow statistical comparisons. Comparing granitic rock associated soil HSG groups A and B soil uranium data, group B data (less permeable soil) are significantly greater in background uranium abundance than group A. Comparing granitic rock HSG combined groups A+B and B+C soil uranium data; group A+B data (higher permeability soil) are significantly greater in background uranium abundance than those in group B+C. These uranium differences may reflect variations in background uranium levels in the underlying granitic rocks. They also could be related to increased background uranium concentrations in the more permeable (fractured) portions of the underlying granitic rocks. Lack of uranium data for granitic rocks below the soil horizon prevents these possibilities from being further evaluated at this time.

Calaveras Complex associated soils in Amador, Calaveras and Tuolumne counties belong to HSG groups A, B, C, and D but soil map units may contain 2 or three HGS groups in some parts of these counties. Calaveras Complex associated HSG groups C and D uranium populations are not statistically different. This suggests any difference between the soil forming processes for these two HSG groups is too small to have caused any significant differences in background between the HSG C and D group soils. It could also mean that there is little variation in background uranium abundance within the Calaveras Complex itself. The similarity in background uranium abundance for Calaveras HSG C and D soils suggests there may be little variation in radon potential within Calaveras Complex areas.

Based on the above findings for relationships between soil HSG units, indoor radon data and NURE soil uranium data, the available HSG permeability information does not appear useful for ranking geologic unit radon potentials in Amador, Calaveras and Tuolumne Counties. Consequently, ranking of these county radon potentials is based on indoor-radon data, NURE soil uranium data and NURE airborne radiometric equivalent uranium data. The application of HSG information in evaluating geologic unit radon potentials for these counties should be revisited whenever NRCS completes a soil map for the currently unmapped portions of Calaveras and Tuolumne counties.

With regard to regional radon potential trends, the increased presence of higher permeability HSG units in the central and eastern parts of Amador, Calaveras and Tuolumne counties suggests that radon potentials should generally increase eastward in these counties. Previously mentioned eastward increasing background uranium abundance in Sierra Nevada granitic rocks. Increasing elevation as one moves east in the Sierra Nevada leads to longer and colder winters in the eastern portions of Amador, Calaveras and Tuolumne counties and also supports an eastward increasing radon potential trend.

RADON POTENTIAL ZONES

Final Amador, Calaveras and Tuolumne County Geologic Unit Radon Potentials

Final Amador, Calaveras and Tuolumne County geologic unit radon potentials were assigned using review results for:

1. Indoor radon data
2. NURE surface soil U data, and
3. NURE airborne eU data.

NRCS soil permeabilities (hydrologic soil groups) were not considered in geologic unit rankings based on results discussed in the previous section of this report. Amador, Calaveras and Tuolumne county geologic units with insufficient indoor-radon data available were assigned radon potentials of units with radon data based on similarities in NURE soil, sediment and airborne uranium data. Tables 18 and 19 show the geologic units classified as high radon potential and moderate radon potential with comments about supporting information. Appendix L contains information for geologic units assigned to the low radon potential and unknown radon potential categories.

Geologic Unit (symbol and name)	**Indoor Radon Data**	**NURE Soil Uranium Data**	**NURE Airborne eU data**	**Assigned Radon Potential (comments)**
Shoo Fly Complex (DOsf) and Shoo Fly gneiss (Pzsg)	Strongly supports high radon potential; high 8.2 pCi/L in Calaveras Co. on first floor	Supports moderate to high radon potential	Supports moderate to high radon potential	High
Calaveras Complex (MzPzcc)	Strongly supports high radon potential; high 38.8 pCi/L in Amador Co. floor not provided	Strongly supports low radon potential	Supports low radon potential	High (P) (conflict between radon data and NURE data)

Strongly supports = More than 25 measurements available and they support assigned potential
Supports = 10 to 24 indoor radon measurements available and they support assigned potential
Weakly supports = Less than 10 measurements available and they support assigned potential
ID = Insufficient data to evaluate support or non-support of assigned potential
ND = No data
(P) = Provisional, radon potential confidence less certain (limited data available)

Table 18. Amador, Calaveras and Tuolumne county geologic units and strength of supporting data for high radon potential designation

Geologic Unit (symbol and name)	**Indoor Radon Data**	**NURE Soil Uranium Data**	**NURE Airborne eU data**	**Assigned Radon Potential**
Ione Formation (Ei)	Supports moderate potential; high 4.4 pCi/Lin Amador Co. floor not provided	Weakly supports moderate to high potential; few data	Supports moderate or high radon potentials	Moderate (P)
Gopher Ridge Formation undifferentiated (Jgo)	Supports moderate potential; high 5.4 pCi/L in Calaveras Co. on first floor	Weakly supports low radon potential	Supports low radon potential	Moderate (P)
Mehrten Formation (MPm)	Strongly supports moderate potential; high 39.5 pCi/L in Calaveras Co. in basement, highest first floor measurement 29.4 pCi/l in Amador Co.	Supports low to moderate potential Calaveras and Tuolumne counties (in both SAC and WL Quads); supports low potential in Amador County.	Supports low radon potential Sacramento Quad; Low to moderate radon potential Walker Lake Quad	Moderate (P)
granitic rocks, undifferentiated (Mzg)	Strongly supports moderate potential; high 40.4 pCi/L in Amador Co. in basement	Strongly supports moderate to high potential overall; Mzg in Calaveras may have higher potential than in Amador or Tuolumne counties.	Supports Moderate or high radon potentials	Moderate
mafic plutonic rocks, undifferentiated (Mzpm)	Strongly supports moderate potential; high 15.0 pCi/L in Tuolumne Co. on 1^{st} floor	Weakly supports low potential; few data	Supports Low radon potential	Moderate (P)
Valley Springs Formation (OMvs)	Strongly supports Moderate Potential; high 4.7 pCi/L in Amador Co. on first floor	Strongly supports moderate to high potential	Supports moderate to high radon potential	Moderate (P)
Calaveras Complex, marble (in Tuolumne County) Pzcm	Supports moderate potential; high 4.6 pCi/L in Tuolumne Co. floor not provided	ND	ND	Moderate (P)

(see Table 18 footnotes for abbreviation and symbol definitions)

Table 19. Amador, Calaveras and Tuolumne county geologic units and strength of supporting data for moderate radon potential designation

Radon Potential Zone Creation

Radon zone development utilizes GIS procedures. As previously discussed, Amador, Calaveras and Tuolumne counties have geologic units with high, low or unknown radon potential, so they will have high, low and unknown radon potential zones. Zones are created by simply combining the geologic units into groups based on their final assigned radon potential. The high potential zone is all of the occurrences of high potential geologic units. Some occurrences adjoin each other creating a larger high potential area; others are isolated creating smaller high potential areas. Moderate, low and unknown potential zone are also created this way. Figure 9 is a miniature and simplified version of the Amador, Calaveras and Tuolumne counties radon potential map showing the high, moderate, low and unknown zones. Figure 10 shows the radon potential zones with supporting data. Plate 1 is the final radon potential map for Amador, Calaveras and Tuolumne counties, showing radon potential zones and hydrologic, road and other base data.

Radon Potential Zone Characteristics

Tables 20, 21, 22 and 23 summarize indoor-radon data for each radon zone in Amador, Calaveras and Tuolumne counties.

Table 20 shows the number of radon measurements, the median, 25 percent and 75 percent quartile radon concentrations, and the minimum and maximum radon concentrations for each radon potential zone and for Amador, Calaveras and Tuolumne counties as a whole.

Table 21 shows the number and percentage of ≥ 4.0 pCi/L, ≥ 10.0 pCi/L and ≥ 20.0 pCi/L radon measurements. It also lists the total area, in square miles, for each radon potential zone in the Amador, Calaveras and Tuolumne counties radon potential map area.

Table 22 shows the percentages of ≥ 4.0 pCi/L, ≥ 10.0 pCi/L and ≥ 20.0 pCi/L radon measurements distributed between the radon potential zones, and the percent land area for each zone relative to the CGS radon map area. It also shows the cumulative percent of ≥ 4.0 pCi/L measurements and cumulative percent land area for each zone from high potential to unknown potential.

Table 23 shows the number of ≥ 4.0 pCi/L measurements per square mile and the total number of radon measurements per square mile within the portions of Amador, Calaveras and Tuolumne counties covered by the CGS radon potential map.

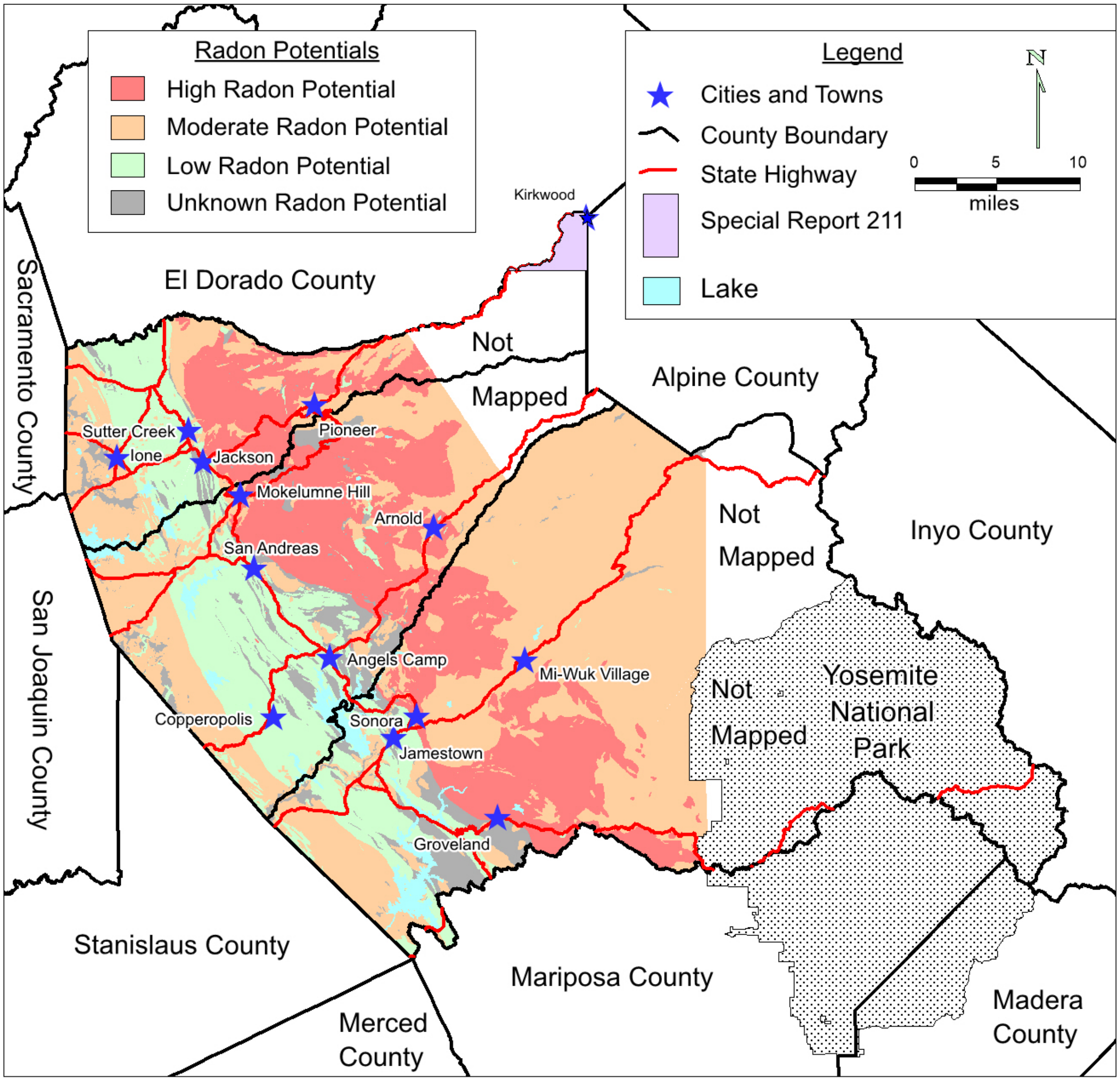

Figure 9. Amador, Calaveras and Tuolumne counties radon potential zones

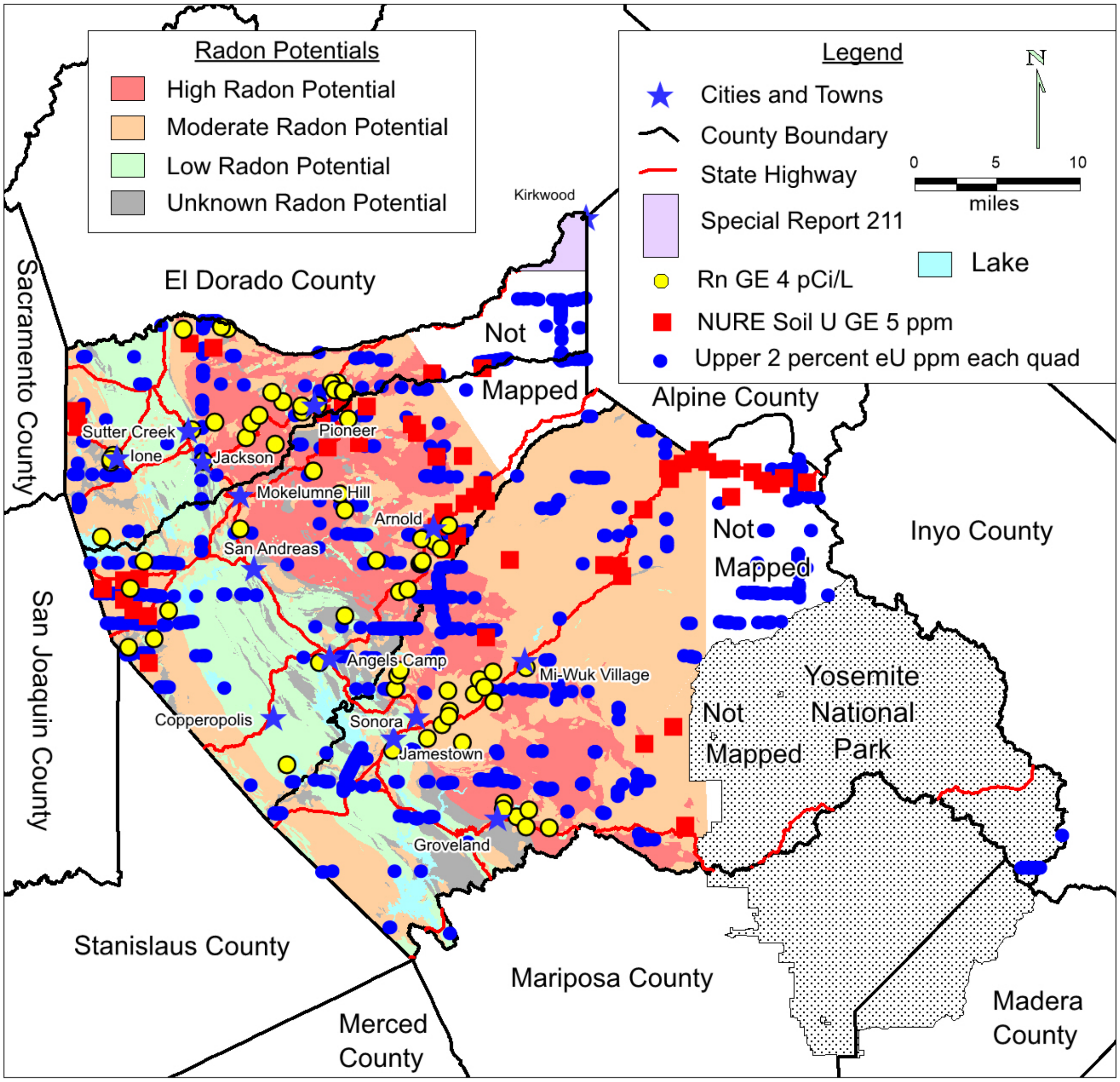

Figure 10. Amador, Calaveras and Tuolumne counties radon potential zones with supporting anomalous indoor-radon survey data and NURE project data

Zone	N	Median pCi/L	pCi/L at 25%	pCi/L at 75%	Min pCi/L	Max pCi/L
High	110	2.25	1.2	4.35	<0.5	38.8
Moderate	240	1.8	1.1	2.8	<0.5	40.4
Low	96	1.1	0.7	1.68	<0.5	16.7
Unknown	32	1.95	0.98	3.78	<0.5	12.0
All	478	1.80	1.0	3.0	<0.5	40.4

Table 20. CDPH radon-survey data characteristics for Amador, Calaveras and Tuolumne county radon potential zones

Zone	N	n ≥ 4.0 pCi/L data	% data ≥ 4.0 pCi/L	n ≥ 10.0 pCi/L data	% data ≥ 10.0 pCi/L	n ≥ 20.0 pCi/L data	% data ≥ 20.0 pCi/L	Mapped Area (sq-mi) land only
High	110	30	27.3	4	3.6	1	0.91	647.5
Moderate	240	30	12.5	7	2.9	3	1.25	1,307.0
Low	96	3	3.1	1	1.0	0	0.0	496.3
Unknown	32	7	21.9	3	9.4	0	0.0	252.6
All	478	70	14.6	15	3.1	4	0.84	2,703.4

Table 21. Number and percent of CDPH radon-survey measurements (n) ≥ 4.0 pCi/L, ≥ 10.0 pCi/L, and ≥ 20.0 pCi/L for Amador, Calaveras and Tuolumne county radon potential zones

Zone	% of all ≥ 4.0 pCi/L measurements	% of all ≥ 10.0 pCi/L measurements	% of all ≥ 20.0 pCi/L measurements	% Area	Cumulative % of ≥ 4.0 pCi/L measurements	Cumulative % of Mapped Area
High	42.9	26.7	25.0	23.95	42.9	23.95
Moderate	42.9	46.7	75.0	48.35	85.8	72.30
Low	4.3	6.7	0.0	18.36	90.1	90.66
Unknown	10.0	20.0	0.0	9.34	100.1	100.0
All	100.1	100.0	100..0	100.0		

Table 22. Percent of ≥ 4.0 pCi/L, ≥ 10.0 pCi/L, and ≥ 20.0 pCi/L CDPH radon-survey measurements for Amador, Calaveras and Tuolumne County radon potential zones

Zone	Average Rate: n ≥ 4.0 pCi/L measurements per square mile	Average Rate: All Measurements per square mile
High	0.0463	0.1699
Moderate	0.0230	0.1836
Low	0.0060	0.1934
Unknown	0.0277	0.1267
All	0.0259	0.1768

Table 23. Average CDPH radon-survey measurements per square mile for Amador, Calaveras and Tuolumne county radon potential zones

RADON POTENTIAL ZONE STATISTICS

Indoor Radon Measurements—Data Population Characteristics

Appendices M and N list indoor-radon data population statistics for each radon potential zone in in the three county study area. Appendix M provides statistics for non-transformed radon data and Appendix N provides statistics for log-transformed (natural logarithm) radon data.

Indoor Radon Data—Frequency Distributions

Frequency distributions of trace element concentration data, such as for uranium and radon in rocks, soils and sediments, are often approximated using a lognormal distribution. However, because of the variety of geologic units and complex history of processes affecting them, trace element geochemical data cannot always be fit to a specific frequency distribution (Rose and others, 1979, p. 33).

Normal and log-transformed indoor-radon data for the Amador, Calaveras and Tuolumne counties radon potential zones were evaluated for normality using the Shapiro-Wilk normality test. Appendix O shows these test results. Log-transformed indoor-radon data for the high radon potential zone and the unknown radon potential zone are lognormally distributed. The normal (not log-transformed) data for these zones is not normally distributed. Neither the normal nor the log-transformed data for the moderate and low radon potential zones are normally distributed. Non-normality for both log-transformed and untransformed moderate and low radon potential zone data populations likely results from each population consisting of multiple sub-populations. On an individual basis some of these sub-populations may be log-normal. However, in aggregate the data are commonly non-normal and non-lognormal.

Data non-normality has important implications for certain statistical tests. For example, t-test comparisons should not be used for comparing non-normal (non-parametric) populations. Uncertainty about moderate and low zone radon population distributions is one reason this study uses the Mann-Whitney rank sum test for comparing radon zone populations. This test, not dependent upon population distribution, also has advantages in dealing with censored data (Helsel, 2012, p. 13). The radon survey data in this study are censored because radon levels below the charcoal test minimum detection limit of 0.5 pCi/L can only be reported as < 0.5 pCi/L and not as a specific radon concentration.

Non-normality also has negative consequences for predictions of percentages of homes with indoor-radon levels exceeding 4.0 pCi/L when such predictions incorrectly assume a lognormal population distribution for radon data. Consequently, this study used percentages of Amador, Calaveras and Tuolumne counties radon survey data at or above ≥4.0 pCi/L, ≥ 10.0 pCi/L and 20.0 pCi/L and radon zone population estimates to calculate the number of individuals exposed to ≥4.0 pCi/L, ≥ 10.0 pCi/L and ≥ 20.0 pCi/L radon levels.

Statistical Comparison of Indoor Radon Data by Radon Potential Zone

Appendix P lists Mann-Whitney rank sum test statistical comparison results for the high, moderate, low and unknown radon potential zone indoor-radon data populations. The results show:

1) The high, moderate and low potential zones indoor-radon data populations are statistically different
2) The high and unknown potential zones indoor-radon data populations are not statistically different
3) The moderate and unknown potential zones are not statistically different
4) The low and unknown potential zones are statistically different

Amador, Calaveras and Tuolumne radon potential map validity is supported by result 1 and the fact that zone medians decrease in magnitude from the high zone to the low zone (Table 20). If more indoor-radon data become available for unknown zone areas, some could end up meeting the criteria for any of the radon potential categories, high, moderate or low in a future update.

Estimated Population Exposed to 4.0 pCi/L or Greater Indoor Air Radon Concentrations in Amador, Calaveras and Tuolumne Counties

The population and home estimates in Table 18, and Tables 19, 20, 21 and 22 provide some perspective about the significance of the indoor-radon issue in Amador, Calaveras and Tuolumne counties. These estimates are based on 2010 U.S. Census data and radon zone boundaries.

Table 18 shows estimates for the population and the number of homes for each radon potential zone within each county. To make radon zone population estimates, census tract boundaries were compared with radon zone boundaries using GIS. A census tract's population was assigned to a radon zone if the census tract area was entirely within that radon zone. A census tract located within multiple zones had its population divided among the zone in proportion to the percentage of census tract area within each zone. The number of homes per radon potential zone was estimated by dividing the estimated zone population by the average number of persons per household obtained for each county (obtained from U.S. Census Bureau QuickFacts, https://www.census.gov/quickfacts/table/PST045215/00)

Tables 25, 26 and 27 contain estimates of the number of residents residing in homes with radon at or above 4.0, 10.0 and 20.0 pCi/L for each radon potential zone in Amador, Calaveras and Tuolumne counties respectively. These estimates were made by multiplying the percentages of ≥ 4.0 pCi/L, ≥ 10.0 pCi/L, and ≥ 20.0 pCi/L measurements for each zone (from Table 21) by the estimated total population for each zone. Table 28 has the combined estimates for the entire three county radon potential map area.

Radon Potential Zone	Estimated Total Population within Zone-2010 Census Statistics	Estimated Total Homes within Zone-using 2010 Census Statistics	
Amador County		**Average Persons per Household***	**Homes****
High	10,915	2.36	4,625
Moderate	14,733	2.36	6,243
Low	8,106	2.36	3,435
Unknown	4,262	2.36	1,806
Total for Amador County	38,016	2.36	16,108
Calaveras County		**Average Persons per Household***	**Homes****
High	9,056	2.38	3,805
Moderate	16,479	2.38	6,924
Low	14,222	2.38	5,976
Unknown	5,656	2.38	2,376
Total for Calaveras County	45,413	2.38	19,081
Tuolumne County		**Average Persons per Household***	**Homes****
High	11,492	2.28	5,040
Moderate	30,106	2.28	13,204
Low	10,491	2.28	4,601
Unknown	3,214	2.28	1,410
Total for Tuolumne County	55,303	2.28	24,256
Totals for the entire Amador, Calaveras and Tuolumne Study Area		**Average persons per Household**	**Homes****
High	31,463	2.33	13,470
Moderate	61,318	2.33	26,371
Low	32,819	2.33	14,01
Unknown	13,132	2.33	5,592
Total within the study area	138,732	2.33	59,445

*Average persons per household in the county using 2010 census statistics

**Estimated homes for each zone = estimated population for each zone by GIS using zone geographic boundaries and 2010 census block data

Table 24. Population and Homes Estimated by Radon Potential Zone and County within the Amador, Calaveras and Tuolumne County Study Area

Radon Potential Zones	**Estimated Population for Zone**	**Estimated Population at ≥ 4.0 pCi/L**	**Estimated Population at ≥ 10.0 pCi/L**	**Estimated Population at ≥ 20.0 pCi/L**	**Area Mapped**	
					%	**mi²**
High	10,915	2,980	393	99	29.0	133.4
Moderate	14,733	1,742	427	184	34.7	159.4
Low	8,106	251	81	0	28.0	128.7
Unknown	4,262	933	400	0	8.3	38.1
Radon Exposure Estimates for Amador County						
Population Estimate Weighted by Radon Zone						
Totals (weighted, i.e., sum of Zone population estimates)	38,016	5,906	1,301	283	100.0	459.7 (76.0 % of county land area)
Population Estimate Not Weighted by Radon Zone						
Totals for Amador County	38,016	5,550	1,178	346	100.0	459.7

Table 25 . Estimates of Amador County population exposed to 4.0 pCi/L or greater indoor radon levels in residences

Radon Potential Zones	**Estimated Population for Zone**	**Estimated Population at ≥ 4.0 pCi/L**	**Estimated Population at ≥ 10.0 pCi/L**	**Estimated Population at ≥ 20.0 pCi/L**	**Area Mapped**	
					%	**mi²**
High	9,056	2,472	326	82	27.2	246.3
Moderate	16,479	2,060	478	150	31.1	281.8
Low	14,222	440	142	0	28.0	253.3
Unknown	5,656	1,239	532	0	13.6	123.4
Radon Exposure Estimates for Calaveras County						
Population Estimate Weighted by Radon Zone						
Totals (weighted, i.e., sum of Zone population estimates)	45,413	6,213	1,478	232	99.9	904.8 (87.4 % of county land area)
Population Estimate Not Weighted by Radon Zone						
Totals for Calaveras County	45,413	6,630	1,408	381	99.9	904.8

Table 26. Estimates of Calaveras County population exposed to 4.0 pCi/L or greater indoor radon levels in residences

Radon Potential Zones	Estimated Population for Zone	Estimated Population at ≥ 4.0 pCi/L	Estimated Population at ≥ 10.0 pCi/L	Estimated Population at ≥ 20.0 pCi/L	Area Mapped	
					%	mi²
High	11,492	3,137	418	105	17.0	267.6
Moderate	30,106	3,763	873	376	69.6	1,099.0
Low	10,491	325	105	0	7.3	114.8
Unknown	3,214	704	302	0	6.1	97.0
Radon Exposure Estimates for Tuolumne County						
Population Estimate Weighted by Radon Zone						
Totals (weighted, i.e., sum of Zone population estimates)	55,303	7,959	1,698	481	100.0	1,578.4 (69.4% of county land area)
Population Estimate Not Weighted by Radon Zone						
Totals for Tuolumne County	55,313	8,076	1,715	465	100.0	1,578.4

Table 27. Estimates of Tuolumne County population exposed to 4.0 pCi/L or greater indoor radon levels in residences

	Estimated Total Population for the Amador, Calaveras and Tuolumne counties study area	Estimated Population at ≥ 4.0 pCi/L	Estimated Population at ≥ 10.0 pCi/L	Estimated Population at ≥ 20.0 pCi/L
All of the Amador, Calaveras and Tuolumne Study Area (Radon Zone weighted and CDPH Zip Code Database proportional totals)	138,732	20,078 weighted radon survey total 19,145 unweighted estimate using CDPH Zip Code Database ≥ 4.0 pCi/L ratio for 1989-2010 data, excluding known tests measured >6 days after exposure and "0" data	4,477 weighted radon survey total	996 weighted radon survey total

Table 28. Estimates of the Total Amador, Calaveras and Tuolumne County Study Area Population Exposed to 4.0 pCi/L or Greater Indoor Radon Levels in Residences. (based on 2010 U.S. Census Data)

Tables 25 to 28 contain two total population estimates for radon exposures in Amador, Calaveras and Tuolumne counties. The first, under table heading "*Population Estimates Weighted by Radon Zone*," estimates totals for the ≥ 4.0 pCi/L, ≥ 10.0 pCi/L and ≥ 20.0 pCi/L exposure categories by summing the estimated populations for each for high, low and unknown zone for each estimated population category. The second estimate, under heading "*Population Estimate Not Weighted by Radon Zone*" was calculated by multiplying the total population for each county in Table 18 by the Table 21 row "All" percentages for ≥ 4.0 pCi/L (14.6%), ≥ 10.0 pCi/L (3.1%) and ≥ 20.0 pCi/L (0.84%) for each county.

Table 22 shows weighted and not weighted estimates for the total population exposed to ≥ 4.0 pCi/L radon levels in homes in Amador, Calaveras and Tuolumne counties. The weighted estimate is the sum of the estimated ≥ 4.0 pCi/L radon for each radon potential zone in each county. The unweighted estimate is based on the ≥ 4.0 pCi/L ratio for the 1989-2010 CDPH Zip Code Database and the total population for the three counties. Tests in the CDPH Zip Code Database measured > 6 days after exposure and "0" data were excluded in determining the ≥ 4.0 pCi/L ratio.

AMADOR, CALAVERAS AND TUOLUMNE COUNTIES RADON MAPPING PROJECT SUMMARY

Short-term radon test data from CDPH, NURE project soil and stream-sediment uranium data, and airborne eU data were used to evaluate geologic units in Amador, Calaveras and Tuolumne counties for their potential to have associated homes with indoor air exceeding the U.S. EPA recommended action level of 4.0 pCi/L. Geologic units were classified as having high, low or unknown radon potential, based on the percentage of 4.0 pCi/L or higher indoor radon measurements, the presence of anomalous data for uranium, and the amount of data available.

The final radon potential zones have the following characteristics:

<u>High Radon Potential Zone</u>: this zone comprises 23.95 percent (647.5 square miles) of the Amador, Calaveras and Tuolumne counties study area. It contains 42.9 percent of the ≥ 4.0 pCi/L measurements, 26.7 percent of the ≥ 10 pCi/L measurements and 25.0 percent of the ≥ 20 pCi/L measurements in the CDPH indoor-radon survey database for Amador, Calaveras and Tuolumne counties. The maximum radon survey measurement for a home in this zone is 38.8 pCi//L in Amador County (floor not specified by homeowner).

<u>Moderate Radon Potential Zone</u>: this zone comprises 48.35 percent (1,307.0 square miles) of the Amador, Calaveras and Tuolumne counties study area. It contains 42.9 percent of the ≥ 4.0 pCi/L measurements, 46.7 percent of the ≥ 10 pCi/L measurements and 75.0 percent of the ≥ 20 pCi/L measurements in the CDPH indoor-radon survey database for Amador, Calaveras and Tuolumne counties. The maximum radon survey measurement for a home in this zone is 40.4 pCi/L in a basement in Amador County.

<u>Low Radon Potential Zone</u>: this zone comprises 18.36 percent (496.3 square miles) of the Amador, Calaveras and Tuolumne counties study area and contains 4.3 percent of the ≥ 4.0 pCi/L measurements, 6.7 percent of the ≥ 10 pCi/L measurements and 0.0

percent of the ≥ 20 pCi/L measurements in the CDPH indoor-radon survey database for Amador, Calaveras and Tuolumne counties. The maximum radon survey measurement for a home in this zone is 16.7 pCi//L in a basement in Amador County.

Unknown Radon Potential Zone: this zone comprises 9.34 percent (252.6 square miles) of the Amador, Calaveras and Tuolumne counties study area and contains 10.0 percent of ≥ 4.0 pCi/L measurements, 20.0 percent of the ≥ 10 pCi/L measurements and 0.0 percent of the ≥ 20 pCi/L measurements in the CDPH indoor-radon survey database for Amador, Calaveras and Tuolumne counties. The maximum radon survey measurement for a home in this zone is 12.0 pCi//L on the first floor in a home in Calaveras County.

Both indoor-radon concentrations exceeding the U.S. EPA recommended action level of 4.0 pCi/L and indoor-radon concentrations below this action level are present in each radon potential zone in Amador, Calaveras and Tuolumne counties. Indoor-radon levels are the result of very complex site-specific multi-component processes. For this reason, reliable prediction of indoor-radon levels for specific buildings through modeling is not possible. The only way to know the indoor-radon concentration in a particular home, school or other building is by testing the indoor-air for radon, regardless of the zone in which the building is located.

Statistical comparison of the indoor-radon data populations for the high, moderate and low radon potential zones, using the Mann-Whitney rank sum test, shows these populations differ from each other statistically. This result supports the increased likelihood of a building in the high potential zone area having indoor-radon exceeding 4.0 pCi/L relative to moderate zone areas and low potential zone areas.

RECOMMENDATIONS

Indoor-radon testing should be encouraged in portions of Amador, Calaveras and Tuolumne counties within high and moderate radon potential zone areas. Additional indoor-radon testing within unknown radon potential zone areas should also be encouraged. Based on CDPH radon survey results, testing should be encouraged in all homes with basements regardless of radon zone. Basements typically have higher radon concentrations than other floors of homes. Indoor-radon testing should also be encouraged in homes in the unmapped portions of Amador, Calaveras and Tuolumne counties in the Sierra Nevada. The cooler climate, more severe weather and areas with elevated background uranium concentrations in rocks, soil and sediment are all things in the Sierra Nevada that increase the odds for elevated indoor-radon levels in buildings.

Those considering new home construction, particularly at sites within high radon potential areas or in unmapped portions of Amador, Calaveras and Tuolumne counties within the Sierra Nevada may wish to consider radon resistant new construction practices. Such construction practice should be considered for any new home in Amador, Calaveras and Tuolumne counties that will have a basement. Post construction radon mitigation is possible, if necessary, but will be more expensive than the cost of adding radon-reducing features during house construction.

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APPENDIX A

Concurrent indoor-Radon Test Data

(Multiple short-term radon measurements in a residence conducted at the same time)

High (pCi/L)	Low (pCi/L)	Difference (pCi/L	Percent Difference*	Comments on Test Locations
12.5	9.2	3.3	26.4	Both are basement locations
12.5	4.1	8.4	67.2	Both are basement locations
9.2	4.1	5.1	55.4	Both are basement locations
6.9	6.4	0.5	7.2	Dining room vs master bedroom
6.0	5.3	0.7	11.7	Both are first floor locations
3.5	0.5	3.0	85.7	Both are first floor locations
2.9	2.5	0.4	13.8	No location information
1.1	0.9	0.2	18.2	Both are basement locations
1.1	0.9	0.2	18.2	Both are basement locations
0.9	0.9	0.0	0.0	Both are basement locations
0.7	<0.5	>0.2	>28.6	First floor dining room vs basement/crawlspace
0.5	<0.5	>0.1	>20.0	First floor-bedroom
0.5	<0.5	>0.1	>20.0	First floor-dining room at landing
<0.5	<0.5	0.0?	0.0?	First floor-stairs at kitchen

* Percent Difference = Difference ÷ High X 100

APPENDIX B

2008-2009 Charcoal Detector Field Blanks

Test Kit ID	Blank Results pCi/L
CA18002	<0.5
CA18014	<0.5
CA18028	<0.5

APPENDIX C

2008-2009 Charcoal Detector Laboratory Spikes

Test Kit ID	Mean Chamber Radon Concentration pCi/L	Test Result pCi/L	Percent Difference from Mean Chamber Concentration pCi/L
CA18000	18.2	30	39.3
CA18010	18.2	23	20.9
CA18022	18.2	20.7	12.1
CA18027	18.2	19.5	6.7
CA18029	18.2	20.3	10.3
CA18031	18.2	16.3	-10.4
CA18035	18.2	17.9	-1.7
CA18052	18.2	21.6	15.7
CA18058	18.2	20.2	9.9
CA18075	18.2	17.7	-2.8

APPENDIX D

Results of Follow-up Tests in Homes

Test 1 pCi/L	Test 2 pCi/L	Difference pCi/L	Percent Difference*	Time Between Tests	Date Test 1	Date Test 2
40.4^	36.5^	3.9	9.7	35 days	1/16/2009	2/20/2009
12.5[1]	1.1[1]	11.4	91.2	78 days	4/12/2009	6/29/2009
12.5[1]	0.9[1]	11.6	92.8	78 days	4/12/2009	6/29/2009
12.5[1]	0.9[1]	11.6	92.8	78 days	4/12/2009	6/29/2009
9.2[1]	1.1[1]	8.1	88.0	78 days	4/12/2009	6/29/2009
9.2[1]	0.9[1]	8.3	90.2	78 days	4/12/2009	6/29/2009
9.2[1]	0.9[1]	8.3	90.2	78 days	4/12/2009	6/29/2009
4.1[1]	1.1[1]	3.0	73.2	78 days	4/12/2009	6/29/2009
4.1[1]	0.9[1]	3.2	78.0	78 days	4/12/2009	6/29/2009
4.1[1]	0.9[1]	3.2	78.0	78 days	4/12/2009	6/29/2009
9.0	7.9	1.1	12.2	30 days	1/21/2010	2/21/2010
8.3[2]	6.9[2]	1.4	16.9	354 days	12/30/2008	12/19/2009
8.3[2]	6.4[2]	1.9	22.9	354 days	12/30/2008	12/19/2009
6.0	4.4	1.6	26.7	4 years 2 days	2/29/2008	2/27/2004
6.0	2.0	4.0	66.7	20 days	1/26/2009	2/15/2009
5.1	1.8	3.3	64.7	4 days	1/7/2009	1/11/2009
4.7	4.1	0.6	12.8	4 years, 9 months, 22 days	1/17/2009	3/26/2004
4.6	3.7	0.6	13.0	372 days	1/14/2010	1/7/2009
3.0	2.3	0.7	23.3	4 years, 9 months, 20 days	3/26/2004	1/15/2009
2.8	0.8	2.0	71.4	4 years, 10 months, 23 days	2/18/2004	1/10/2009
1.1	0.6	0.5	45.4	249 days	12/30/2010	4/25/2010

*Percent Difference = Difference ÷ the higher of Test 1 or Test 2

^Basement measurements

[1]Multiple measurements in basement of one house

[2]Multiple measurements on first floor of one house

APPENDIX E

Maps and reports used by CGS Regional Mapping staff in constructing the unpublished geologic map for the Amador, Calaveras and Tuolumne radon mapping study

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Lindgren, W. and Turner, H.W., 1891, Geologic Atlas of the United States: Placerville Folio, USGS, scale 1:125,000.

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Morgan, B.A., 1976, Geologic Map of the Chinese Camp and Moccasin Quadrangles, Tuolumne County, California. USGS Miscellaneous Field Studies Map MF-840, scale 1:24,000.

Pask, J.A. and Turner, M.D., 1952, Geology and Ceramic Properties of the Ione Formation, Buena Vista Area, Amador County, California: Division of Mines Special Report 19, Plate 1, scale 1:12,000.

Parkison, G.A., 1976, Tectonics and Sedimentation along a Late Jurassic(?) Active Continental Margin, Western Sierra Nevada Foothills, California: University of California, Berkeley, M.S. Thesis, 160 p., Plate 1, scale 1:12,000.

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Piper, A.M., Gale, H.S., Thomas, H.E., and Robinson, T.W., 1939, Geology and Ground-Water Hydrology of the Mokelumne Area, California: U.S. Geological Survey Water Supply Paper 780, 230 p., Plate 1, scale 1:63,360.

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APPENDIX F

CDPH Indoor-Radon Survey Data by Geologic Unit* for Amador, Calaveras and Tuolumne Counties, California

Unit Symbol	Unit Name	N	Indoor-Radon Data pCi/L			Median pCi/L	25% pCi/L	75% pCi/L	% ≥ 4.0 pCi/L
af	artificial fill	0							
am	amphibolite schist	0							
db	diabase and porphyrite	0							
DSof	Shoo Fly Complex	40	8.2	3.5	1.3	2.1	1.1	4.35	30.0
			8.2	3.2	1.2				
			6.8	3.2	1.1				
			6.1	3.2	1.1				
			6.0	2.5	0.9				
			6.0	2.1	0.7				
			5.9	2.1	0.7				
			5.7	2.1	0.7				
			4.8	2.0	0.6				
			4.4	1.9	0.6				
			4.2	1.8	0.6				
			4.0	1.8	0.6				
			3.9	1.6	<0.5				
			3.6						
Ei	Ione Fm.	14	4.4	2.1	0.9	1.95	0.9	2.775	14.3
			4.0	2.0	0.9				
			3.0	1.9	0.7				
			2.7	1.7	<0.5				
			2.2	1.6					
Ei?	Ione Fm. queried	0							
f	felsite dikes	0							
fp	feldspar porphyry	0							
fp?	feldspar porphyry queried	0							
gb	gabbro	3	4.3	1.0	0.7	1.0	0.7	4.3	33.3
gbd	gabbro-diorite	0							
gd	quartz monzonite	0							
gs	greenstone	0							

Unit Symbol	Unit Name	N	Indoor-Radon Data pCi/L			Median pCi/L	25% pCi/L	75% pCi/L	% ≥ 4.0 pCi/L
ha	hornblende andesite	0							
Jch and Jvc	Copper Hill Volcanics	9	2.5 1.5 1.4	1.0 0.9 0.8	0.7 0.7 <0.5	0.9	0.7	1.45	0.0
Jch?	Copper Hill Volcanics queried	0							
Jcha	Copper Hill Volcanics, amphibolite	0							
Jchb	Copper Hill Volcanics, thick bedded volcanic breccia	0							
Jchf	Copper Hill Volcanics, felsic dikes	0							
Jchl	Copper Hill Volcanics, amygdaloidal mafic lava	0							
Jchqp	Copper Hill Volcanics, quartz porphyry	0							
Jdp	Don Pedro Terrane, phyllite and schist of Clark	3	12.0	0.9	0.8	0.9	0.8	12.0	66.7
Jdpt	Don Pedro Terrane, talc schist of Clark	1	5.9			--	--	--	100.0
Jdpv	Don Pedro Terrane, greenschist (metavolcanic) of Clark	15	1.1 1.1 0.8 0.7 0.6	0.5 <0.5 <0.5 <0.5 <0.5	<0.5 <0.5 <0.5 <0.5 <0.5	<0.5	<0.5	0.7	0.0
Jga	Quartz andesite plug	0							
Jgo	Gopher Ridge Fm. undifferentiated	16	5.4 4.0 2.8 2.2 2.0 1.7	1.1 1.0 0.7 0.7 0.5	<0.5 <0.5 <0.5 <0.5 <0.5	0.85	<0.5	2.15	12.5

Unit Symbol	Unit Name	N	Indoor-Radon Data pCi/L			Median pCi/L	25% pCi/L	75% pCi/L	% ≥ 4.0 pCi/L
Jgo?	Gopher Ridge Fm. undifferentiated, queried	0							
Jgoa	Gopher Ridge Fm., amphibolite facies	4	2.2 0.5	<0.5	<0.5	<0.5	<0.5	1.775	0.0
Jgof	Gopher Ridge Fm., feldspar porphyry (?)	0							
Jgoqp	Gopher Ridge Fm., quartz porphyry	9	1.7 1.6 1.2	1.0 0.9 0.8	<0.5 <0.5 <0.5	0.9	<0.5	1.4	0.0
Jlr and Jvl	Logtown Ridge Fm.	10	16.7 2.8 2.1 1.3	1.2 0.9 0.9	0.7 0.7 0.7	1.05	0.7	2.275	10.0
Jm	Mariposa Fm. (in Tuolumne County mélange)	5	2.2 2.1	1.5 0.6	0.5	1.5	0.55	2.15	0.0
Jmb	Metavolcanic unit, possibly Mariposa Fm., Brower Creek Member	8	6.7 2.7 2.1	2.0 1.4 0.7	0.6 <0.5	1.7	0.625	2.55	12.5
Jpb and Jvp	Penon Blanco Volcanics	0							
Jsg	Sullivan Creek terrane, greenschist belt	13	3.1 1.7 1.6 1.3 1.3	1.2 1.0 0.8 0.7	0.6 <0.5 <0.5 <0.5	1.0	0.45	1.45	0.0
Jsp	Sullivan Creek terrane, phyllite belt	6	10.1 2.8	1.9 1.6	1.0 0.6	1.75	0.9	4.625	16.7

Unit Symbol	Unit Name	N	Indoor-Radon Data pCi/L	Median pCi/L	25% pCi/L	75% pCi/L	% ≥ 4.0 pCi/L
Jss	Salt Springs Slate (with some Mariposa Fm.)	22	4.3 1.3 0.6 3.9 1.3 0.5 2.5 1.0 0.5 2.3 1.0 <0.5 1.8 0.9 <0.5 1.7 0.6 <0.5 1.6 0.6 <0.5 1.4	1.00	0.5	1.725	4.5
Jss?	Salt Springs Slate (with some Mariposa Fm.), queried	0					
JTrj	Jasper Point Fm., undifferentiated	0					
JTrjc	Jasper Point Fm., metachert	0					
JTrsb	Part of Calaveras Complex? East of Don Pedro Terrane (Jdp)	0					
Jv	Metavolcanic rocks (undifferentiated)	0					
Jvr	Metarhyolite	0					
Kc?	Chico Fm., queried	0					
ls	limestone or marble	0					
ls?	limestone or marble, queried	0					
Md	diatomite	0					
Mev	Eureka Valley Tuff	0					

Unit Symbol	Unit Name	N	Indoor-Radon Data pCi/L			Median pCi/L	25% pCi/L	75% pCi/L	% ≥ 4.0 pCi/L
MPm	Mehrten Fm.	47	39.5	2.2	1.4	1.9	1.1	2.4	8.5
			29.4	2.1	1.4				
			6.2	2.1	1.3				
			4.2	2.0	1.1				
			3.7	2.0	0.9				
			3.6	1.9	0.9				
			3.6	1.9	0.7				
			2.7	1.9	0.7				
			2.7	1.9	0.6				
			2.6	1.9	0.6				
			2.5	1.6	0.6				
			2.4	1.6	0.5				
			2.3	1.5	0.1				
			2.3	1.5	<0.5				
			2.3	1.4	<0.5				
			2.3	1.4					
ms	metasedimentary rocks	1	<0.5			--	--	--	0.0
ms?	metasedimentary rocks, queried (some polygons are serpentinite)	0							
Mtm	Table Mountain Latite	0							
mv	metavolcanic rocks (includes some metasedimentary rocks)	3	1.1	0.6	0.5	0.6	0.5	1.1	0.0
mv?	metavolcanic rocks, queried	0							
Mzd	diorite	0							

Unit Symbol	Unit Name	N	Indoor-Radon Data pCi/L			Median pCi/L	25% pCi/L	75% pCi/L	% ≥ 4.0 pCi/L
Mzg	granitic rocks, undifferentiated	93	40.4	2.7	1.4	1.8	1.2	3.15	17.2
			13.1	2.5	1.4				
			11.5	2.5	1.4				
			10.2	2.5	1.3				
			9.4	2.4	1.3				
			9.2	2.3	1.2				
			8.8	2.3	1.2				
			8.4	2.2	1.2				
			6.9	2.2	1.2				
			5.8	2.2	1.1				
			5.5	2.2	1.1				
			4.7	2.1	1.0				
			4.5	1.9	0.9				
			4.4	1.8	0.9				
			4.2	1.8	0.9				
			4.1	1.8	0.9				
			3.6	1.7	0.8				
			3.6	1.7	0.8				
			3.6	1.7	0.7				
			3.5	1.7	0.7				
			3.3	1.7	0.7				
			3.2	1.7	0.6				
			3.2	1.7	0.6				
			3.1	1.7	0.6				
			2.9	1.6	0.4				
			2.9	1.6	0.4				
			2.9	1.6	0.2				
			2.9	1.6	0.1				
			2.8	1.5	<0.5				
			2.8	1.4	<0.5				
			2.7	1.4	<0.5				

Unit Symbol	Unit Name	N	Indoor-Radon Data pCi/L			Median pCi/L	25% pCi/L	75% pCi/L	% ≥ 4.0 pCi/L
Mzm	Marine metasedimentary rocks (unit is very small in extent, consisting of a singleconsists of only GIS polygon very small in areal extent)	0							
Mzpm	Mafic plutonic rocks, undifferentiated (diorite to gabbro; locally pyroxenite and hornblendite)	29	15.0	2.3	1.0	1.5	0.9	2.9	10.3
			5.2	1.9	0.9				
			4.9	1.9	0.9				
			3.1	1.8	0.8				
			3.1	1.5	0.6				
			3.1	1.4	0.5				
			3.0	1.4	<0.5				
			2.8	1.1	<0.5				
			2.5	1.1	<0.5				
			2.3	1.0					

Unit Symbol	Unit Name	N	Indoor-Radon Data pCi/L			Median pCi/L	25% pCi/L	75% pCi/L	% ≥ 4.0 pCi/L
MzPzcc	Calaveras Complex, undifferentiated	70	38.8 12.5 12.3 8.7 7.6 7.5 7.0 6.8 6.7 6.4 6.1 6.0 5.9 4.8 4.8 4.7 4.4 4.0 3.5 3.4 3.4 3.4 3.3 3.3	3.2 3.0 3.0 2.9 2.9 2.8 2.7 2.7 2.6 2.4 2.3 2.2 2.1 2.1 2.1 2.0 2.0 1.9 1.9 1.9 1.8 1.8 1.8	1.7 1.5 1.5 1.5 1.4 1.2 1.1 1.1 1.1 1.1 1.0 1.0 1.0 1.0 1.0 0.9 0.8 0.7 0.7 0.6 0.5 0.5 <0.5	2.25	1.175	4.10	25.7
MzPzcls	Calaveras Complex, limestone	1	<0.5			--	--	--	0.0
MzPzct	Calaveras Complex, talc schist	0							
MzPzcv	Calaveras Complex, volcanics	0							

Unit Symbol	Unit Name	N	Indoor-Radon Data pCi/L			Median pCi/L	25% pCi/L	75% pCi/L	% ≥ 4.0 pCi/L
OMvs	Valley Springs Fm.	30	4.7 4.2 3.5 3.0 2.6 2.5 2.4 2.1 2.0 1.8	1.6 1.6 1.5 1.4 1.4 1.1 1.1 1.1 1.0 0.9	0.8 0.8 0.7 0.6 0.6 0.5 <0.5 <0.5 <0.5 <0.5	1.25	0.675	2.175	6.7
OMvs?	Valley Springs Fm., queried	0							
OMvsw	Valley Springs Fm., welded rhyolitic tuff	0							
pCC	Marine metasedimentary rock	0							
Pl	Laguna Fm.	1	1.9			--	--	--	0.0
Pl?	Laguna Fm., queried	1	9.0			--	--	--	100.0
Pzcm	Calaveras Complex, marble	11	4.6 1.7 1.2 1.0	1.0 0.8 <0.5 <0.5	<0.5 <0.5 <0.5	0.8	<0.5	1.2	9.1
Pzm	Marine metasedimentary rock	0							
Pzsg	Shoo Fly Complex, gneiss	0							
q	ankerite-talc schist and mariposite, quartz	0							
Qa	alluvium	1	1.7			--	--	--	0.0
Qal	alluvium (also Qa)	0							

Unit Symbol	Unit Name	N	Indoor-Radon Data pCi/L	Median pCi/L	25% pCi/L	75% pCi/L	% ≥ 4.0 pCi/L
Qc	colluvium	0					
Qg	glacial deposits	0					
Qha	Holocene alluvium	0					
Qls	landslide deposit	0					
Qm	Modesto Fm.	1	1.2	--	--	--	0.0
Qm1	Modesto Fm. unit 1	0					
Qm2	Modesto Fm. unit 2	4	4.0 2.9 2.6 3.0	2.95	2.675	3.75	25.0
Qm2?	Modesto Fm. unit 2 queried	0					
Qr	Riverbank Fm.	1	1.3	--	--	--	0.0
Qr?	Riverbank Fm., queried	2	3.7 0.7	2.2	0.7	3.7	0.0
Qr2	Riverbank Fm. unit 2						
Qr2?	Riverbank Fm. unit 2 queried	0					
Qr3	Riverbank Fm. unit 3	0					
Qr3?	Riverbank Fm. unit 3 queried	0					
Qt	terrace deposits	0					
Qtl?	Turlock Lake Fm., queried	0					
QTnm	North Merced Gravels	0					
QTnm?	North Merced Gravels, queried	0					
Qv	Quaternary volcanics undifferentiated	0					
sc	Interbedded chert and slate	0					
sp	serpentinite	2	1.6 <0.5	0.95	<0.5	1.6	0.0
sp?	Serpentinite, queried	0					
t	dredge or mine tailings	1	10.1	--	--	--	100.0

Unit Symbol	Unit Name	N	Indoor-Radon Data pCi/L	Median pCi/L	25% pCi/L	75% pCi/L	% ≥ 4.0 pCi/L
Tg	Tertiary gravels (auriferous)	1	0.6	--	--	--	0.0
Tml	Table Mountain Latite	0					
Tvd	Tertiary volcanics, dacite	0					
	totals	478					14.6

*100 geologic units total

APPENDIX G

Geologic Units Preliminarily Assigned as having Unknown Radon Potential

Unit Symbol	Unit Name	Unit Symbol	Unit Name
af	artificial fill	Jvr	Metarhyolite
am	amphibolite schist	Kc?	Chico Fm., queried
db	diabase and porphyrite	ls	limestone or marble
Ei?	Ione. Fm. queried	ls?	limestone or marble, queried
f	felsite dikes	Md	diatomite
fp	feldspar porphyry	Mev	Eureka Valley Tuff
fp?	feldspar porphyry, queried	ms	metasedimentary rocks
gb	gabbro	ms?	Metasedimentary rocks, queried
gbd	gabbro-diorite	Mtm	Table Mountain Latite
gd	quartz monzonite	mv	Metavolcanic rocks (includes some metasedimentary rocks)
gs	greenstone	mv?	Metavolcanic rocks, queried
ha	hornblende andesite	Mzd	diorite
Jch?	Copper Hill Volcanics, queried	Mzm	Marine metasedimentary rocks
Jcha	Copper Hill Volcanics, amphibolite	MzPzcls	Calaveras Complex, limestone
Jchb	Copper Hill Volcanics, thick bedded volcanic breccia	MzPzct	Calaveras Complex, talc schist
Jchf	Copper Hill Volcanics, felsic dikes	MzPzcv	Calaveras Complex, volcanics
Jchl	Copper Hill Volcanics, amygdaloidal mafic lava	OMvs?	Valley Springs Fm., queried
Jchqp	Copper Hill Volcanics, quartz porphyry	OMvsw	Valley Springs Fm., welded rhyolitic tuff
Jdp	Don Pedro Terrane, phyllite and schist of Clark	pCC	Marine metasedimentary rock
Jdpt	Don Pedro Terrane, talc schist of Clark	Pl	Laguna Fm.
Jga	Quartz andesite plug	Pl?	Laguna Fm., queried
Jgo?	Gopher Ridge Fm. undifferentiated, queried	Pzm	Marine metasedimentary rock
Jgoa	Gopher Ridge Fm, amphibolite facies	Pzsg	Shoo Fly Complex, gneiss
Jgof	Gopher Ridge Fm., feldspar porphyry?	q	Ankerite-talc schist and mariposite, quartz
Jm	Mariposa Fm. (in Tuolumne County mélange)	Qa	alluvium
Jmb	Metavolcanic unit, possibly Mariposa Fm., Brower Creek Member	Qal	alluvium (also Qa)
Jpb and Jvp	Penon Blanco Volcanics	Qc	colluvium
Jsp	Sullivan Creek terrane, phyllite belt	Qg	glacial deposits
Jss?	Salt Springs Slate (with some Mariposa Fm.), queried	Qha	Holocene alluvium
JTrj	Jasper Point Fm., undifferentiated	Qls	landslide deposit
JTrjc	Jasper Point Fm., metachert	Qm	Modesto Fm.

APPENDIX G continued

Unit Symbol	Unit Name	Unit Symbol	Unit Name
JTrsb	Part of Calaveras Complex? East of Don Pedro Terrane (Jdp)	Qm1	Modesto Fm. unit 1
Jv	Metavolcanic rocks, undifferentiated	Qm2	Modesto Fm. unit 2
Qm2?	Modesto Fm. unit 2, queried	QTnm?	North Merced Gravels, queried
Qr	Riverbank Fm.	Qv	Quaternary volcanics undifferentiated
Qr?	Riverbank Fm., queried	sc	interbedded chert and slate
Qr2	Riverbank Fm. unit 2	sp	serpentinite
Qr2?	Riverbank Fm. unit 2, queried	sp?	serpentinite, queried
Qr3	Riverbank Fm. unit 3	t	dredge or mine tailings
Qr3?	Riverbank Fm. unit 3, queried	Tg	Tertiary gravels (auriferous)
Qt	Terrace deposits	Tml	Table Mountain Latite
Qtl?	Turlock Lake Fm., queried	Tvd	Tertiary volcanics, dacite
QTnm	North Merced Gravels		

APPENDIX H

NURE Soil and Sediment Uranium Data by Geologic Unit for Amador, Calaveras and Tuolumne Counties, California

Uranium data are by neutron activation. Shaded rows are soil data. The total number of stream sediment and soil samples is 883. Samples listed as “0”ppm uranium in the original NURE databases are not included in this table as such entries likely represent “no analysis” or an analytical error rather than 0 ppm uranium. Uranium data for the few talus samples in the NURE databases are not included in this table. Abbreviations are defined at the bottom of the table.

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
af	artificial fill	0								
am-C ssed	amphibolite schist-Calaveras County Sacramento Quad-stream sediment	1	2.0			2.0	2.0	2.0	2.0	0.0
db	diabase and porphyrite	0								
DOsf-all data	Shoo Fly Complex-Amador, Calaveras, and Tuolumne counties data-Sacramento Quad, and Tuolumne County data-Mariposa Quad--stream sediment and soil data	41	8.0 6.7 6.6 6.6 5.9 5.2 5.1 4.5 4.5 4.4 4.2 4.2 4.1 4.0	4.0 4.0 4.0 3.8 3.8 3.4 3.2 3.2 3.2 3.1 3.1 3.1 3.0 3.0	2.9 2.8 2.7 2.6 2.6 2.5 2.5 2.5 2.4 2.3 1.9 1.6 0.9	3.7	3.2	2.8	4.3	17.1
DOsf-all ssed	Shoo Fly Complex-Sacramento Quad-all stream sediment data	18	5.9 4.5 4.0 3.4 3.2 3.2	3.1 3.1 3.0 3.0 2.9 2.8	2.7 2.6 2.6 2.5 2.5 2.4	3.2	3.0	2.6	3.3	5.6

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
DOsf-all soil	Shoo Fly Complex-Sacramento Quad-all soil data	23	8.0 6.7 6.6 6.6 5.2 5.0 4.5 4.4	4.2 4.2 4.1 4.0 4.0 4.0 3.8 3.8	3.2 3.2 3.1 2.3 1.9 1.6 0.9	4.1	4.0	3.2	5.0	26.1
DOsf-A ssed	Shoo Fly Complex-Amador County Sacramento Quad-stream sediment	1	2.9			2.9	2.9	2.9	2.9	0.0
DOsf-A soil	Shoo Fly Complex-Amador County Sacramento Quad-soil	5	6.6 4.5	3.2 3.1	1.9	3.9	3.2	2.5	5.6	20.0
DOsf-C ssed	Shoo Fly Complex-Calaveras County Sacramento Quad-stream sediment	13	5.9 4.5 3.2 3.1 3.0	3.0 2.8 2.7 2.6	2.6 2.5 2.5 2.4	3.1	2.8	2.6	3.2	7.7
DOsf-C soil	Shoo Fly Complex-Calaveras County Sacramento Quad-soil	15	8.0 6.7 6.6 5.2 4.4	4.2 4.2 4.1 4.0 4.0	3.8 3.8 2.3 1.6 0.9	4.3	4.1	3.8	5.2	26.7
DOsf-TMAR ssed	Shoo Fly Complex-Tuolumne County, Mariposa Quad-stream sediment	1	3.2			3.2	3.2	3.2	3.2	0.0
DOsf-TMAR soil	Shoo Fly Complex-Tuolumne County, Mariposa Quad soil	0								
DOsf-TSAC ssed	Shoo Fly Complex – Tuolumne County Sacramento Quad stream sediment	3	4.0	3.4	3.1	4.1	4.0	3.2	5.0	0.0
DOsf-TSAC soil	Shoo Fly Complex-Tuolumne County Sacramento Quad-soil	3	5.0	4.0	3.2	3.5	3.4	3.1	4.0	33.3

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Ei-all data	Ione Formation-Amador and Calaveras counties-Sacramento Quad all data	9	18.9 10.5 8.4	4.8 4.2 3.3	2.8 2.6 1.7	6.4	4.2	2.7	9.5	33.3
Ei-all ssed	Ione Formation-Sacramento Quad all stream sediment data	3	18.9	2.8	2.6	8.1	2.8	2.6	18.9	33.3
Ei-all soil	Ione Formation-Sacramento Quad all soil data	6	10.5 8.4	4.8 4.2	3.3 1.7	5.5	4.5	2.9	8.9	33.3
Ei-A ssed	Ione Formation-Amador County Sacramento Quad-stream sediment	3	18.9	2.8	2.6	8.1	2.8	2.6	18.9	33.3
Ei-A soil	Ione Formation-Amador County Sacramento Quad soil	3	8.4	3.3	1.7	4.5	3.3	1.7	8.4	33.3
Ei-C ssed	Ione Formation-Calaveras County Sacramento Quad-stream sediment	0								
Ei-C soil	Ione Formation-Calaveras County Sacramento Quad-soil	3	10.5	4.8	4.2	6.5	4.8	4.2	10.5	33.3
Ei?	Ione Fm. queried	0								
f	felsite dikes	0								
fp	feldspar porphyry	0								
fp?	feldspar porphyry queried	0								
gb-all data	Gabbro-Calaveras County Sacramento Quad-all data	3	3.4	3.2	0.9	2.5	3.2	0.9	3.4	0.0
gb-C ssed	Gabbro-Calaveras County Sacramento Quad-stream sediment	2	3.4	3.2		3.3	3.3	3.2	3.4	0.0
gb-C soil	Gabbro-Calaveras County Sacramento Quad-soil	1	0.9			0.9	0.9	0.9	0.9	0.0
gbd-A ssed	gabbro/diorite-Amador County Sacramento Quad stream sediment	1	0.7			0.7	0.7	0.7	0.7	0.0
gd	quartz monzonite	0								
gs	Greenstone	0								

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
ha	hornblende andesite	0								
Jch (and Jvc)-all data	Copper Hill Volcanics-Amador and Calaveras counties Sacramento Quad-all stream sediment and soil data	10	4.4 1.3 1.2 1.1	1.1 0.9 0.8	0.7 0.7 0.7	1.3	1.0	0.7	1.2	0.0
Jch-all ssed	Copper Hill Volcanics-Amador and Calaveras counties Sacramento Quad-stream sediment	6	4.4 1.3 1.2	1.1 1.1 0.7	0.7 0.7	1.4	1.1	0.7	1.3	0.0
Jch-all soil	Copper Hill Volcanics-Amador and Calaveras counties Sacramento Quad-soil data	2	0.9	0.8		0.9	0.9	0.8	0.9	0.0
Jch-A ssed	Copper Hill Volcanics-Amador County Sacramento Quad stream sediment	5	4.4 1.3	1.0 0.7	0.7	1.6	1.1	0.7	2.9	0.0
Jch-A soil	Copper Hill Volcanics-Amador Sacramento Quad soil	1	0.8			0.8	0.8	0.8	0.8	0.0
Jch-C ssed	Copper Hill Volcanics-Calaveras County Sacramento Quad-stream sediment	3	1.2	1.1	0.7	1.0	1.1	0.7	1.2	0.0
Jch-C soil	Copper Hill Volcanics-Calaveras County Sacramento Quad-soil	1	0.9			0.9	0.9	0.9	0.9	0.0
Jch?	Copper Hill Volcanics queried	0								
Jcha-C soil	Copper Hill Volcanics, amphibolite-Calaveras County Sacramento Quad-soil	2	2.0	0.6	0.6	1.1	0.6	0.6	2.0	0.0
Jchb	Copper Hill Volcanics, thick bedded volcanic breccia	0								
Jchf	Copper Hill Volcanics, felsic dikes	0								

Unit Symbol	Unit Name	N	NURE U Data (ppm)	Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Jchl-C ssed	Copper Hill Volcanics- amygdaloidal mafic lava- Calaveras County Sacramento Quad- stream sediment	2	1.4 0.9	1.2	1.2	0.9	1.4	0.0
Jchqp	Copper Hill Volcanics- quartz porphyry	0						
Jdp-all data	Don Pedro Terrane, phyllite and schist of Clark-Calaveras County Sacramento Quad-all data	4	2.5 2.2 1.7 2.4 2.1	2.8	2.2	1.9	2.5	0.0
Jdp-C ssed	Don Pedro Terrane, phyllite and schist of Clark- Calaveras County Sacramento Quad- stream sediment	3	2.4 2.2 1.7	2.1	2.2	1.7	2.4	0.0
Jdp-C soil	Don Pedro Terrane, phyllite and schist of Clark-Calaveras County Sacramento Quad-soil	2	2.5 2.1	2.3	2.3	2.1	2.5	0.0
Jdpt-C all data	Don Pedro Terrane, talc schist of Clark-Calaveras County Sacramento Quad-all data	2	3.2 1.4	2.3	2.3	1.4	3.2	0.0
Jdpt-C ssed	Don Pedro Terrane, talc schist of Clark-Calaveras County Sacramento Quad- stream sediment	1	3.2	3.2	3.2	3.2	3.2	0.0
Jdpt-C soil	Don Pedro Terrane, talc schist of Clark-Calaveras County Sacramento Quad-soil	1	1.4	1.4	1.4	1.4	1.4	0.0
Jdpv-all data	Don Pedro Terrane, greenschist (metavolcanic) of Clark-Calaveras County Sacramento Quad-all data	11	2.4 1.6 1.2 2.3 1.3 0.9 2.2 1.3 0.6 1.8 1.2	1.5	1.3	1.2	2.2	0.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)	Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Jdpv-C ssed	Don Pedro Terrane, greenschist (metavolcanic) of Clark- Calaveras County Sacramento Quad-stream sediment	7	2.3 1.8 1.3 2.3 1.6 1.3 2.2	1.8	1.1	0.7	1.2	0.0
Jdpv-C soil	Don Pedro Terrane, greenschist (metavolcanic) of Clark-Calaveras County Sacramento Quad-soil	4	1.2 0.9 0.6 1.2	1.0	1.8	1.3	2.3	0.0
Jga	Quartz andesite plug	0						
Jgo-all data	Gopher Ridge Formation, undifferentiated-Amador and Calaveras counties Sacramento Quad-all data	13	2.9 1.1 0.7 2.8 1.0 0.7 2.7 0.9 0.6 1.7 0.7 0.5 1.3	1.4	1.0	0.7	2.2	0.0
Jgo-all ssed	Gopher Ridge Formation, undifferentiated-Amador and Calaveras counties Sacramento Quad-all stream sediment	8	2.8 1.0 0.7 2.7 0.9 0.6 1.7 0.7	1.4	1.0	0.7	2.5	0.0
Jgo-all soil	Gopher Ridge Formation, undifferentiated-Amador and Calaveras counties Sacramento Quad-all soil	5	2.9 1.1 0.5 1.3 0.7	1.3	1.1	0.6	2.1	0.0
Jgo-A ssed	Gopher Ridge Formation, undifferentiated-Amador County Sacramento Quad stream sediment	3	2.8 1.7 0.9	1.8	1.7	0.9	2.8	0.0
Jgo-A soil	Gopher Ridge Formation, undifferentiated-Amador County Sacramento Quad soil	2	0.7 0.5	0.6	0.6	0.5	0.7	0.0
Jgo-C ssed	Gopher Ridge Formation, undifferentiated-Calaveras County Sacramento Quad stream sediment	5	2.7 0.7 0.6 1.0 0.7	1.1	0.7	0.7	1.9	0.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Jgo-C soil	Gopher Ridge Formation, undifferentiated-Calaveras County Sacramento Quad soil	3	2.9	1.3	1.1	1.8	1.3	1.1	2.9	0.0
Jgo?	Gopher Ridge Formation, undifferentiated, queried	0								
Jgoa-C soil	Gopher Ridge Formation, amphibolite facies-Calaveras County Sacramento Quad-soil	2	1.2	0.7		1.0	1.0	0.7	1.2	0.0
Jgof-A ssed	Gopher Ridge Formation, feldspar porphyry (?)-Amador County Sacramento Quad-stream sediment	1	1.0			1.0	1.0	1.0	1.0	0.0
Jgoqp-C soil	Gopher Ridge Fm., quartz porphyry-Calaveras County Sacramento Quad-soil	1	1.5			1.5	1.5	1.5	1.5	0.0
Jlr-(and Jvl)-all data	Logtown Ridge Formation-Amador and Calaveras counties Sacramento Quad-all data	11	3.8 3.2 2.1 1.9	1.9 1.9 1.8 1.3	1.2 1.2 1.2	2.0	1.9	1.2	2.1	0.0
Jlr-all ssed	Logtown Ridge Formation-Amador and Calaveras counties Sacramento Quad-all stream sediment	8	3.2 2.1 1.9	1.9 1.3	1.2 1.2	1.8	1.9	1.2	2.1	0.0
Jlr-all soil	Logtown Ridge Formation-Amador and Calaveras counties Sacramento Quad-all soil	4	3.8 1.9	1.8	1.2	2.2	1.9	1.4	3.3	0.0
Jlr-A ssed	Logtown Ridge Formation-Amador County Sacramento Quad stream sediment	6	3.2 1.9	1.9 1.3	1.2 1.2	1.8	1.6	1.2	2.2	0.0
Jlr-A soil	Logtown Ridge Formation-Amador County Sacramento Quad soil	2	3.8	1.2		2.5	2.5	1.2	3.8	0.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)	Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Jlr-C ssed	Logtown Ridge Formation-Calaveras County Sacramento Quad stream sediment	1	2.1	2.1	2.1	2.1	2.1	0.0
Jlr-C soil	Logtown Ridge Formation-Calaveras County Sacramento Quad soil	2	1.9 1.8	1.9	1.9	1.8	1.9	0.0
Jm-all data	Mariposa Formation-Amador and Calaveras counties Sacramento Quad-all data	11	3.9 2.5 2.1 2.8 2.5 2.0 2.7 2.5 1.6 2.6 2.4	2.5	2.5	2.1	2.7	0.0
Jm-all ssed	Mariposa Formation-Amador and Calaveras counties Sacramento Quad-all stream sediment	7	2.8 2.4 2.0 2.6 2.1 1.6 2.5	2.3	2.4	2.0	2.6	0.0
Jm-all soil	Mariposa Formation-Amador and Calaveras counties Sacramento Quad-all soil	4	3.9 2.5 2.5 2.7	2.9	2.6	2.5	3.6	0.0
Jm-A ssed	Mariposa Formation-Amador County Sacramento Quad-stream sediment	3	2.8 2.6 2.4	2.6	2.6	2.4	2.8	0.0
Jm-A soil	Mariposa Formation-Amador County Sacramento Quad-soil	3	3.9 2.7 2.5	3.3	2.7	2.5	3.9	0.0
Jm-C ssed	Mariposa Formation-Calaveras County Sacramento Quad-stream sediment	4	2.5 2.0 1.6 2.1	2.1	2.1	1.7	2.4	0.0
Jm-C soil	Mariposa Formation-Calaveras County Sacramento Quad-soil	1	2.5	2.5	2.5	2.5	2.5	0.0
Jmb-C soil	Metavolcanic unit, possibly Mariposa Formation, Brower Creek Member-Calaveras County Sacramento Quad-soil	2	1.2 1.1	1.15	1.15	1.1	1.2	0.0
Jpb and Jvp	Penon Blanco Volcanics	0						

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Jsg	Sullivan Creek terrane, greenschist belt	0								
Jsp	Sullivan Creek terrane, phyllite belt	0								
Jss-all data	Salt Springs Slate (with some Mariposa Formation)-Sacramento and Calaveras counties Sacramento quadrangle-all data	11	3.9 3.0 2.8 2.7	2.5 2.5 2.1 1.9	1.6 0.7 0.4	2.2	2.5	1.6	2.8	0.0
Jss-all ssed	Salt Springs Slate (with some Mariposa Formation)-Sacramento and Calaveras counties Sacramento quadrangle-all stream sediment	6	2.7 2.5	2.5 2.1	1.9 1.6	2.2	2.3	1.8	2.6	0.0
Jss-all soil	Salt Springs Slate (with some Mariposa Formation)-Sacramento and Calaveras counties Sacramento quadrangle-all soil	5	3.9 3.0	2.8 0.7	0.4	2.2	2.8	0.6	3.5	0.0
Jss-A ssed	Salt Springs Slate (with some Mariposa Formation)-Amador County Sacramento Quad-stream sediment	0								
Jss-A soil	Salt Springs Slate (with some Mariposa Formation)-Amador County Sacramento Quad-soil	3	3.9	3.0	2.8	3.2	3.0	2.8	3.9	0.0
Jss-C ssed	Salt Springs Slate (with some Mariposa Formation)-Calaveras County Sacramento Quad-stream sediment	6	2.7 2.5	2.5 2.1	1.9 1.6	2.2	2.3	1.8	2.6	0.0
Jss-C soil	Salt Springs Slate (with some Mariposa Formation)-Amador County Sacramento Quad-soi	2	0.7	0.4		0.6	0.6	0.4	0.7	0.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)	Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Jss?	Salt Springs Slate (with some Mariposa Formation), queried	0						
JTrj	Jasper Point Formation, undifferentiated	0						
JTrjc	Jasper Point Formation, metachert	0						
JTrsb	Part of Calaveras Complex? East of Don Pedro Terrane (Jdp)	0						
Jv	Metavolcanic rocks (undifferentiated)	0						
Jvr	Metarhyolite	0						
Kc?	Chico Formation, queried	0						
ls	limestone or marble	0						
ls?	limestone or marble, queried	0						
Md	diatomite	0						
Mev	Eureka Valley Tuff	0						

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
MPm-A-C-TSAC-all data	Mehrten Formation-Amador, Calaveras and Tuolumne counties Sacramento Quad-all data	64	9.6	3.3	2.5	3.2	2.9	2.3	3.6	6.3
			7.7	3.2	2.4					
			6.5	3.2	2.4					
			5.1	3.2	2.4					
			4.7	3.1	2.3					
			4.5	3.1	2.3					
			4.3	3.0	2.2					
			4.3	3.0	2.2					
			4.1	3.0	2.2					
			4.1	3.0	2.2					
			3.9	2.8	2.1					
			3.8	2.8	2.1					
			3.7	2.8	2.1					
			3.7	2.7	2.1					
			3.7	2.7	2.1					
			3.6	2.7	2.1					
			3.6	2.7	1.9					
			3.6	2.5	1.9					
			3.5	2.5	1.9					
			3.5	2.5	1.8					
			3.4	2.5	1.6					
			3.4							
MPm-A-C-TSAC-all ssed	Mehrten Formation-Amador, Calaveras and Tuolumne counties Sacramento Quad-all stream sediment	27	5.1	3.2	2.5	3.1	3.0	2.4	3.6	3.7
			4.7	3.2	2.5					
			4.5	3.1	2.4					
			3.8	3.0	2.3					
			3.7	3.0	2.2					
			3.6	3.0	2.2					
			3.6	2.8	2.2					
			3.6	2.7	2.1					
			3.3	2.7	2.1					

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
MPm-A-C-TSAC-all Soil	Mehrten Formation-Amador, Calaveras and Tuolumne counties Sacramento Quad-all soil	37	9.6 7.7 6.5 4.3 4.3 4.1 4.1 3.9 3.7 3.7 3.5 3.5 3.4	3.4 3.2 3.1 3.0 2.8 2.8 2.7 2.7 2.5 2.5 2.5 2.4	2.4 2.3 2.2 2.1 2.1 2.1 2.1 1.9 1.9 1.9 1.8 1.6	3.3	2.8	2.5	3.7	8.1
MPm-A ssed	Mehrten Formation-Amador County Sacramento Quad-stream sediment	3	3.7	3.0	2.7	3.1	3.0	2.7	3.7	0
MPm-A soil	Mehrten Formation-Amador County Sacramento Quad-soil	9	3.5 3.4 2.7	2.5 2.5 2.4	2.1 1.9 1.9	2.5	2.5	2.0	3.1	0
MPm-C ssed	Mehrten Formation-Calaveras County Sacramento Quad-stream sediment	8	3.6 3.3 3.0	2.7 2.2 2.2	2.2 2.1	2.7	2.5	2.2	3.2	0
MPm-C soil	Mehrten Formation-Calaveras County Sacramento Quad-soil	17	7.7 6.5 4.3 4.3 4.1 4.1	3.9 3.7 3.7 3.4 3.1 2.8	2.3 2.2 2.1 2.1 1.9	3.7	3.7	2.3	4.2	11.8
MPm-TSAC ssed	Mehrten Formation-Tuolumne County Sacramento Quad-stream sediment	16	5.1 4.7 4.5 3.8 3.6 3.6	3.2 3.2 3.1 3.0 2.8	2.5 2.5 2.4 2.3 2.1	3.3	3.2	2.5	3.8	6.3

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
MPm-TSAC soil	Mehrten Formation-Tuolumne County Sacramento Quad-soil	11	9.6	2.8	2.1	3.2	2.7	2.1	3.2	9.1
			3.5	2.7	1.8					
			3.2	2.5	1.6					
			3.0	2.4						
MPm-TWL-all data	Mehrten Formation-Tuolumne County Walker Lake Quad-all data	94	52.27	4.7	3.4	5.3	4.1	2.9	5.6	29.8
			32.4	4.7	3.2					
			21.3	4.7	3.1					
			15.5	4.6	3.0					
			10.9	4.3	3.0					
			8.2	4.3	3.0					
			7.9	4.3	2.9					
			7.8	4.2	2.9					
			7.6	4.2	2.8					
			7.5	4.2	2.8					
			6.9	4.1	2.7					
			6.8	4.1	2.7					
			6.8	4.1	2.7					
			6.7	4.1	2.7					
			6.5	4.1	2.7					
			6.4	4.0	2.6					
			6.1	3.9	2.5					
			6.1	3.9	2.5					
			6.0	3.8	2.5					
			5.9	3.7	2.5					
			5.9	3.6	2.5					
			5.8	3.6	2.3					
			5.6	3.6	2.2					
			5.6	3.6	2.1					
			5.3	3.6	2.1					
			5.2	3.5	2.1					
			5.2	3.5	2.1					
			5.1	3.5	2.0					
			4.9	3.4	2.0					
			4.8	3.4	2.0					
			4.8	3.4	1.6					
			4.7							

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
MPm-TWL ssed	Mehrten Formation-Tuolumne County Walker Lake Quad-stream sediment	82	52.27	4.8	3.4	5.5	4.1	2.9	5.7	31.7
			32.4	4.7	3.2					
			21.3	4.7	3.1					
			15.5	4.7	3.0					
			10.9	4.6	3.0					
			8.2	4.3	2.9					
			7.9	4.3	2.9					
			7.8	4.3	2.8					
			7.6	4.2	2.8					
			7.5	4.2	2.7					
			6.9	4.1	2.7					
			6.8	4.1	2.7					
			6.7	4.1	2.7					
			6.5	4.1	2.7					
			6.4	4.1	2.6					
			6.1	4.0	2.5					
			6.0	3.9	2.5					
			5.9	3.9	2.5					
			5.9	3.8	2.5					
			5.8	3.7	2.5					
			5.6	3.6	2.2					
			5.6	3.6	2.1					
			5.6	3.6	2.1					
			5.2	3.5	2.1					
			5.2	3.4	2.0					
			5.1	3.4	2.0					
			4.9	3.4	1.6					
			4.8							
MPm-TWL soil	Mehrten Formation-Tuolumne County Walker Lake Quad-soil	12	6.8	3.6	3.0	3.8	3.6	2.5	4.6	16.7
			6.1	3.6	2.3					
			4.7	3.5	2.1					
			4.2	3.5	2.0					
ms-A-C-all ssed	metasedimentary rocks-Amador and Calaveras counties Sacramento Quad-all stream sediment	10	2.6	2.1	1.7	2.0	2.0	1.7	2.4	0.0
			2.4	1.9	1.5					
			2.4	1.8	0.9					
			2.3							

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
ms-A ssed	metasedimentary rocks-Amador County Sacramento Quad-stream sediment	8	2.6 2.3 2.1	1.9 1.8 1.7	1.5 0.9	1.9	1.9	1.6	2.3	0.0
ms-A soil	metasedimentary rocks-Amador County Sacramento Quad-soil	0								
ms-C ssed	metasedimentary rocks-Calaveras County Sacramento Quad-stream sediment	2	2.4	2.4		2.4	2.4	2.4	2.4	0.0
ms-C soil	metasedimentary rocks-Calaveras County Sacramento Quad-soil	0								
ms?	metasedimentary rocks, queried (some polygons are serpentinite)	0								
Mtm	Table Mountain Latite	0								
mv-A ssed	metavolcanic rocks (includes some metasedimentary rocks)-Amador County Sacramento Quad-stream sediment	2	2.3	1.7		2.0	2.0	1.7	2.3	0.0
mv?	metavolcanic rocks, queried	0								
Mzd-C all data	Diorite-Calaveras County Sacramento Quad-all data	11	6.1 5.9 4.7 4.5	4.3 4.2 3.7 3.2	3.2 3.1 2.1	4.1	4.2	3.2	4.7	18.2
Mzd-C ssed	Diorite-Calaveras County Sacramento Quad-stream sediment	4	5.9 4.3	4.2	2.1	4.1	4.3	2.6	5.5	25.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)	Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Mzd-C soil	Diorite-Calaveras County Sacramento Quad-soil	7	6.1 3.7 3.2 4.7 3.2 3.1 4.5	4.1	3.7	3.2	4.7	14.3
Mzg-A-C-TSAC-TMAR-all data	granitic rocks, undifferentiated-Amador, Calaveras and Tuolumne counties Sacramento Quad, and Tuolumne County Mariposa Quad-all data	91	11.6 4.7 3.2 10.9 4.6 3.2 10.8 4.6 3.2 10.3 4.6 2.9 8.3 4.4 2.9 8.0 4.3 2.9 7.8 4.3 2.8 7.3 4.3 2.7 6.6 4.2 2.7 6.5 4.2 2.7 6.4 4.2 2.7 6.3 4.1 2.7 6.3 4.1 2.6 6.2 4.0 2.6 5.9 4.0 2.6 5.9 4.0 2.5 5.8 3.9 2.5 5.7 3.9 2.4 5.4 3.9 2.4 5.4 3.8 2.3 5.2 3.8 2.3 5.2 3.8 2.3 5.2 3.8 2.2 5.2 3.7 2.1 5.2 3.6 1.8 5.1 3.6 1.7 5.1 3.5 1.6 5.0 3.5 1.6 5.0 3.4 1.6 5.0 3.4 0.9 4.8	4.4	4.0	2.7	5.2	33.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
zg- A-C-TSAC-TMAR-all ssed	granitic rocks, undifferentiated-Amador, Calaveras and Tuolumne counties Sacramento Quad, and Tuolumne County Mariposa Quad-all stream sediment	52	10.9	4.2	3.2	4.1	3.9	2.7	5.0	25.0
			10.8	4.2	2.9					
			7.8	4.1	2.9					
			7.3	4.0	2.8					
			6.2	4.0	2.7					
			5.9	3.9	2.7					
			5.9	3.9	2.6					
			5.7	3.9	2.5					
			5.4	3.8	2.5					
			5.2	3.8	2.4					
			5.2	3.8	2.3					
			5.2	3.6	2.3					
			5.0	3.6	2.2					
			4.8	3.5	1.8					
			4.6	3.4	1.7					
			4.4	3.4	1.6					
			4.3	3.2	0.9					
			4.2							
g-A-C-TSAC-TMAR-all soil	granitic rocks, undifferentiated-Amador, Calaveras and Tuolumne counties Sacramento Quad, and Tuolumne County Mariposa Quad-all soil	39	11.6	5.1	3.5	4.7	4.6	2.7	5.8	43.6
			10.3	5.1	3.2					
			8.3	5.0	2.9					
			8.0	5.0	2.7					
			6.6	4.7	2.7					
			6.5	4.6	2.7					
			6.4	4.6	2.6					
			6.3	4.3	2.6					
			6.3	4.3	2.4					
			5.8	4.1	2.3					
			5.4	4.0	2.1					
			5.2	3.8	1.6					
			5.2	3.7	1.6					
Mzg-A ssed	granitic rocks, undifferentiated-Amador County Sacramento Quad-stream sediment	2	4.0	2.5		3.3	3.3	2.5	4.0	0

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Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Mzg-A soil	granitic rocks, undifferentiated-Amador County Sacramento Quad-soil	9	6.4 6.3 5.8	4.3 2.7 2.6	2.4 2.3 1.6	3.8	2.7	2.4	6.1	25.0
Mzg-C ssed	granitic rocks, undifferentiated-Calaveras County Sacramento Quad-stream sediment	7	10.8 4.4 4.2	4.0 3.2	1.8 1.6	4.3	4.0	1.8	4.4	14.3
Mzg-C soil	granitic rocks, undifferentiated-Calaveras County Sacramento Quad-soil	11	11.6 10.3 8.3 8.0	6.6 6.5 6.3 5.1	4.3 3.2 1.6	6.5	6.5	4.3	8.3	57.1
Mzg-TMAR ssed	granitic rocks, undifferentiated-Tuolumne County Mariposa Quad-stream sediment	2	5.2	3.4		4.3	4.3	3.4	5.2	50.0
Mzg-TMAR soil	granitic rocks, undifferentiated-Tuolumne County Mariposa Quad-soil	7	5.1 5.0 5.0	4.7 4.6	3.8 3.5	4.5	4.7	3.8	5.0	42.9
Mzg-TSAC ssed	granitic rocks, undifferentiated-Tuolumne Sacramento Quad-stream sediment	41	10.9 7.8 7.3 6.2 5.9 5.9 5.7 5.4 5.2 5.2 5.0 4.8 4.6 4.3	4.2 4.2 4.1 3.9 3.9 3.9 3.8 3.8 3.8 3.6 3.6 3.5 3.4 3.2	2.9 2.9 2.8 2.7 2.7 2.6 2.5 2.4 2.3 2.3 2.2 1.7 0.9	4.1	3.9	2.7	5.0	26.8
Mzg-TSAC soil	granitic rocks, undifferentiated-Tuolumne County Sacramento Quad-soil	12	5.4 5.2 5.2 4.6	4.1 4.0 3.7 2.9	2.7 2.7 2.6 2.1	3.8	4.6	2.7	5.8	25.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Mzg-TWL all data	granitic rocks, undifferentiated-Tuolumne County Walker Lake Quad-all data (1 of 3 pages)	321	368.5	33.2	18.5	17.9	7.3	4.4	17.9	68.5
			2271	32.7	18.4					
			221.2	32.0	18.1					
			156.1	31.71	17.9					
			136.8	31.6	17.8					
			111.5	30.4	17.5					
			107.8	30.1	17.3					
			103.9	29.9	17.3					
			103.4	28.8	17.2					
			80.5	27.9	17.2					
			78.5	27.9	17.0					
			73.9	27.7	16.8					
			73.3	25.9	16.8					
			73.2	25.6	16.8					
			65.8	25.4	16.6					
			65.0	25.1	16.6					
			64.5	24.8	16.5					
			63.0	24.5	16.5					
			61.5	24.4	16.2					
			61.4	24.2	16.2					
			53.5	23.8	16.1					
			49.1	23.8	16.1					
			47.3	23.5	15.3					
			46.9	23.3	15.2					
			46.4	23.2	14.8					
			45.9	23.0	14.5					
			43.6	22.2	14.5					
			40.5	22.1	14.3					
			40.4	21.6	14.3					
			39.9	21.1	14.2					
			39.4	20.7	13.9					
			38.7	20.3	13.9					
			38.6	20.2	13.7					
			37.7	20.0	13.5					
			36.4	20.0	13.4					
			35.9	19.1	13.4					
			35.0	18.9	13.1					
			33.4	18.5	13.1					

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Mzg-TWL-all data cont.	*Continued:* granitic rocks, undifferentiated-Tuolumne County Walker Lake Quad-all data (2 of 3 pages)		13.0	7.9	5.7					
			12.9	7.8	5.7					
			12.8	7.7	5.7					
			12.5	7.7	5.7					
			12.3	7.6	5.6					
			12.2	7.6	5.6					
			12.2	7.4	5.6					
			11.9	7.4	5.6					
			11.6	7.3	5.6					
			11.5	7.3	5.6					
			11.0	7.2	5.5					
			10.9	7.2	5.5					
			10.9	7.1	5.5					
			10.9	7.0	5.4					
			10.8	7.0	5.4					
			10.5	6.9	5.4					
			10.4	6.9	5.4					
			10.3	6.8	5.3					
			10.2	6.8	5.3					
			9.9	6.8	5.3					
			9.7	6.7	5.3					
			9.7	6.6	5.2					
			9.7	6.5	5.2					
			9.6	6.5	5.2					
			9.5	6.3	5.1					
			9.4	6.2	5.1					
			9.3	6.2	5.0					
			9.0	6.2	5.0					
			8.9	6.1	5.0					
			8.8	6.1	5.0					
			8.8	6.0	4.9					
			8.8	5.9	4.8					
			8.6	5.8	4.8					
			8.6	5.8	4.8					
			8.5	5.8	4.8					
			8.5	5.8	4.8					
			8.4	5.7	4.8					
			8.3	5.7	4.8					

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Mzg-TWL-all data cont.	*Continued:* granitic rocks, undifferentiated-Tuolumne County Walker Lake Quad-all data (3 of 3 pages)		4.7	3.7	2.8					
			4.7	3.7	2.8					
			4.7	3.7	2.8					
			4.7	3.7	2.7					
			4.7	3.7	2.7					
			4.6	3.7	2.7					
			4.6	3.7	2.7					
			4.6	3.7	2.7					
			4.6	3.6	2.6					
			4.6	3.6	2.6					
			4.5	3.6	2.6					
			4.5	3.5	2.6					
			4.4	3.5	2.6					
			4.4	3.5	2.5					
			4.4	3.5	2.5					
			4.3	3.4	2.5					
			4.3	3.4	2.4					
			4.3	3.3	2.4					
			4.2	3.3	2.4					
			4.2	3.3	2.4					
			4.2	3.3	2.4					
			4.1	3.2	2.2					
			4.1	3.2	2.2					
			4.1	3.0	2.2					
			4.0	3.0	2.2					
			4.0	2.9	2.1					
			4.0	2.9	1.9					
			3.8	2.9	1.8					
			3.8	2.9	1.8					
			3.8	2.8	1.8					
			3.8	2.8						

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Mzg-TWL-ssed	granitic rocks, undifferentiated-Tuolumne County Walker Lake Quad-stream sediment (1 of 3 pages	249	368.5	33.2	18.4	19.5	8.8	4.8	20.0	69.1
			227.1	32.7	18.1					
			221.2	32.0	17.9					
			156.1	31.71	17.8					
			136.8	30.4	17.5					
			111.5	30.1	17.3					
			107.8	29.9	17.3					
			103.9	28.8	17.2					
			103.4	27.9	17.2					
			80.5	27.9	17.0					
			78.5	27.7	16.8					
			73.9	25.9	16.8					
			73.3	25.6	16.8					
			73.2	25.4	16.6					
			65.8	25.1	16.6					
			65	24.8	16.5					
			64.5	24.5	16.5					
			63	24.4	16.2					
			61.5	24.2	16.1					
			61.4	23.8	15.3					
			53.5	23.8	15.2					
			49.1	23.5	14.8					
			47.3	23.3	14.5					
			46.9	23.2	14.5					
			46.4	23.0	14.3					
			45.9	22.2	14.3					
			43.6	22.1	14.2					
			40.5	21.6	13.9					
			40.4	21.1	13.9					
			39.9	20.7	13.7					
			39.4	20.3	13.4					
			38.7	20.2	13.4					
			38.6	20.0	13.1					
			37.7	20.0	13.1					
			36.4	19.1	13.0					
			35.9	18.9	12.9					
			35.0	18.5	12.8					
			33.4	18.5	12.5					

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Mzg-TWL-ssed	*Continued:* granitic rocks, undifferentiated-Tuolumne County Walker Lake Quad-stream sediment (2 of 3 pages		12.3	7.4	5.4					
			12.2	7.3	5.4					
			12.2	7.3	5.4					
			11.9	7.2	5.4					
			11.6	7.2	5.3					
			11.5	7.1	5.3					
			11.0	7.0	5.3					
			10.9	7.0	5.3					
			10.9	6.9	5.2					
			10.9	6.9	5.2					
			10.8	6.8	5.2					
			10.5	6.8	5.1					
			10.4	6.7	5.1					
			10.3	6.6	5.0					
			10.2	6.5	5.0					
			9.9	6.5	5.0					
			9.7	6.3	5.0					
			9.7	6.2	4.9					
			9.7	6.1	4.8					
			9.6	6.1	4.8					
			9.5	5.9	4.8					
			9.4	5.8	4.8					
			9.3	5.8	4.8					
			9.0	5.8	4.7					
			8.9	5.8	4.7					
			8.8	5.7	4.7					
			8.8	5.7	4.7					
			8.8	5.7	4.7					
			8.6	5.7	4.6					
			8.6	5.7	4.6					
			8.5	5.7	4.6					
			8.5	5.6	4.6					
			8.3	5.6	4.5					
			7.8	5.6	4.5					
			7.7	5.6	4.4					
			7.6	5.6	4.4					
			7.6	5.5	4.4					
			7.4	5.5	4.3					

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Mzg-TWL-ssed	*Continued:* granitic rocks, undifferentiated-Tuolumne County Walker Lake Quad-stream sediment (3 of 3 pages		4.3	3.6	3.2.7					
			4.3	3.5	2.7					
			4.2	3.5	2.6					
			4.1	3.4	2.6					
			4.1	3.4	2.6					
			4.1	3.3	2.6					
			4.0	3.3	2.5					
			4.0	3.3	2.5					
			4.0	3.3	2.4					
			3.8	3.2	2.4					
			3.8	3.0	2.4					
			3.7	2.9	2.4					
			3.7	2.9	2.2					
			3.7	2.9	2.2					
			3.7	2.8	2.2					
			3.7	2.8	2.1					
			3.7	2.8	1.8					
			3.6	2.8	1.8					
			3.6							
Mzg-WL soil	granitic rocks, undifferentiated-Tuolumne County Walker Lake Quad-soil	36	31.6	4.8	3.0	5.5	3.8	2.7	6.2	33.3
			16.2	4.8	2.9					
			13.5	4.6	2.8					
			8.4	4.2	2.7					
			7.9	4.2	2.7					
			7.7	3.8	2.7					
			6.8	3.8	2.5					
			6.2	3.7	2.4					
			6.2	3.7	2.2					
			6.0	3.5	2.2					
			5.6	3.5	1.9					
			5.5	3.2	1.8					
Mzm	Marine metasedimentary rocks (one polygon)	0								

Unit Symbol	Unit Name	N	NURE U Data (ppm)	Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Mzpm-all soil data	Mafic plutonic rocks, undifferentiated (diorite to gabbro; locally pyroxenite and hornblendite in Tuolumne County Sacramento and Mariposa Quads-all soil data	4	4.1 2.6 1.4 3.5	2.9	3.1	1.7	3.95	0.0
Mzpm-TSAC-soil	Mafic plutonic rocks, undifferentiated (diorite to gabbro; locally pyroxenite and hornblendite in Tuolumne County Sacramento Quad-soil data	3	4.1 2.6 1.4	2.7	2.6	1.4	4.1	0.0
Mzpm-TMAR-soil	Mafic plutonic rocks, undifferentiated (diorite to gabbro; locally pyroxenite and hornblendite in Tuolumne County Mariposa Quad-soil data	1	3.5	3.5	3.5	3.5	3.5	0.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
MzPzcc-A-C-TSAC-all data	Calaveras Complex, undifferentiated-Amador, Calaveras and Tuolumne counties Sacramento Quad-all data	70	5.7	2.8	2.2	2.	2.5	2.1	3.0	1.4
			4.8	2.7	2.1					
			4.8	2.7	2.1					
			4.8	2.7	2.1					
			4.7	2.7	2.1					
			3.8	2.6	2.1					
			3.7	2.5	2.1					
			3.7	2.5	2.0					
			3.6	2.5	2.0					
			3.6	2.5	2.0					
			3.5	2.5	1.9					
			3.3	2.5	1.9					
			3.1	2.5	1.9					
			3.1	2.5	1.9					
			3.1	2.5	1.9					
			3.1	2.5	1.7					
			3.1	2.4	1.6					
			3.0	2.3	1.6					
			3.0	2.3	1.6					
			2.9	2.3	1.6					
			2.9	2.3	1.4					
			2.9	2.3	1.3					
			2.8	2.2	1.2					
			2.8							
MzPzcc-A-C-all ssed	Calaveras Complex, undifferentiated-Amador, Calaveras and Tuolumne counties Sacramento Quad-all stream sediment	36	4.7	2.5	2.1	2.4	2.3	1.9	2.5	0.0
			3.7	2.5	2.0					
			3.1	2.5	2.0					
			3.1	2.5	1.9					
			3.0	2.4	1.9					
			2.9	2.3	1.7					
			2.8	2.3	1.6					
			2.7	2.3	1.6					
			2.5	2.3	1.6					
			2.5	2.1	1.4					
			2.5	2.1	1.3					
			2.5	2.1	1.2					

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
MzPzcc – A-C-TSAC-all soil	Calaveras Complex, undifferentiated-Amador, Calaveras and Tuolumne counties Sacramento Quad-all soil	34	5.7 4.8 4.8 4.8 3.8 3.7 3.6 3.6 3.5 3.3 3.1 3.1	3.1 3.0 2.9 2.9 2.8 2.8 2.7 2.7 2.7 2.6 2.5	2.5 2.3 2.2 2.2 2.1 2.1 2.0 1.9 1.9 1.9 1.6	3.0	2.8	2.2	3.5	2.9
MzPzcc-A ssed	Calaveras Complex, undifferentiated-Amador County Sacramento Quad-stream sediment	14	3.1 2.8 2.5 2.3 2.3	2.3 2.1 2.1 2.1 2.0	1.6 1.6 1.3 1.2	2.1	2.1	1.6	2.4	0.0
MzPzcc-A soil	Calaveras Complex, undifferentiated-Amador County Sacramento Quad-soil	18	5.7 4.8 3.6 3.6 3.3 3.1	3.1 3.1 2.9 2.9 2.8 2.7	2.5 2.3 2.0 1.9 1.9 1.6	3.0	2.9	2.2	3.4	5.6
MzPzcc-Cs ssed	Calaveras Complex, undifferentiated-Calaveras County Sacramento Quad-stream sediment	17	4.7 3.1 3.0 2.9 2.7 2.5	2.5 2.5 2.5 2.4 2.3 2.1	2.0 1.9 1.9 1.7 1.6	2.5	2.5	2.0	2.8	0.0
MzPzcc-C soil	Calaveras Complex, undifferentiated-Calaveras County Sacramento Quad-soil	13	4.8 4.8 3.7 3.5 3.0	2.8 2.7 2.7 2.5	2.2 2.2 2.1 1.9	3.0	2.7	2.2	3.6	0.0
MzPzcc-TSAC ssed	Calaveras Complex, undifferentiated-Tuolumne County Sacramento Quad-stream sediment	5	3.7 2.5	2.5 2.5	1.4	2.5	2.5	2.0	3.1	0.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
MzPzcc-TSAC soil	Calaveras Complex, undifferentiated-Tuolumne County Sacramento Quad-soil	3	3.8	2.6	2.1	2.8	2.6	2.1	3.8	0.0
MzPzcls-C ssed	Calaveras Complex, limestone (C)	2	2.3	1.2		1.75	1.75	1.2	2.3	0.0
MzPzct	Calaveras Complex, talc schist	0								
MzPzcv-all data	Calaveras Complex, volcanics-Amador and Calaveras counties Sacramento Quad-all data	2	2.6	2.3		2.45	2.45	2.3	2.6	0.0
MzPzcv-A soil	Calaveras Complex, volcanics-Amador County Sacramento Quad-soil	1	2.3			2.3	2.3	2.3	2.3	0.0
MzPzcv-C ssed	Calaveras Complex, volcanics-Calaveras County Sacramento Quad-stream sediment	1	2.6			2.6	2.6	2.6	2.6	0.0
OMvs-A-C-all data	Valley Springs Formation-Amador and Calaveras counties Sacramento Quad-all data	31	6.6 6.2 6.0 5.9 5.8 5.6 5.6 5.4 5.3 5.1 4.9	4.8 4.6 4.3 4.0 3.8 3.7 3.7 3.6 3.4 3.3	3.2 3.1 3.1 3.1 3.0 2.8 2.7 1.8 1.8 1.7	4.1	3.8	3.1	5.4	32.3
OMvs-A-C-all ssed	Valley Springs Formation-Amador and Calaveras counties Sacramento Quad-all stream sediment	14	6.6 5.8 4.9 3.7 3.6	3.4 3.3 3.1 3.0 2.8	2.7 1.8 1.8 1.7	3.4	3.2	2.5	4.0	14.3

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
OMvs-all soil	Valley Springs Formation-Amador and Calaveras counties Sacramento Quad-all soil	17	6.2 6.0 5.9 5.6 5.6 5.4	5.3 5.1 4.8 4.6 4.3 4.0	3.8 3.7 3.2 3.1 3.1	4.7	4.8	3.8	5.6	47.1
OMvs-A ssed	Valley Springs Formation-Amador County Sacramento Quad-soil	6	6.6 4.9	3.7 3.6	3.3 2.7	4.1	3.7	3.2	5.2	16.7
OMvs-A-soil	Valley Springs Formation-Amador County Sacramento Quad-stream sediment	1	6.0			6.0	6.0	6.0	6.0	100
OMvs-C ssed	Valley Springs Formation-Calaveras County Sacramento Quad-stream sediment	8	5.8 3.4 3.1	3.0 2.8 1.8	1.8 1.7	2.9	2.9	1.8	3.3	12.5
OMvs-C soil	Valley Springs Formation-Calaveras County Sacramento Quad-soil	16	6.2 5.9 5.6 5.6 5.4 5.3	5.1 4.8 4.6 4.3 4.0	3.8 3.7 3.2 3.1 3.1	4.6	4.7	3.7	5.6	43.8
OMvs-TWL-all data	Valley Springs Formation-Tuolumne County Walker Lake Quad-all data	10	23.5 12.5 6.4 6.4	5.8 5.3 4.9	4.6 4.5 2.8	7.7	5.6	4.6	7.9	60.0
OMvs TWL-ssed	Valley Springs Formation-Tuolumne County Walker Lake Quad-stream sediment	8	23.5 12.5 6.4	6.4 5.8 4.9	4.6 4.5	8.6	6.4	4.7	11.0	62.5
OMvs-TWL soil	Valley Springs Formation-Tuolumne County Walker Lake Quad-soil	2	5.3	2.8		4.1	4.1	2.8	5.3	50
OMvs?	Valley Springs Fm., queried	0								

Unit Symbol	Unit Name	N	NURE U Data (ppm)	Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
OMvsw-C ssed	Valley Springs Fm., welded rhyolitic tuff-Calaveras County Sacramento Quad-stream sediment	1	2.0	2.0	2.0	2.0	2.0	0.0
pCC	Marine metasedimentary rock	0						
Pl	Laguna Fm.	0						
Pl?	Laguna Fm., queried	0						
Pzcm TSAC soil	Calaveras Complex, marble-Tuolumne County Sacramento Quad-soil	1	1.8	1.8	1.8	1.8	1.8	0.0
Pzm	Marine metasedimentary rock	0						
Pzsg-C-TSAC-all data	Shoo Fly Complex, gneiss-Calaveras and Tuolumne counties Sacramento Quad-all data	4	4.8 4.1 3.8 4.8	4.4	4.5	3.9	4.8	0.0
Pzsg-C ssed	Shoo Fly Complex, gneiss-Calaveras County Sacramento Quad-stream sediment	2	4.1 3.8	4.0	4.0	3.8	4.1	0.0
Pzsg-TSAC ssed	Shoo Fly Complex, gneiss-Tuolumne County Sacramento Quad-stream sediment	1	4.8	4.8	4.8	4.8	4.8	0.0
Pzsg-TSAC soil	Shoo Fly Complex, gneiss-Tuolumne County Sacramento Quad-soil	1	4.8	4.8	4.8	4.8	4.8	0.0
q	ankerite-talc schist and mariposite, quartz	0						
Qa-A-C-all data	alluvium-Amador and Calaveras counties-all data	8	6.2 2.0 1.7 3.7 1.9 1.6 2.0 1.8	2.6	2.0	1.7	3.3	12.5
Qa-A-C-all ssed	alluvium-Amador and Calaveras counties-all stream sediment	7	6.2 1.9 1.7 2.0 1.8 1.6 2.0	2.5	1.9	1.7	2.0	14.3
Qa-A ssed	alluvium-Amador County Sacramento Quad-stream sediment	4	6.2 1.9 1.6 2.0	2.9	2.0	1.7	5.2	25.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Qa-A soil	alluvium-Amador County Sacramento Quad-stream sediment	0								
Qa-C ssed	alluvium-Calaveras County Sacramento Quad-stream sediment	3	2.0	1.8	1.7	1.8	1.8	1.7	2.0	0.0
Qa-C soil	alluvium-Calaveras County Sacramento Quad-soil	1	3.7			3.7	3.7	3.7	3.7	0.0
Qa-TWL ssed	alluvium-Tuolumne County Walker Lake Quad-stream sediment	5	26.8 10.1	6.5 5.4	5.2	10.8	6.5	5.3	18.5	100.0
Qa-TWL soil	alluvium-Tuolumne County Walker Lake Quad-soil	0								
Qal	alluvium (also Qa)	0								
Qc	colluvium	0								
Qg-TWL-all data	glacial deposits-Tuolumne County Walker Lake Quad-all data	5	131.8 22.4	21.1 7.8	1.2	36.86	21.1	4.5	77.1	80.0
Qg-TWL ssed	glacial deposits-Tuolumne County Walker Lake Quad-stream sediment	3	131.8	24.1	22.4	59.4	24.1	22.4	131.8	100
Qg-TWL soil	glacial deposits-Tuolumne County Walker Lake Quad-soil	2	7.8	1.2		4.5	4.5	1.2	7.8	50
Qha-A ssed	Holocene alluvium-Amador County Sacramento Quad-stream sediment	1	2.1			2.1	2.1	2.1	2.1	0.0
Qls	landslide deposit	0								
Qm-C soil	Modesto Formation-Calaveras County Sacramento Quad-soil	1	2.8			2.8	2.8	2.8	2.8	0.0
Qm1	Modesto Fm. unit 1	0								
Qm2-A-all data	Modesto Fm. unit 2-Amador County Sacramento Quad-all data	2	2.6	2.1		2.35	2.35	2.1	2.6	0.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)	Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
Qm2-A ssed	Modesto Fm. unit 2-Amador County Sacramento Quad-stream sediment	1	2.6					
Qm2-A soil	Modesto Fm. unit 2-Amador County Sacramento Quad-soil	1	2.1	2.1	2.1	2.1	2.1	2.1
Qm2?	Modesto Fm. unit 2 queried	0						
Qr-C-all data	Riverbank Formation-Calaveras County Sacramento Quad-all data	2	4.4 3.0	3.7	3.7	3.0	4.4	0.0
Qr-C ssed	Riverbank Formation-Calaveras County Sacramento Quad-stream sediment	1	4.4	4.4	4.4	4.4	4.4	0.0
Qr-C soil	Riverbank Formation-Calaveras County Sacramento Quad-soil	1	3.0	3.0	3.0	3.0	3.0	0.0
Qr?	Riverbank Fm., queried	0						
Qr2	Riverbank Fm. unit 2	0						
Qr2?	Riverbank Fm. unit 2 queried	0						
Qr3	Riverbank Fm. unit 3	0						
Qr3?-A ssed	Riverbank Fm. unit 3 queried-Amador County Sacramento Quad-stream sediment	2	24.6 9.1	16.85	16.85	9.1	24.6	100.0
Qt	Terrace deposits	0						
Qtl?	Turlock Lake Fm., queried	0						
QTnm	North Merced Gravels	0						
QTnm?	North Merced Gravels, queried	0						
Qv	Quaternary volcanics undifferentiated	0						
sc	interbedded chert and slate	0						
sp-A-C-all data	Serpentinite-Amador and Calaveras counties Sacramento Quad-all data	5	2.5 1.0 0.6 2.0 0.8	1.4	1.0	0.7	2.3	0.0
sp-A soil	Serpentinite-Amador County Sacramento Quad-soil	1	0.8	0.8	0.8	0.8	0.8	0.0

Unit Symbol	Unit Name	N	NURE U Data (ppm)			Mean ppm	Median ppm	25%* ppm	75%* ppm	% ≥ 5.0 ppm
sp-C ssed	Serpentinite-Calaveras County Sacramento Quad-stream sediment	3	2.5	1.0	0.6	1.4	1.0	0.6	2.5	0.0
sp-C soil	Serpentinite-Calaveras County Sacramento Quad-soil	1	2.0			2.0	2.0	2.0	2.0	0.0
sp?	serpentinite queried	0								
t-A-C-all data	dredge or mine tailings-Amador and Calaveras counties Sacramento Quad-all data	3	2.3	2.0	1.4	1.9	2.0	1.4	2.3	0.0
t-A ssed	dredge or mine tailings-Amador County Sacramento Quad-stream sediment	2	2.3	2.0		2.2	2.2	2.0	2.3	0.0
t-C soil	dredge or mine tailings-Calaveras County Sacramento Quad-soil	1	1.4			1.4	1.4	1.4	1.4	0.0
Tg-A-TSAC-all data	Tertiary gravels (auriferous)-Amador and Tuolumne counties Sacramento Quad-all data	2	3.3	2.9		3.1	3.1	2.9	3.3	0.0
Tg-A soil	Tertiary gravels (auriferous)-Amador County Sacramento Quad-soil	1	2.9			2.9	2.9	2.9	2.9	0.0
Tg-TSAC ssed	Tertiary gravels (auriferous)-Tuolumne County Sacramento Quad-stream sediment	1	3.3			3.3	3.3	3.3	3.3	0.0
Tml	Table Mountain Latite	0								
Tvd	Tertiary volcanics, dacite	0								

*Quartile

Note: If a geologic unit does not have a listing for soil or stream sediment then there are no associated NURE soil or stream sediment samples for that unit in the NURE databases. In some cases, a geologic unit will have a soil or stream sediment listing with N = 0, meaning there were no such samples in the NURE databases. Such listings are included in the table where the author felt it would make the table easier to use.

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Appendix G Abbreviations:
A = Amador County NURE data in Sacramento 1X2 degree quadrangle
C = Calaveras County NURE data in Sacramento 1X2 degree quadrangle
TSAC = Tuolumne County NURE data in Sacramento 1X2 degree quadrangle
TMAR = Tuolumne County NURE data in Mariposa 1X2 degree quadrangle
TWL = Tuolumne County NURE data in Walker Lake 1X2 degree quadrangle
ppm = parts per million
ssed = stream sediment sample(s)

Appendix I

Mann-Whitney Rank Sum Test Statistical Comparison of NURE soil and stream-sediment uranium data spatially associated with geologic units by county and 1X2 degree quadrangle

Unit Symbol	Unit Name	County	1X2 Deg. Quadrangle	N Soil	N Sed.	Statistical Comparison
DOsf	Shoo Fly Fm.	Calaveras	Sacramento	15	13	NSD P=0.059
Jdpv	Don Pedro Terrane, greenschist	Calaveras	Sacramento	4	7	SD P=0.006 sed. med. higher
MPm	Mehrten Fm.	Calaveras	Sacramento	17	8	NSD P=0.090
MPm	Mehrten Fm.	Tuolumne	Sacramento	11	16	NSD P=0.159
MPm	Mehrten Fm.	Tuolumne	Walker Lake	18	82	NSD P=0.279
Mzg	granitic rocks, undifferentiated	Calaveras	Sacramento	11	7	NSD P=0.103
Mzg	granitic rocks, undifferentiated	Tuolumne	Sacramento	12	41	NSD P=0.774
Mzg	granitic rocks, undifferentiated	Tuolumne	Walker Lake	36	285	SD P=0.001 sed. med. higher
MzPzcc	Calaveras Complex, undifferentiated	Amador	Sacramento	18	14	SD P=0.007 soil med. higher
MzPzcc	Calaveras Complex, undifferentiated	Calaveras	Sacramento	13	17	NSD P=0.110
OMvs	Valley Springs Formation	Calaveras	Sacramento	16	8	SD P=0.005 soil med. higher

Abbreviations: SD=significant statistical difference between populations; NSD= no significant statistical difference between populations; sed.= stream sediment; med.=median value; P= p-value statistic (A p-value above 0.05 indicates there is not enough evidence to conclude the population means are the same at the 0.05 significance level.)

APPENDIX J

NURE Airborne Equivalent Uranium (eU) Measurements for Geologic Units in Amador, Calaveras and Tuolumne counties, by 1x2 degree Quadrangle

San Jose 1X2 degree quadrangle data are shaded gray—data unreliable/excessively high (see discussion in Airborne Radiometric Section). Under Geologic Unit Reference, (S) = Sacramento 1x2 degree quadrangle; (SJ) = San Jose 1X2 degree quadrangle; (M) = Mariposa 1X2 degree quadrangle; and (WL) = Walker Lake 1X2 degree quadrangle

Geologic Unit Reference	Geologic Unit Name	N	N ≥ 5.0 ppm eU	% ≥ 5.0 ppm eU	Low ppm eU	High ppm eU	Median ppm eU
af	artificial fill	0					
am (S)	amphibole schist	27	0	0	0.8	4.9	2.4
db (S)	diabase and porphyrite	23	0	0	0.4	4.9	2.2
DOsf (S)	Shoo Fly Complex	3472	368	10.6	0.2	13.5	3.2
DOsf (SJ)	Shoo Fly Complex	1041	475	45.6	0.4	44.1	4.8
DOsf (M)	Shoo Fly Complex	238	13	5.5	0.7	9.2	2.9
Ei (S)	Ione Fm.	590	81	13.7	1.0	9.5	3.4
Ei?	Ione Fm. queried	0					
f	felsite dikes	0					
fp (S)	feldspar porphyry	8	0	0	1.3	2.6	2.1
fp? (S)	feldspar porphyry queried	3	0	0	1.9	2.9	2.2
gb (S)	gabbro	94	0	0	0.1	4.9	1.9
gb (SJ)	gabbro	43	18	41.9	0.3	8.2	4.5
gbd (S)	gabbro-diorite	7	1	14.3	3.2	5.0	3.3
gd (S)	quartz monzonite	2	0	0	2.1	2.1	2.1
gs	greenstone	0					
ha	hornblende andesite	0					
Jch (S)	Copper Hill Volcanics	1004	6	0.06	<0.5	5.5	1.9
Jch (SJ)	Copper Hill Volcanics	363	76	20.9	<0.9	9.9	3.6
Jch?	Copper Hill Volcanics queried	0					
Jcha (S)	Copper Hill Volcanics, amphibolite	264	2	0.76	0.2	6.0	2.0
Jchb (S)	Copper Hill Volcanics, thick bedded volcanic breccia	17	0	0	0.6	3.0	1.9
Jchf (S)	Copper Hill Volcanics, felsic dikes	25	0	0	0.5	2.6	1.3
Jchl (S)	Copper Hill Volcanics, amygdaloidal mafic lava	44	0	0	0.6	3.5	1.95
Jchqp (S)	Copper Hill Volcanics, quartz porphyry	73	1	1.37	0.4	5.3	2.2
Jvc	Copper Hill Volcanics	0					
Jdp (S)	Don Pedro Terrane, phyllite and schist of Clark	667	18	2.7	0.5	6.3	2.8
Jdpt	Don Pedro Terrane, talc schist of Clark	0					

Geologic Unit Reference	Geologic Unit Name	N	N ≥ 5.0 ppm eU	% ≥ 5.0 ppm eU	Low ppm eU	High ppm eU	Median ppm eU
Jdpv (S)	Don Pedro Terrane, greenschist (metavolcanic) of Clark	651	4	0.61	0.4	7.1	2.5
Jga	quartz andesite plug	0					
Jgo (S)	Gopher Ridge Fm. undifferentiated	963	27	2.8	0.3	7.3	2.6
Jgo (SJ)	Gopher Ridge Fm.	1936	1187	61.3	<1.2	17.3	5.5
Jgoa (S)	Gopher Ridge Fm., amphibolite facies	74	1	1.4	0.1	5.1	1.8
Jgof	Gopher Ridge Fm., feldspar porphyry?	0					
Jgoqp (S)	Gopher Ridge Fm., quartz porphyry	53	1	1.9	0.9	5.0	2.9
Jgoqp (SJ)	Gopher Ridge Fm., quartz porphyry	237	105	44.3	<0.1	18.5	4.7
Jlr (S)	Logtown Ridge Fm.	585	15	2.6	0.4	5.8	2.2
Jlr (SJ)	Logtown Ridge Fm.	2	2	100	6.9	7.1	7.0
Jvl	Logtown Ridge Fm.	0					
Jm (S)	Mariposa Fm.	717	21	2.9	0.2	7.3	2.8
Jm (SJ)	Mariposa Fm.	26	7	26.9	0.1	10.2	2.1
Jmb (S)	metavolcanic unit, possibly Mariposa Fm., Brower Creek Member	463	22	4.8	0.0	9.4	2.5
Jpb (SJ)	Penon Blanco Volcanics	71	42	59.2	0.4	16.2	5.6
Jvp	Penon Blanco Volcanics	0					
Jsg (SJ)	Sullivan Creek Terrane, greenschist belt	344	172	50.0	0.4	13.2	4.95
Jsp (S)	Sullivan Creek terrane, phyllite belt	12	0	0	1.4	3.4	2.25
Jsp (SJ)	Sullivan Creek terrane, phyllite belt	550	303	55.1	<0.2	14.7	5.3
Jss (S)	Salt Springs Slate (with some Mariposa Fm.)	845	54	6.4	0.1	8.6	3.0
Jss (SJ)	Salt Springs Slate (with some Mariposa Fm.)	1114	676	60.7	0.0	18.1	5.8
Jss?	Salt Springs Slate (with some Mariposa Fm.)	0					
JTrj (SJ)	Jasper Point Fm., undifferentiated	69	39	56.5	1.5	10.6	5.2
JTrjc (SJ)	Jasper Point Fm., metachert	2	2	100	6.5	7.4	6.95
JTrsb (S)	Part of Calaveras Complex? East of Don Pedro Terrane (Jdp)	7	1	14.3	1.7	5.3	3.3
Jv (SJ)	metavolcanic rocks (undifferentiated)	92	73	79.3	2.1	12.1	6.2

Geologic Unit Reference	Geologic Unit Name	N	N ≥ 5.0 ppm eU	% ≥ 5.0 ppm eU	Low ppm eU	High ppm eU	Median ppm eU
Jvc (SJ)	Copper Hill Fm.	164	144	87.8	2.7	13.7	7.15
Jvp (SJ)	Penon Blanco Fm.	342	145	42.4	0.4	13.7	4.6
Jvr (SJ)	Metarhyolite	16	12	75.0	3.1	9.8	6.95
Kc? (All)	Chico Fm., queried	40	4	10.0	0.0	6.6	3.70
Kc? (S)	Chico Fm., queried	32	4	12.5	2.8	6.6	3.95
Kc? (SJ)	Chico Fm., queried	8	0	0	0.0	1.9	1.0
ls (S)	limestone or marble	47	2	4.3	1.6	5.4	2.5
ls? (S)	limestone or marble, queried	1	0	0	4.9	4.9	4.9
Md	diatomite	0					
Mev (S)	Eureka Valley Tuff	12	0	0	1.5	3.9	2.3
MPm	Mehrten Fm.						
MPm (S)	Mehrten Fm.	4924	221	4.5	0.5	10.5	2.7
MPm (SJ)	Mehrten Fm.	266	92	34.6	<1.6	19.6	3.85
MPm (M)	Mehrten Fm.	14	0	0	0.9	3.2	2.45
MPm (WL)	Mehrten Fm.	1837	172	9.4	<0.1	9.6	2.5
ms (S)	metasedimentary rocks	571	20	3.5	0.1	7.5	2.6
ms (SJ)	metasedimentary rocks	95	68	71.6	0.8	14.8	5.6
ms? (S)	metasedimentary rocks, queried	3	0	0	1.9	2.6	2.4
Mtm (S)	Table Mountain Latite	14	13	92.9	4.8	11.5	8.0
Mtm (SJ)	Table Mountain Latite	27	20	74.1	3.1	8.6	6.0
mv (All)	metavolcanic rocks (includes some metasedimentary rocks)						
mv (S)	metavolcanic rocks (includes some metasedimentary rocks)	396	6	1.5	0.2	6.0	2.5
mv (SJ)	metavolcanic rocks (includes some metasedimentary rocks)	47	0	0	0.0	3.7	0.5
Mzd (S)	diorite	453	28	6.2	0.3	7.6	3.0
Mzd (SJ)	diorite	22	0	0	0.2	4.0	1.95
Mzg (S)	granitic rocks, undifferentiated	5259	232	4.4	0.0	8.9	2.8
Mzg (SJ)	granitic rocks, undifferentiated	1281	561	43.8	0.0	18.1	4.6
Mzg (M)	granitic rocks, undifferentiated	1836	23	1.3	0.3	11.7	2.4
Mzg (WL)	granitic rocks, undifferentiated	4706	490	10.4	0.0	9.7	2.9
Mzm	marine metasedimentary rocks (one polygon)	0					

Geologic Unit Reference	Geologic Unit Name	N	N ≥ 5.0 ppm eU	% ≥ 5.0 ppm eU	Low ppm eU	High ppm eU	Median ppm eU
Mzpm (S)	mafic plutonic rocks, undifferentiated (diorite to gabbro; locally pyroxenite and hornblendite)	454	6	1.3	0.4	6.9	2.2
Mzpm (SJ)	mafic plutonic rocks, undifferentiated (diorite to gabbro; locally pyroxenite and hornblendite)	631	249	39.5	<0.1	15.5	4.3
Mzpm (M)	mafic plutonic rocks, undifferentiated (diorite to gabbro; locally pyroxenite and hornblendite)	41	0	0	0.6	4.2	2.3
Mzpm (WL)	mafic plutonic rocks, undifferentiated (diorite to gabbro; locally pyroxenite and hornblendite)	19	1	5.3	<0.3	5.2	3.5
MzPzcc (S)	Calaveras Complex, undifferentiated	4941	192	3.9	<0.1	8.9	2.9
MzPzcc (SJ)	Calaveras Complex, undifferentiated	1521	881	57.9	0.0	69.7	5.6
MzPzcc (M)	Calaveras Complex, undifferentiated	53	0	0	0.9	4.5	2.5
MzPzcls (S)	Calaveras Complex, limestone	98	27	27.6	2.0	9.4	3.8
MzPzct (S)	Calaveras Complex, talc schist	9	0	0	1.5	3.8	2.7
MzPzv (S)	Calaveras Complex, volcanics	23	2	8.7	2.1	5.6	3.3
OMvs (S)	Valley Springs Fm.	1291	308	23.9	0.7	9.6	4.0
OMvs (WL)	Valley Springs Fm.	70	2	2.9	0.2	6.1	2.6
OMvs?	Valley Springs Fm., queried	0					
OMvsw (S)	Valley Springs Fm., welded rhyolitic tuff	14	1	7.1	1.6	6.1	3.45
pCC (WL)	marine metasedimentary rock	66	9	13.6	1.7	6.8	3.7
Pl (S)	Laguna Fm.	81	5	6.2	1.1	5.9	3.2
Pl? (S)	Laguna Fm., queried	5	0	0	0.9	3.0	2.3
Pzcm (S)	Calaveras Complex, marble	124	5	4.0	0.9	6.4	3.05
Pzcm (SJ)	Calaveras Complex, marble	29	14	48.3	2.0	7.5	4.9
Pzm	marine metasedimentary rock	0					
Pzsg (S)	Shoo Fly Complex, gneiss	263	69	26.4	0.9	11.3	4.0

Geologic Unit Reference	Geologic Unit Name	N	N ≥ 5.0 ppm eU	% ≥ 5.0 ppm eU	Low ppm eU	High ppm eU	Median ppm eU
q (SJ)	ankerite-talc schist and mariposite, quartz	2	0		3.2	3.6	3.4
Qa (S)	alluvium	125	23	18.4	1.0	7.4	3.7
Qa (SJ)	alluvium	13	13	100.0	7.4	12.1	9.8
Qa (WL)	alluvium	32	1	3.1	0.5	5.2	2.95
Qa?	alluvium, queried	0					
Qal	alluvium	0					
Qc (S)	colluvium	41	0	0	0.8	3.8	2.1
Qg (WL)	glacial deposits	0					
Qha (S)	Holocene alluvium	0					
Ql (SJ)	landslide deposits	4	3	75.0	4.2	7.0	5.9
Qls	landslide deposits	0					
Qm (S)	Modesto Fm.	62	17	27.4	2.5	6.7	4.2
Qm1	Modesto Fm. unit 1	0					
Qm2 (S)	Modesto Fm. unit 2	172	2	1.2	1.1	5.3	2.9
Qm2 (SJ)	Modesto Fm. unit 2	9	0	0	0.6	1.8	1.2
Qm2? (S)	Modesto Fm. unit 2, queried	2	0	0	3.2	3.5	3.35
Qr	Riverbank Fm.	0					
Qr? (S)	Riverbank Fm., queried	20	1	5.0	1.3	5.4	3.0
Qr2 (SJ)	Riverbank Fm. unit 2	14	0	0	1.1	4.7	1.65
Qr2? (S)	Riverbank Fm. unit 2, queried	3	0	0	2.8	4.5	3.4
Qr3 (S)	Riverbank Fm. unit 3	31	0	0	1.5	4.6	3.1
Qr3? (S)	Riverbank Fm. unit 3 queried	40	7	17.5	2.2	7.7	3.35
Qt	terrace deposits	0					
Qtl?	Turlock Lake Fm. queried	0					
QTnm (S)	North Merced Gravels	12	1	8.3	1.0	5.3	2.9
QTnm? (S)	North Merced Gravels, queried	26	2	7.7	1.5	5.3	3.1
Qv	Quaternary volcanics, undifferentiated	10	0	0	2.7	4.9	3.35
sc	interbedded chert and slate	14	0	0	0.5	3.5	1.85
sp (S)	serpentinite	361	0	0	0.0	4.8	1.8
sp (SJ)	serpentinite	656	437	66.6	0.1	18.8	5.9
sp?	serpentinite, queried	0					
t (S)	dredge or mine tailings	70	1	1.4	0.4	5.0	2.8
t (SJ)	dredge or mine tailings	174	16	9.2	4.4	10.7	8.2
Tg (S)	Tertiary gravels (auriferous)	84	15	17.9	1.7	7.9	3.4
Tml (S)	Table Mountain Latite	52	14	26.9	1.5	7.7	3.6
Tml (SJ)	Table Mountain Latite	69	63	65.6	2.2	17.9	8.5
Tvd	Tertiary volcanics, dacite	0					

APPENDIX K

County NRCS Soil Units and Indoor-Radon Measurements*

Permeability (saturated hydraulic conductivity class) abbreviations: VR = very rapid; R = rapid; MR = moderately rapid; M = moderate; MS = moderately slow; S = slow; and VS = very slow or impermeable

Shrink-Swell (SH-SW) abbreviations: S = severe; M = moderate; and L = low

AMADOR COUNTY										
Soil Unit	**Soil Unit Name**	**Permeability by Soil Sub-unit** (unit thickness)	**Hydrologic Soil Group**	**Soil Characteristics and Parent Material** (geologic map unit symbol)	**SH-SW**	**Depth[1] to Bed Rock** (inches)	**N**	**N ≥ 4.0 pCi/L**	**% N ≥ 4.0 pCi/L**	**Median**	**Indoor-Radon Data pCi/L**
AaC2	Ahawahnee loam, 9-16 percent slopes	M (28”) VS to S (5”+)	B	≈ 3 feet loam on Paralithic bedrock = strongly weathered, moderately cemented granitic rock (**Mzg**)	L --	20-40	1	0	0	1.9	1.9
AhB	Aiken loam, 3-9 percent slopes	M (24”) MS (15”) M (55”)	B	≈ 8 feet cobbly loam, cobbly clay loam and cobbly clay over deeply weathered volcanic conglomerate (**MPm*^, MzPzcc**)	L M L	92+	3	0	0	2.1	3.6 2.1 1.4
AhC	Aiken loam, 9-16 percent slopes	M (24”) MS (15”) M (55”)	B	≈ 8 feet cobbly loam, cobbly clay loam and cobbly clay over deeply weathered volcanic conglomerate (**DOsf^, MPm*, Mzg**)	L M L	92+	6	0	0	1.75	2.3 2.0 1.9 1.6 1.3 1.1
AkC	Aiken cobbly loam, 3-16 percent slopes	M (24”) MS (15”) M (55”)	B	≈ 8 feet cobbly loam, cobbly clay loam and cobbly clay over deeply weathered volcanic conglomerate (**MPm**)	L M L	92+	4	1	25	3.0	29.4 3.7 2.3 1.9

Soil Unit	**Soil Unit Name**	**Permeability by Soil Sub-unit** (unit thickness)	**Hydrologic Soil Group**	**Soil Characteristics and Parent Material** (geologic map unit symbol)	**SH-SW**	**Depth[1] to Bed Rock** (inches)	**N**	**N ≥ 4.0 pCi/L**	**% N ≥ 4.0 pCi/L**	**Median**	**Indoor-Radon Data pCi/L**
AkD	Aiken cobbly loam, 16-31 percent slopes	M (24”) MS (15”) M (55”)	B	≈ 8 feet cobbly loam, cobbly clay loam and cobbly clay over deeply weathered volcanic conglomerate (**MPm**)	L M L	92+	1	0	0	1.4	1.4
AmE	Aiken very rocky loam, 16-51 percent slopes	M (24”) MS (15”) M (55”)	B	≈ 8 feet cobbly loam, cobbly clay loam and cobbly clay over deeply weathered volcanic conglomerate (**DOsf*^, gb, Mzg^**)	L M L	92+	13	3	23.1	1.7	6.0 4.8 4.4 3.5 3.2 2.3 1.7 0.9 0.7 0.7 0.6 0.6 0.6
AoD	Argonaut very rocky loam, 3-31 percent slopes	M (2”) M (4”) MS (4”) VS (11”) VS (6”+)	D	≈ 8 feet gravelly heavy loam and clay over Paralithic bedrock = deeply weathered, moderately cemented meta-andesite (**Jlr**)	L L M H --	18-30	1	0	0	1.2	1.2
ApD	Auburn silt loam, 0-31 percent slopes	M (14”) VS (4”+)	C	≈ 2 feet of silt loam and heavy silt loam over Paralithic bedrock = partly weathered, very strongly cemented metabasic rock (**Jch)**	L --	10-28	1	0	0	0.8	0.8
AsD	Auburn very rocky silt loam, 3-31 percent slopes	M (14”) VS (4”+)	C	≈ 2 feet of silt loam and heavy silt loam over Paralithic bedrock = partly weathered, very strongly cemented metabasic rock (**Jm*^, Jmb*^**)	L --	10-28	7	0	0	0.9	2.1 2.1 2.0 0.9 0.7 0.6 0.6

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Soil Characteristics and Parent Material (geologic map unit symbol)	SH-SW	Depth[1] to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
AsE	Auburn very rocky silt loam, 31-51 percent slopes	M (14”) VS (4”+)	C	≈ 2 feet of silt loam and heavy silt loam over Paralithic bedrock = partly weathered, very strongly cemented metabasic rock **(Jlr)**	L --	10-28	1	1	100	16.7	16.7
AxD	Auburn	M (14”) VS to S (4”+)	D	Very rocky silt loam Lithic bedrock = strongly cemented (J**mb**)	L --	10-28	1	0	0	0.7	0.7
	Argonaut very rocky silt loams, 3-31 percent slopes	M (6”) MS (4”) VS (11”) VS (4”+)	D	Very rock silt loam Paralithic bedrock = moderately cemented (**Jmb**)	L M L --	18-30					
CbE	Cohasset very cobbly loam, 16-51 percent slopes	M (8”) M (40”) VS (4”+)	B	≈ 1 foot of cobbly loam and 2 feet of clay loam over Paralithic bedrock = ≈ 4 feet of weathered, moderately cemented andesitic conglomerate (**MPm**)	L M --	40-72	7	0	0	1.5	3.6 2.0 1.6 1.5 1.4 0.7 0.6
CcE	Cohasset very cobbly loam, moderately deep, 16-51 percent slopes	M (10”) M (20”) VS to S (4”+)	B	≈ 1 foot of cobbly loam and 2 feet of clay loam over Paralithic bedrock = ≈ 4 feet of weathered, moderately cemented andesitic conglomerate (**MPm**)	L M --	24-40	1	0	0	2.4	2.4
EcE	Exchequer very rocky silt loam, 31-51 percent slopes	M (6”) VS to S (4”+)	D	≈ 1 foot of silt loam over Lithic bedrock = very strongly cemented metabasic rock (**Jlr*^, Jm**)	L --	4-20	4	0	0	1.2	2.1 1.5 0.9 0.7

Soil Unit	**Soil Unit Name**	**Permeability by Soil Sub-unit** (unit thickness)	**Hydrologic Soil Group**	**Soil Characteristics and Parent Material** (geologic map unit symbol)	**SH-SW**	**Depth[1] to Bed Rock** (inches)	**N**	**N ≥ 4.0 pCi/L**	**% N ≥ 4.0 pCi/L**	**Median**	**Indoor-Radon Data pCi/L**
EhD	Exchequer	M (6") VS to MS (4")	D	Loam Lithic bedrock = very strongly cemented metabasic rock and weathered metabasic rock (**Jlr)**	L --	4-20	1	0	0	2.8	2.8
	Auburn loams, 3-31 percent slopes	M (14") VS (4"+)	D	Loam Lithic bedrock = very strongly cemented metabasic rock and weathered metabasic rock (**Jlr**)	L --	10-28					
ExD	Exchequer	M (6") VS to MS (4")	D	Very rocky loam Lithic bedrock = very strongly cemented metabasic rock and weathered metabasic rock (**Jm^, Jmb***)	L --	4-20	4	1	25	1.75	6.7 2.2 1.3 0.5
	Auburn very rocky loams, 2-31 percent slopes	M (14") VS (4"+)	D	Very rocky loam Lithic bedrock = very strongly cemented metabasic rock and weathered metabasic rock (**Jm^, Jmb***)	L --	10-28					
FdC	Fiddletown gravelly loam, 9-16 percent	M (45") VS to S (4"+)	A	≈ 3 feet of gravelly loam over Paralithic bedrock = weathered and fractured schist and slate (**MzPzcc**)	Low --	20-45	1	0	0	1.1	1.1

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Soil Characteristics and Parent Material (geologic map unit symbol)	SH-SW	Depth[1] to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
HcD	Holland coarse sandy loam, 5-9 percent slopes	MR (10") M (12") M (16") MS (6"+)	C	≈ 1 foot coarse sandy loam, 1 foot heavy coarse sandy loam, 2 feet coarse sandy loam, and 1.5 feet light coarse sandy clay loam over Paralithic bedrock = weakly cemented weathered granitic rock (**MPm**)	L M L --	20-40	1	0	0	1.9	1.9
HdD	Holland coarse sandy loam, 9-16 percent slopes	MR (10") M (12") M (16") MS (6"+)	B	≈ 1 foot coarse sandy loam, 1 foot heavy coarse sandy loam, 2 feet coarse sandy loam, and 1.5 feet light coarse sandy clay loam over Paralithic bedrock = weakly cemented weathered granitic rock (**MPm**)	L M L --	60	1	0	0	0.7	0.7
HfD	Holland very rocky coarse sandy loam, 9-16 percent slopes	MR (10") M (12") M (16") MS (4"+)	C	Very rocky coarse sandy loam Paralithic bedrock = weakly cemented weathered granitic rock (**Mzg**)	L L M --	20-40	1	1	100	40.4	40.4
HfE	Holland very rocky coarse sandy loam, 16-51 Percent slopes	MR (10") M (12") M (16") MS (4"+)	C	Very rocky coarse sandy loam Paralithic bedrock = weakly cemented weathered granitic rock (**Mzg**)	L L M --	20-40	1	0	0	1.8	1.8
Ho	Honcut very fine sandy loam	M (27") S (33")	C	≈ 2.5 feet very fine sandy loam over 3 feet or more of silt loam; soils consist of stratified alluvium (**Qm2**)	L L	> 60	3	1	33.3	2.9	4.0 2.9 2.6

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Soil Characteristics and Parent Material (geologic map unit symbol)	SH-SW	Depth[1] to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
IrE	Inks loam, 3-45 percent slopes and Rock land	M (10") M (5") MS (4+)	D	≈ 1 foot loam, over 0.5 foot heavy loam over Lithic bedrock = strongly cemented hard andesitic sandstone (**MPm^, OMvs***)	L L --	10 to 20	3	1	33.3	2.3	4.7 2.4 2.3
IsE	Iron Mountain very stony loam 9-15 percent slopes and Rock land	M (20")	D	≈ 2 feet very stony loam over Lithic bedrock = hard, strongly cemented tuffaceous breccia (**MPm**)	L	20-25	1	0	0	0	0.1
JmD	Josephine loam, 16-61 percent slopes	M (9") MS (28") MS (10") VS (4")	C	≈ 1 foot gravelly loam over 3 feet silty clay loam over Paralithic bedrock = moderately cemented decomposed schist (**MzPzcc**)	L M M --	30-60	1	0	0	2.6	2.6
JoE	Josephine very rocky loam, 16-51 percent slopes Rock outcrop	M (9") MS (28") MS (10") VS (4")	C	Very rocky loam Paralithic bedrock = moderately cemented decomposed schist (**MzPzcc**)	L M L --	20-60	4	1	25	2.85	6.0 3.5 2.2 1.0

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Soil Characteristics and Parent Material (geologic map unit symbol)	SH-SW	Depth[1] to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
JpE	Josephine very rocky loam, 16-51 percent slopes Rock outcrop	M (9") MS (28") MS (10") VS (4")	C	Very rocky loam Paralithic bedrock = moderately cemented decomposed schist (**DOsf*, MzPzcc^**)	L M L --	20-60	2	1	50	4.75	6.1 3.4
JxE	<u>Josephine</u>-Mariposa complex, 16-61 percent slopes Mariposa Rock outcrop	M (9") MS (28") MS (10") VS (4") M (4") M (19") VS (4")	C C	Very rocky loam Paralithic bedrock = moderately cemented decomposed schist (**MPm**) Very rocky loam Lithic bedrock = strongly cemented decomposed schist (**MPm**)	L M L -- L L --	20-60 12-35	2	0	0	2.4	2.7 2.1
Lo	Loamy alluvial land	M (10") M (20") M (30")	A	Small areas of recent alluvial deposits adjacent to stream channels; subject to flooding; soil material similar to Honcut soils (**MzPzcc**)	L L L	--	1	1	100	6.1	6.1
McD	Mariposa very rocky loam, 9-31 percent slopes Rock outcrop	M (4") M (19") VS (4")	C	≈ 2 feet silt loam over Lithic bedrock = strongly cemented decomposed schist (**DOsf*, MzPzcc^**)	L L --	12-35	4	0	0	1.2	1.8 1.2 1.2 0.5

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Soil Characteristics and Parent Material (geologic map unit symbol)	SH-SW	Depth[1] to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
McE	Mariposa very rocky loam, 31-51 percent slopes Rock outcrop	M (4”) M (19”) VS (4”) -- 	C -- 	Very rocky loam Lithic bedrock = strongly cemented decomposed schist (**MzPzcc**)	L L --	12-35	3	1	33.3	2.1	38.8 2.1 2.0
MdE	<u>Mariposa</u>-Maymen complex, 16-51 percent slopes Maymen Rock outcrop	M (4”) M (19”) VS (4”) M (7”) VS to S (4”)	C D	≈ 2 feet silt loam over Lithic bedrock = very strongly cemented decomposed schist (**MzPzcc**) ≈ 1 foot rocky loam over Lithic bedrock = very strongly cemented tilted slate (**MzPzcc**)	L L -- L	12-35 7-20	1	0	0	0.5	0.5
Mn	Mine tailings and Riverwash	-- R (6”) R (54”)	-- D	Very stony and cobbly material in beds of rivers and creeks in areas that have been placer mined, and in mine dumps, subject to flooding in periods of high water (**MzPzcc**)	-- L L		1	0	0	2.9	2.9
Mo	Mixed alluvial land	R (10”) R (50”)	A	Unclassified alluvial soils from mixed sources in narrow stringers adjacent to stream channels; soil material is highly stratified and variable throughout (**Jlr^, Mzg, MzPzcc***)	L L		3	1	33.3	1.3	12.5 1.3 0.7

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Soil Characteristics and Parent Material (geologic map unit symbol)	SH-SW	Depth[1] to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
Mt	Mokelumne soils and	MR (13”) VS (9”) VS (17”) MR (13”) VS to S (4”)	D	≈ 1 foot sandy loam over 1 foot sandy clay over 2 feet coarse sandy clay loam over Paralithic bedrock = moderately cemented old sandstone or clayey marine deposits (**Qm2**)	L M M L --	50-60 --	1	0	0	3.0	3.0
	Alluvial land	MR (10”) MR (20”) MR (30”)	A	Sandy loam Sandy clay loam to clay loam (**Qm2**)	L	--					
MvC	Musick very rocky sandy loam, 9-16 percent slopes	M (14”) M (9”) MS (24”) MS (50”)	C	≈ 2 feet sandy loam and heavy loam over 2 feet heavy clayey loam over 4 feet fine sandy loam over weathered granitic rock (**Mzg**)	L L L L	97+	4	1	25	2.95	4.4 4.2 1.7 1.4
MvE	Musick very rocky sandy loam, 16-61 percent slopes Rock outcrop	MR (14”) M (9”) M (24”) MR (50”)	B	Very rocky sandy loam (**MPm**)	L L M L	--	1	0	0	1.9	1.9
MwE	Musick very rocky sandy loam, moderately deep, 16-51 percent slopes Rock outcrop	MR (11”) MS (29”) MS (10”)	C	Very rocky sandy loam Paralithic bedrock = moderately cemented (**MzPzcc**)	L M	30-50	1	0	0	3.3	3.3

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Soil Characteristics and Parent Material (geologic map unit symbol)	SH-SW	Depth[1] to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
PoE	Pentz sandy loam, very shallow, 2-51 percent slopes	MR (5”) MR (3”) VS (4”)	D	≈ 1.5 feet of sandy loam over Paralithic bedrock = hard, moderately cemented volcanic tuff (horizontally bedded volcanic rock outcrops are common) (**MPm**)	L L --	8-20	1	0	0	1.3	1.3
Pw	Placer diggings	R (10”) R (50”)	A	Stony, cobbly, and gravelly material in beds of streams and creeks and fines from stamp mills or placer diggings that have settled behind debris dams; subject to frequent flooding (**Mzg**)	L L	--	1	1	100	10.2	10.2
	Riverwash	R (6”) R (54”)	D		L L						
RbB	Red Bluff	M (7”) M (4”) MS (29”)	D	Gravelly loam Cemented horizon, indurated, 11-50” (**Ei**)	L L M	11-50	2	1	50	2.45	4.0 0.9
	Mokelumne complex, 0-5 percent slopes	MR (10”) VS (29”) VS (7”)	D	Gravelly sandy loam Paralithic bedrock, moderately cemented (**Ei**)	L M --	39-60					

Soil Unit	**Soil Unit Name**	**Permeability by Soil Sub-unit** (unit thickness)	**Hydrologic Soil Group**	**Soil Characteristics and Parent Material** (geologic map unit symbol)	**SH-SW**	**Depth[1] to Bed Rock** (inches)	**N**	**N ≥ 4.0 pCi/L**	**% N ≥ 4.0 pCi/L**	**Median**	**Indoor-Radon Data pCi/L**
RbD	Red bluff Mokelumne complex, 5-16 percent slopes	M (7”) M (4”) MS (29”) MR (10”) VS (29”) VS (7”)	D D	Gravelly loam Cemented horizon, indurated, 11-60” **(Ei)** Gravelly sandy loam Paralithic bedrock, moderately cemented **(Ei)**	L L M L M --	11-60 39-60	7	1	14.3	2.1	4.4 3.0 2.7 2.1 2.0 1.6 0.9
Ro	Rock land	VS (60”)	D	Lithic bedrock, indurated, extremely rocky, stony, cobbly land on uplands; bedrock is granodiorite, andesite, conglomeratic, breccia and metamorphosed sedimentary and basic rocks; rock outcrops cover from 40 to 90 percent of the surface; material is excessively drained; runoff is rapid (**MzPzcc**)	--	0	1	0	0	2.3	2.3
Sa	Sedimentary rock land	VS (60”)	D	Paralithic bedrock, moderately cemented. A thin mantle of mixed gravelly soil and exposed sandstone and clay of the Ione Formation (**Ei**)	--	0	1	0	0	2.2	2.2
SgC	Sierra coarse sandy loam, 9-16 percent slopes	M (6”) MS (18”) MS (42”) Moderately slow (12”)	C	≈ 1 foot of coarse sandy loam over 4 feet of clay loam over Paralithic bedrock, moderately cemented deeply weathered granitic rock (**gd**)	L M L --	30-70	1	0	0	1.0	1.0

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Soil Characteristics and Parent Material (geologic map unit symbol)	SH-SW	Depth[1] to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
SkD	Sierra very rocky coarse sandy loam, 16-31 percent slopes	M (10”) MS (30”) MS(20”) MS (4”)	C	≈ 1 foot of coarse sandy loam over 4 feet of clay loam over Paralithic bedrock, moderately cemented deeply weathered granitic rock (**Mzg**)	L M L --	30-70	1	1	100	11.5	11.5
SnC	Sites loam, 9-16 percent slopes	M (15”) M (20”) MS (32”) MR (5) VS (5”)	C	≈ 1 foot of loam over 4 feet of gravelly clay over Paralithic bedrock, moderately cemented weathered slate and schist (**DOsf**)	L M M M --	30-80	1	1	100	5.7	5.7
SnE	Sites loam, 31-51 percent slopes	M (15”) M (20”) MS (32”) MR (5) VS (5”)	C	≈ 1 foot of loam over 4 feet of gravelly clay over Paralithic bedrock, moderately cemented weathered slate and schist (**MzPzcc**)	L M M M --	30-80	1	0	0	2.8	2.8
SoD	Sites loam, moderately deep, 16-31 percent slopes	M (10”) M (11”) MS (14”) MS (5”) VS (4”)	C	Loam over silty clay loam or clay Paralithic bedrock, moderately cemented (**MzPzcc**)	L M M M --	25-50	1	0	0	0.9	0.9
SoE	Sites loam, moderately deep, 31-51 percent slopes	M (10”) M (11”) MS (14”) MR (5”) VS (4”)	C	Loam over silty clay loam or clay Paralithic bedrock, moderately cemented **(MzPzcc**)	L M M M --	25-50	2	1	50	3.75	4.8 2.7

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Soil Characteristics and Parent Material (geologic map unit symbol)	SH-SW	Depth[1] to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
SrC	Sites very rocky loam, 3-16 percent slopes Rock outcrop	M (15”) M (20”) MS (32”) MR (5”) VS (4”)	C	Very rocky loam Paralithic bedrock, moderately cemented **(MzPzcc**)	L L M M --	30-80	3	1	33.3	1.8	4.7 1.8 1.5
SrE	Sites very rocky loam, 16-51 percent slopes Rock outcrop	M (15”) M (20”) MS (32”) MR (5”) VS (4”)	C	Very rocky loam to silt loam Paralithic bedrock, moderately cemented (**DOsf*, MzPzcc^**)	L L M M -- --	30-80	2	1	50	4.4	5.9 2.9
StE	Sites-Mariposa complex, 16-51 percent slopes Mariposa	M (15”) MS (8”) MS (14”) MS (5”) VS (10”) M (4”) M (19”) VS (4”)	C C	Very rocky loam Paralithic bedrock, moderately cemented (**Mzg^, MzPzcc***) Very rocky loam Lithic bedrock, very strongly cemented (**Mzg^, MzPzcc***)	L L M L -- L L --	20-40 12-35	5	1	20	1.9	7.5 3.0 1.9 1.1 0.2
W	Water	Test location mapped as within a water area on the 1960s NRCS soil map					1	0	0	2.9	2.9
	Amador County Radon Data Totals						126	24	19.0		

CALAVERAS COUNTY-NRCS CA731 Stanislaus National Forest Parts											
Soil Unit	**Soil Unit Name**	**Permeability by Soil Sub-unit** (unit thickness)	**Hydrologic Soil Group**	**Parent Material** (geologic map unit symbol)	**SH-SW**	**Depth to Bed Rock** (inches)	**N**	**N ≥ 4.0 pCi/L**	**% N ≥ 4.0 pCi/L**	**Median**	**Indoor-Radon Data pCi/L**
112	Fiddletown family, moderately deep Ovall family	MR (30”) VS to S (30”) MR (33”) VS to S (10”)	B B	Parent material = residuum weathered from granitic rocks Paralithic bedrock (**Mzg**) Parent Material = residuum weathered from granitic rocks Paralithic bedrock (**Mzg**)	L -- Low (33”) --	30-34 33-37	1	0	0		0.9
121	Gerle family, deep Wintoner family	MR (65”) VS to S (14”) M (13”) MS (47”)	A C	Parent material = till from granitic rocks Paralithic bedrock (**Mzg**) Parent material = till from granitic rocks (**Mzg**)	L -- L M	>60 >60	1	0	0		1.8
136	Holland family, deep, dark surface Holland family, moderately deep, dark surface	M (50”) VS to S (10”) M (39”) VS to S (5”)	B C	Parent material = residuum weathered from tuff Paralithic bedrock (**MPm**) Parent material = residuum weathered from tuff breccia Paralithic bedrock **(MPm)**	L (10”) M (40”) -- L M --	50-54 39-43	2	0	0		2.5 1.6

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Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Parent Material (geologic map unit symbol)	SH-SW	Depth to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
137	Holland family, deep, dark surface	M(10") M(40") VS to S (10")	B	Parent material = residuum weathered from tuff Paralithic bedrock (**MPm**)	L M --	50-54	3	0	0		2.7 2.6 2.3
	Holland family, moderately deep, dark surface	M (10") M (29) VS to S (4")	C	Parent material = residuum weathered from tuff breccia Paralithic bedrock (**MPm**)	L M --	39-43					
	McCarthy family, moderately deep	M (35") VS to S (10")	B	Parent material = residuum weathered from tuff breccia Lithic bedrock (**MPm**)	L --	35-39					
139	Holland family, moderately deep	M (5") M(30") VS to S (5")	C	Parent material = residuum weathered form granite Paralithic bedrock (**DOsf, Mzg*^**)	L M --	35-39	5	3	60.0	4	8.8 6.9 4 3.6 3.5
	Holland family, deep	M (3") M (75") VS to S (19"+)	B	Parent material = residuum weathered from tuff breccia Paralithic bedrock (**DOsf, Mzg*^**)	L M --	60-64					

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Parent Material (geologic map unit symbol)	SH-SW	Depth to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
153	Josephine family, deep	M (7”) M (58”) VS to S (19”)	B	Parent material = residuum weathered from metasedimentary rock Paralithic bedrock (**DOsf**)	Low M --	65-69	1	0	0	0	0.6
	Josephine family, moderately deep	M (5”) M (30) VS to S (25”)	C	Parent material = residuum weathered from metasedimentary rock Paralithic bedrock (**DOsf**)	Low M --	35-39					
155	Josephine family, deep	M (7”) M (58”) VS to S (19”)	B	Parent material = residuum weathered from metasedimentary rock Paralithic bedrock (**DOsf**)	Low M --	65-69	3	2	66.7	4.2	6.0 4.2 3.2
	Sites family, deep	M (10”) M (8”) MS (42”) VS to S (19”)	C	Parent material = residuum weathered from metasedimentary rock Paralithic bedrock (**DOsf**)	Low M M --	60-64					
160	Josephine, moderately deep	M (5”) M (30”) VS to S (25”)	C	Parent material = residuum weathered from metasedimentary rock Paralithic bedrock (**DOsf*^, MPm**)	L M --	35-39	3	0	0	2.2	3.2 2.2 1.6
	Josephine, deep	M (7”) M (58”) V to S (14)	B	Parent material = residuum weathered from metasedimentary rock Paralithic bedrock (**DOsf*^,MPm**)	L M --	65-69					

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Soil Characteristics and Parent Material (geologic map unit symbol)	SH-SW	Depth[1] to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
175	Lithic Xerumbrepts	M (10”) S to R (10”)	D	Parent material = residuum weathered from tuff breccia Lithic bedrock (**MPm**)	L --	10-20	1	1	100	39.5	39.5
	McCarthy family, moderately deep	M (35”) V to S (10”)	B	Parent material = residuum weathered from tuff breccia Lithic bedrock (**MPm**)	L --	35-39					
	Rock outcrop	VS		Lithic bedrock (**MPm**)	--	0-0					
176	McCarthy family, deep	M (50”) VS to S (10”)	A	Parent material = residuum weathered from tuff breccia Paralithic bedrock (**Mzg**)	Low --	39-50	1	0	0	2.2	2.2
	McCarthy family, deep	M (35”) VS to S (10”)	B	Parent material = residuum weathered from tuff breccia Lithic bedrock (**Mzg**)	L --	35-54					
188	Sites family, deep	M (10”) MS (50”) VS to S (4”)	C	Parent material = residuum weathered from metasedimentary rock Paralithic bedrock (**DOs**f)	Low M --	60-64	2	0	0	2.75	3.6 1.9
200	Xerolls	M (60”)	B	Parent material = alluvium (**DOsf**)	Low	--	1	0	0	8.2	8.2
Calaveras County Radon Data Totals							24	5	20.8		

TUOLUMNE COUNTY-NRCS CA731 Stanislaus National Forest Parts											
Soil Unit	**Soil Unit Name**	**Permeability by Soil Sub-unit** (unit thickness)	**Hydrologic Soil Group**	**Parent Material** (geologic map unit symbol)	**SH-SW**	**Depth to Bed Rock** (inches)	**N**	**N ≥ 4.0 pCi/L**	**% N ≥ 4.0 pCi/L**	**Median**	**Indoor-Radon Data pCi/L**
126	Holland family, deep	M (3") M (57") VS to S (19")	B	Parent material = residuum weathered from granite Paralithic bedrock (**Mzg**)	L M --	60-64	2	1	50	3.5	4.5 2.5
127	Holland family, deep	M (3") M (57") VS to S (19")	B	Parent material = residuum weathered from granite Paralithic bedrock (**Mzg**)	L M --	60-64	1	0	0	1.0	1.0
136	Holland family, deep, dark surface	M (10") M (40") VS to S (10")	B	Parent material = residuum weathered from tuff Paralithic bedrock (**MPm**)	L M --	50-54	1	0	0	1.1	1.1
	Holland family, moderately deep, dark surface	M (10") M (29") VS to S (5")	C	Parent material = residuum weathered from tuff breccia Paralithic bedrock (**MPm**)	L M --	39-43					
159	Josephine family, moderately deep	M (5") M (30") V S to S (25")	C	Parent material = residuum weathered from metasedimentary rock Paralithic bedrock (**MzPzcc**)	L M --	35-39	1	1	100	11.3	11.3
	Josephine family, deep	M (7") M (58") VS to S (14")	B	Parent material = residuum weathered from metasedimentary rock Paralithic bedrock (**MzPzcc**)	L M --	65-69					

Soil Unit	Soil Unit Name	Permeability by Soil Sub-unit (unit thickness)	Hydrologic Soil Group	Soil Characteristics and Parent Material (geologic map unit symbol)	SH-SW	Depth[1] to Bed Rock (inches)	N	N ≥ 4.0 pCi/L	% N ≥ 4.0 pCi/L	Median	Indoor-Radon Data pCi/L
161	Josephine family, moderately deep	M (5”) M (30”) VS to S (25”)	C	Parent material = residuum weathered from metasedimentary rock Paralithic bedrock (**DOsf**)	Low M --	35-39	1	0	0	<0.5	<0.5
	Sites family, moderately deep	M (7”) MS (30”) VS to S (23”)	C	Parent material = residuum weathered from metasedimentary rock Paralithic bedrock (**DOsf**)	L M --	37-41					
Tuolumne County Radon Data Totals							6	2	33.3		

*Geologic unit with the highest indoor-radon measurement for this soil. ^Geologic unit with the lowest indoor-radon measurement for this soil.
[1] Depth to bedrock or depth to restrictive layer
* Soil information summarized from Soil Survey Amador Area, California, Series 1961, No. 26, Issued September 1965; U.S. Department of Agriculture, Soil Conservation Service (*now National Resource Conservation Service*), 167 p.

APPENDIX L

Amador, Calaveras and Tuolumne Counties geologic units (89) assigned to low or unknown radon potential status

ND = no data

Geologic Unit (symbol and name)	Indoor Radon Data	NURE Soil Uranium Data number (ppm)	NURE Airborne eU data	Assigned Radon Potential (comments)
artificial fill (af)	ND	ND	ND	unknown
amphibolite schist (am)	ND	ND	supports low potential	Low (P)
diabase and porphyrite (db)	ND	ND	supports low potential	Low (P)
Ione Fm. queried (Ei?)	ND	ND	ND	unknown
felsite dikes (f)	ND	ND	ND	unknown
feldspar porphyry (fp)	ND	ND	weekly supports low potential	Low (P)
feldspar porphyry queried (fp?)	ND	ND	weekly supports low potential	Low (P)
gabbro (gb)	3	1(0.9)	supports low potential	Low (P)
gabbro-diorite (gdb)	ND	ND	supports low to moderate potential	unknown
quartz monzonite (gd)	ND	ND	weakly supports low potential	unknown

Geologic Unit (symbol and name)	Indoor Radon Data	NURE Soil Uranium Data number(ppm)	NURE Airborne eU data	Assigned Radon Potential (comments)
greenstone (gs)	ND	ND	ND	unknown
hornblende andesite (ha)	ND	ND	ND	unknown
Copper Hill Volcanics (Jch, Jvc)	9-weakly supports low potential	2(0.9,0.8)	supports low potential	Low
Copper Hill Volcanics, queried (Jvc?)	ND	ND	ND	unknown
Copper Hill Volcanics, amphibolite (Jcha)	ND	3(2.0,0.6,0.6)	strongly supports low potential	Low (P)
Copper Hill Volcanics, thick bedded volcanic breccia (Jchb)	ND	ND	supports low potential	unknown
Copper Hill Volcanics, felsic dikes (Jchf)	ND	ND	supports low potential	unknown
Copper Hill Volcanics-amygdaloidal mafic lava (Jchl)	ND	ND	strongly support low potential	unknown
Copper Hill Volcanics, quartz porphyry (Jchqp)	ND	ND	strongly supports low potential	unknown
Jdp Don Pedro Terrane, phyllite and schist of Clark (Jdp)	3-weakly supports high potential	2(2.5,2.1)	strongly supports low potential	unknown

Geologic Unit (symbol and name)	Indoor Radon Data	NURE Soil Uranium Data number(ppm)	NURE Airborne eU data	Assigned Radon Potential (comments)
Don Pedro Terrane, talc schist of Clark (Jdpt)	1	1(1.4)	ND	unknown
Don Pedro Terrane, greenschist (metavolcanic) of Clark (Jdpv)	15-supports low potential	weakly supports low potential category	strongly supports low potential	Low
Quartz andesite plug (Jga)	ND	ND	ND	unknown
Gopher Ridge Fm. undifferentiated, queried (Jgo?)	ND	ND	strongly supports low potential	unknown
Gopher Ridge Fm., amphibolite facies (Jgoa)	4-weakly supports low potential	2(1.2,0.7)	strongly supports low potential	Low (P)
Gopher Ridge Fm., feldspar porphyry (Jgof(?))	ND	ND	ND	unknown
Gopher Ridge Fm., quartz porphyry (Jgogp)	9-weakly supports low potential	1(1.5)	strongly supports low potential	Low
Logtown Ridge Formation (Jlr, Jvl)	Supports low to moderate potential limited data; high 16.7 pCi/L (Amador/ basement)	Weakly supports low radon potential	Supports Low radon potential	Low (P)
Mariposa Fm. (in Tuolumne County mélange) (Jm)	5-weakly supports low potential	4(3.9,2.7,2.5,2.5)	strongly supports low potential	Low

Geologic Unit (symbol and name)	Indoor Radon Data	NURE Soil Uranium Data number(ppm)	NURE Airborne eU data	Assigned Radon Potential (comments)
Metavolcanic unit, possibly Mariposa Fm., Brower Creek Member (Jmb)	8-weakly supports moderate potential	2(1.2,1.1)	strongly supports low potential	unknown
Penon Blanco Volcanics (Jpb, Jvp)	ND	ND	ND	unknown
Sullivan Creek Terrane, greenschist belt (Jsg)	13-supports low potential	ND	ND	Low (P)
Sullivan Creek Terrane, phyllite belt (Jsp)	6-weakly supports moderate potential	ND	supports low potential	unknown
Salt Springs Slate (with some Mariposa Fm.) (Jss)	22-strongly supports low potential	5 weakly supports low potential	supports low potential	Low
Salt Springs Slate (with some Mariposa Fm.), queried (Jss?)	ND	ND	ND	unknown
Jasper Point Fm., undifferentiated (JTrj)	ND	ND	ND	unknown
Jasper Point Fm., metachert (JTrjc)	ND	ND	ND	unknown
Part of Calaveras Complex? East of Don Pedro Terrane) (JTrsb)	ND	ND	ND	unknown
Metavolcanic rocks, undifferentiated (Jv)	ND	ND	ND	unknown

Geologic Unit (symbol and name)	Indoor Radon Data	NURE Soil Uranium Data number(ppm)	NURE Airborne eU data	Assigned Radon Potential (comments)
Metarhyolite (Jvr)	ND	ND	ND	unknown
Chico Fm., queried (Kc?)	ND	ND	supports low to moderate potential	unknown
limestone or marble (ls)	ND	ND	supports low potential	Low (P)
limestone or marble, queried (ls?)	ND	ND	weekly supports low potential	unknown
diatomite (Md)	ND	ND	ND	unknown
Eureka Valley Tuff (Mev)	ND	ND	weekly supports low potential	unknown
metasedimentary rocks (ms)	1-weakly supports low potential	ND	strongly supports low potential	Low (P)
metasedimentary rocks, queried (ms?)	ND	ND	weakly supports low potential	unknown
Table Mountain Latite (Mtm, Tml))	ND	ND	supports moderate to high potential	unknown
metavolcanic rocks (includes some metasedimentary rocks) (mv)	3-weakly supports low potential	ND	strongly supports low potential	Low (P)

Geologic Unit (symbol and name)	Indoor Radon Data	NURE Soil Uranium Data number(ppm)	NURE Airborne eU data	Assigned Radon Potential (comments)
metavolcanic rocks, queried (mv?)	ND	ND	ND	unknown
diorite (Mzd)	ND	7 (weakly supports moderate potential)	supports low to moderate potential	unknown
Marine metasedimentary rocks (one polygon) (Mzm)	ND	ND	ND	unknown
Calaveras Complex, limestone (MzPzcls)	1-weakly supports low potential	ND	supports high potential	unknown
Calaveras Complex, talc schist (MzPzct)	ND	ND	weakly supports low potential	unknown
Calaveras Complex, volcanics (MzPzcv)	ND	1(2.3)	supports low to moderate potential	unknown
Valley Springs Fm., queried (OMvs?)	ND	ND	ND	unknown
Valley Springs Fm., welded rhyolitic tyff (OMvsw)	ND	ND	weakly supports low to moderate potential	unknown
Marine metasedimentary rock (pCC)	ND	ND	supports moderate potential	unknown
Laguna Fm. (Pl)	1-weakly supports low potential	ND	supports moderate potential	unknown

Geologic Unit (symbol and name)	Indoor Radon Data	NURE Soil Uranium Data number(ppm)	NURE Airborne eU data	Assigned Radon Potential (comments)
Laguna Fm., queried (Pl?)	1-weakly supports high radon potential	ND	weakly supports low radon potential	unknown
Marine metasedimentary rock (Pzm)	ND	ND	ND	unknown
ankerite-talc schist and mariposite, quartz (q)	ND	ND	ND	unknown
alluvium (Qa)	1-weakly supports low potential	1(3.7)	supports low potential	Low (P)
alluvium (Qal)	ND	ND	ND	unknown
colluvium (Qc)	ND	ND	supports low potential	
glacial deposits (Qg)	ND	2(7.8,1.2)	ND	unknown
Holocene alluvium (Qha)	ND	ND	ND	unknown
landslide deposit (Ql, Qls)	ND	ND	ND	unknown
Modesto Fm. (Qm)	1-weakly supports low potential	1(2.8)	supports high potential	unknown
Modesto Fm. unit 1 (Qm1)	ND	ND	ND	unknown
Modesto Fm. unit 2 (Qm2)	4-weakly supports high potential	1(2.1)	strongly supports low potential	unknown

Geologic Unit (symbol and name)	Indoor Radon Data	NURE Soil Uranium Data number(ppm)	NURE Airborne eU data	Assigned Radon Potential (comments)
Modesto Fm. unit 2, queried (Qm2?)	ND	ND	weakly supports low potential	unknown
Riverbank Fm. (Qr)	1-weakly supports low data	1 (3.0)	ND	unknown
Riverbank Fm., queried Qr?)	2-weakly supports low data	ND	supports low or moderate potential	unknown
Riverbank Fm. unit 2 (Qr2)	ND	ND	weakly supports low potential	unknown
Riverbank Fm. unit 2, queried (Qr2?)	ND	ND	weakly supports low potential	unknown
Riverbank Fm. unit 3 (Qr3)	ND	ND	supports low potential	unknown
Riverbank Fm. unit 3, queried (Qr3?)	ND	ND	supports moderate potential	unknown
Terrace deposits (Qt)	ND	ND	ND	unknown
Turlock Lake Fm., queried (Qtl?)	ND	ND	ND	unknown
North Merced Gravels (QTnm)	ND	ND	supports moderate potential	unknown
North Merced Gravels, queried (QTnm?)	ND	ND	supports moderate potential	unknown

Geologic Unit (symbol and name)	Indoor Radon Data	NURE Soil Uranium Data number(ppm)	NURE Airborne eU data	Assigned Radon Potential (comments)
Quaternary volcanics undifferentiated (Qv)	ND	ND	weekly supports low potential	unknown
Interbedded chert and slate (sc)	ND	ND	supports low potential	unknown
Serpentinite (sp)	2-weakly supports low potential	2(0.8, 2.0))	strongly supports low potential	Low
Serpentinite, queried (sp?)	ND	ND	ND	unknown
Dredge or mine tailings (t)	1-weakly supports high potential	1(1.4)	supports low potential	unknown
Tertiary gravels (auriferous) (Tg)	1-weakly supports low potential	1(2.9)	supports moderate potential	unknown
Tertiary volcanics, dacite (Tvd)	ND	ND	ND	unknown

APPENDIX M

Descriptive Statistics and Statistical Comparison of Untransformed Indoor-Radon Measurements in Amador, Calaveras and Tuolumne Counties by Radon Potential Zone

	All Indoor Radon Data	High Zone Radon Data	Moderate Zone Radon Data	Low Zone Radon Data	Unknown Zone Radon Data
Size (n)	478	110	240	96	32
Mean	2.783	3.482	2.792	1.538	3.193
Std. Dev.	4.099	4.268	4.542	2.000	3.219
Std. Error	0.198	0.411	0.308	0.236	0.588
C.I. of Mean	0.390	0.814	0.608	0.470	1.202
Range	40.3	38.3	40.3	16.2	11.4
Maximum	40.4	38.8	40.4	16.7	12.0
Minimum	0.1	0.5	0.1	0.5	0.6
Median	1.8	2.25	1.8	1.1	1.95
25%	1.0	1.2	1.1	0.7	0.975
75%	3.0	4.35	2.8	1.675	3.775
Skewness	6.180	5.644	6.287	6.390	1.593
Kurtosis	48.721	43.900	45.827	47.659	1.513
K-S Dist/	0.277	0.242	0.287	0.302	0.257
K-S Prob.	<0.001	<0.001	<0.001	<0.001	<0.001
SWilk W	0.451	0.537	0.389	0.404	0.759
SWilk Prob	<0.001	<0.001	<0.001	<0.001	<0.001
Sum	1188.500	376.100	605.900	100.700	95.800
Sum of Squares	10466.230	3258.650	6146.850	454.230	606.500

APPENDIX N

Descriptive Statistics and statistical comparison of Ln-transformed Indoor-Radon Measurements in Amador, Calaveras and Tuolumne Counties by Radon Potential Zone

	All Indoor Radon Data*	High Zone Radon Data*	Moderate Zone Radon Data*	Low Zone Radon Data*	Unknown Zone Radon Data*
Size (n)	478	110	240	96	32
Mean	0.604	0.872	0.600	0.155	0.741
Std. Dev.	0.840	0.839	0.833	0.636	0.913
Std. Error	0.0407	0.807	0.0565	0.0749	0.167
C.I. of Mean	0.0799	0.160	0.111	0.149	0.342
Range	6.001	4.352	6.001	3.509	2.996
Maximum	3.699	3.658	3.699	2.815	2.485
Minimum	-2.303	-0.693	-2.303	-0.693	-0.511
Median	0.588	0.811	0.588	0.0953	0.668
25%	0.000	0.182	0.0953	-0.357	-0.0263
75%	1.099	1.470	1.030	0.515	1.328
Skewness	0.456	0.255	0.345	1.241	0.395
Kurtosis	1.168	0.00389	2.509	3.071	-0.828
K-S Dist/	0.0526	0.0634	0.0727	0.0910	0.0906
K-S Prob.	0.007	0.342	0.007	0.143	0.693
SWilk W	0.975	0.981	0.960	0.917	0.942
SWilk Prob	<0.001	0.128	<0.001	<0.001	0.101
Sum	257.730	91.124	130.197	11.192	22.216
Sum of Squares	456.449	157.302	227.902	30.455	40.790

* except for size (number of data) data are in natural log format

APPENDIX O

Results of the Shapiro-Wilk Normality Test for Untransformed and Ln-Transformed Indoor-Radon Data, by Radon Potential Zone

Data	N	W-Statistic*	P	Result**
All Data-Untransformed	478	0.451	<0.001	Failed
All Data-Ln Transformed	478	0.975	<0.001	Failed
High Zone-Untransformed	110	0.537	<0.001	Failed
High Zone-Ln Transformed	110	0.981	0.128	Passed
Moderate Zone-Untransformed	240	0.389	<0.001	Failed
Moderate Zone-Ln Transformed	240	0.960	<0.001	Failed
Low Zone-Untransformed	96	0.404	<0.001	Failed
Low Zone-Ln Transformed	96	0.917	<0.001	Failed
Unknown Zone-Untransformed	32	0.759	<0.001	Failed
Unknown Zone-Ln Transformed	32	0.942	0.101	Passed

*Shapiro-Wilk Statistic (W)—tests the null hypothesis that the data were sampled from a normal distribution. Small values of W indicate a departure from normality (SigmaPlot® 12 Statistics User's Guide part 2, Systat Software, Inc., p. 23)

**A test that fails indicated that the data varies significantly from the pattern expected if the data were drawn from a population with a normal distribution. A test that passes indicates that the data matches the pattern expected if the data were drawn from a population with a normal distribution.

APPENDIX P

Mann-Whitney Rank Sum Test Comparisons of Indoor-radon Data Between the High, Moderate, Low and Unknown Radon Potential Zones

<table>
<tr><th colspan="6">Mann-Whitney Rank Sum Test</th></tr>
<tr><td>Group</td><td>N</td><td>Missing</td><td>Median</td><td>25%</td><td>75%</td></tr>
<tr><td>High Zone</td><td>110</td><td>2</td><td>2.25</td><td>1.2</td><td>4.35</td></tr>
<tr><td>Moderate Zone</td><td>240</td><td>23</td><td>1.8</td><td>1.1</td><td>2.8</td></tr>
<tr><td>Result</td><td colspan="5">Mann-Whitney U Statistic = 9422.000

T = 19900.000 n(small) = 108 n(big) = 217 (P = 0.004)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = 0.004)</td></tr>
<tr><td>Group</td><td>N</td><td>Missing</td><td>Median</td><td>25%</td><td>75%</td></tr>
<tr><td>High Zone</td><td>110</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Low Zone</td><td>96</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Result</td><td colspan="5">Mann-Whitney U Statistic = 1891.500

T = 4519.500 n(small) = 72 n(big) = 108 (P =<0.001)

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = <0.001)</td></tr>
<tr><td>Group</td><td>N</td><td>Missing</td><td>Median</td><td>25%</td><td>75%</td></tr>
<tr><td>High Zone</td><td>110</td><td>2</td><td>2.25</td><td>1.2</td><td>4.35</td></tr>
<tr><td>Unknown Zone</td><td>32</td><td>2</td><td>1.95</td><td>0.975</td><td>3.775</td></tr>
<tr><td>Result</td><td colspan="5">Mann-Whitney U Statistic = 1452.500

T = 1917.500 n(small) = 30 n(big) = 1.8 (P = 0.388)

The difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.388)</td></tr>
</table>

Group	*N*	*Missing*	*Median*	*25%*	*75%*
Moderate Zone	240	23	1.8	1.1	2.8
Low Zone	96	24	1.1	0.7	1.675
Result	Mann-Whitney U Statistic = 4803.500 T = 7458.500 n(small) = 72 n(big) = 217 (P = <0.001) The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P= <0.001)				
Group	*N*	*Missing*	*Median*	*25%*	*75%*
Moderate Zone	240	23	1.8	1.1	2.8
Unknown Zone	32	2	1.95	0.975	3.775
Result	Mann-Whitney U Statistic = 3048.500 T = 3956.500 n(small) = 30 n(big) = 217 (P = 0.574) The difference in the median values between the two groups is not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.574)				
Group	*N*	*Missing*	*Median*	*25%*	*75%*
Low Zone	96	24	1.1	0.7	1.675
Unknown Zone	32	2	1.95	0.975	3.775
Result	Mann-Whitney U Statistic = 667.500 T = 1957.500 n(small) = 30 n(big) = 72 (P = 0.002) The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = 0.002)				