Homestake Revisited: He

While the contamination of groundwater around the Homestake Mining Co. (HMC) uranium mill near Milan, New Mexico, has been a priority of both local residents and federal and state regulators for parts of five decades (see *Voices,* Spring 2010), another threat to public health has lingered in and near the neighborhoods that border the HMC Superfund site for much of the last 35 years.

Airborne levels of radon — the invisible, odorless radioactive gas that the Environmental Protection Agency says is second only to cigarette smoking as the leading cause of lung cancer in the U.S. (EPA, 2010) — have ranged from three to more than 10 times greater than regional and national background concentrations in the communities next to the Homestake facility since at least 1975 when outdoor air monitoring first started.

An analysis of historic and recent air monitoring data shows that radon levels at air monitors located near residences were significantly higher than regional background concentrations before Homestake closed its uranium mill in 1990, and have remained elevated above background at the company's nearest-residence monitors since then. Between 1975 and 2009, maximum average annual radon concentrations in the vicinity of the nearest residences have ranged from 1.43 to 2.7 picoCuries per liter-air (pCi/l-air), or about 0.9 to 2.2 pCi/l† higher than background.

Chronic exposure to these maximum levels carries substantial lifetime lung cancer risks for the estimated 300 people who live in the neighborhoods bordering the Homestake site.

The analysis of nearly 40 years of outdoor radon levels in the San Mateo Creek drainage basin northwest of Grants, New Mexico — contained in two reports prepared by SRIC staff under EPA's Technical Assistance Services to Community (TASC) program — is the first attempt to compile and analyze radon and radon progeny monitoring data to address community concerns about the potential impacts of the Homestake tailings operations on local health.

The SRIC reports, prepared under contract to E^2 Inc., which implements EPA's TASC program, also showed how the choice of monitor locations for background radon levels influences calculations of the maximum radiation doses to residents who live near the HMC facility. The studies found that calculated doses to local residents would exceed the Nuclear Regulatory Commission's (NRC) limit of 100 millirems per year (mrem/y) if the average historic background concentration of about 0.5 pCi/l-air were used to calculate the doses, rather than a much higher level derived from one of HMC's air monitoring stations that may be influenced by radon releases from nearby abandoned uranium mines.

Both SRIC reports (TASC, 2009 and TASC, 2010) were peer-reviewed by E^2 Inc. staff and approved by EPA officials at the Region 6 office in Dallas before they were distributed to the Bluewater Valley Downstream Alliance (BVDA), the community group that receives TASC services under the federal Superfund law. The reports may be reviewed on the SRIC website at *www.sric.org/uranium.*

The Homestake site consists of two separate tailings piles, one containing about 1.5 million tons of tailings that dates to 1958, and a second dump, called the Large Tailings Pile (LTP), which received mill waste from about 1959 until 1990. (Figure 1). The mammoth LTP contains about 21 million tons of radioactive mill wastes, measures to up 100 feet in height and a mile long at its base, and is topped by the remnants of a two-cell pond system that stored wastewater during mill operations. Both piles are unlined and sit on top of alluvial sands and gravels deposited by the ancestral San Mateo Creek. They are the sources of past and current groundwater contamination of at least four aquifers (EPA, 2006). The tailings operation is licensed by the NRC, has two New Mexico Environment Department (NMED) groundwater discharge permits, and was added to the Superfund National Priorities List by EPA in 1983, in large part because selenium concentrations in groundwater exceeded the federal drinking water standard. A few years later, the Superfund designation was expanded to include an investigation of the source or sources of high indoor and outdoor radon levels in the neighboring communities.

HEALTH RISKS

Compounding concern about the potential health risks of chronic inhalation of outdoor radon and its radioactive decay products, called "daughters" or "progeny," is that even higher levels of radon were found inside homes in the neighboring communities in studies conducted by HMC in the late-1980s (HMC, 1989; EPA, 1989). Eight of 59 homes tested had average annual indoor radon concentrations exceeding the EPA's national "action level" of 4.0 pCi/l-air — a level that the World Health Organization (WHO, 2009) says carries too much risk and should be lowered by at least a third. The average indoor radon level for all homes tested in the residential radon study was 2.7 pCi/l-air (EPA, 1989), or a little more than twice the national indoor average of 1.3 pCi/l-air (EPA, 2010).

According to EPA, the lifetime lung cancer risk from exposure to an average indoor level of 4 pCi/l is about 1 in 143 for non-smokers, and nine times greater for smokers. An outdoor level of 2 pCi/-air — a concentration detected at Homestake's nearest-residence air monitoring stations on several occasions in the last five years — represents a lifetime cancer risk of about 1 in 2,000 people exposed (Millard and Baggett, 1984). For local residents who live within two miles of the Homestake site, these risks are tangible.

Spraying of effluent ab

"We believe this radon exposure has already caused serious health problems for adjacent residents," said Candace Head-Dylla, a BVDA member who lives less than a mile southwest of Homestake's tailings piles.

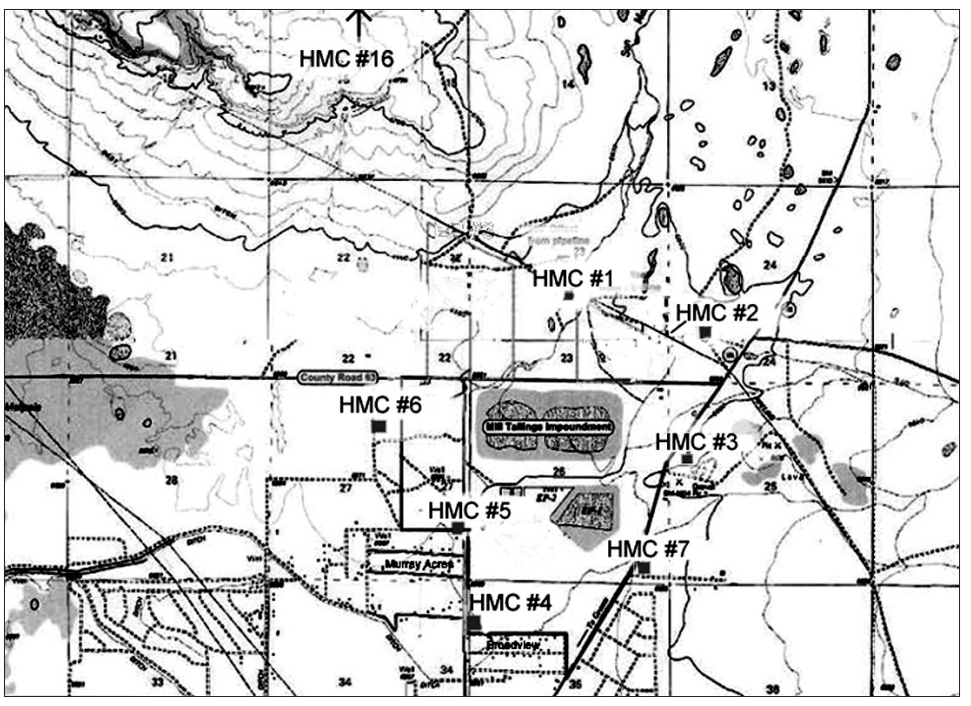
"Many people in our community have serious health issues, everything from thyroid and lung disease to various forms of cancer," Head-Dylla said in sworn testimony at a public hearing on Homestake's state water discharge permit in January. "Since no official health study has been conducted despite more than 30 years of exposure for some residents, there's no way to know for sure what the health effects [from radon exposure] have been."

SOURCES OF RADON

The persistence of elevated levels of outdoor radon has raised questions about whether another source or sources of uranium or radium — the "parent" radionuclides of radon in the radioactive decay of uranium-238 — other than the HMC facility are present in or near the communities. But no other source of TENORM — technologically enhanced naturally occurring radioactive materials, such as abandoned uranium mines or mine wastes — is located closer than five miles from the neighborhoods that border the Homestake site.

One source, the former Anaconda Company uranium mill located near the village of Bluewater about five miles west the HMC site, was dismantled in the late-1980s, and its massive tailings pile — the second largest in the U.S. — was completely covered in the early-1990s. The site is now managed by the U.S. Department of Energy (DOE) under a license issued by NRC. Average annual radon levels measured next to the Anaconda tailings in 1978-1980, while higher than the regional background level of about 0.5 pCi/l-air, were significantly lower than those measured around the Homestake mill and tailings operation. (Table 1). More than 80 abandoned uranium mines are located in the San Mateo Creek drainage basin, but none are closer than six miles from the neighborhoods around Homestake. And no uranium ore deposits are present at or

FIGURE 1: Homestake Site



† In this article, we use the "old" units of radioactivity, measured in fractions of Curies, because they are still widely used in the U.S. The rest of the world uses SI units, which for radioactivity is the Becquerel. A radon concentration of 1 Bq/l-air equals 27.0273 pCi/l-air; accordingly, 4.0 pCi/l-air equals 0.15 Bq/l-air.)

alth Concerns Over Radon

bove EP1, April 2009.

near the surface of the land in the communities next to Homestake.

Conversely, some of the highest concentrations of uranium and radium in soils in the immediate area of the Homestake site were measured on HMC's property in 2009 within a few hundred feet of residences (Baker, 2010a). Aerial surveys conducted by contractors to EPA in 2009 also showed anomalously high gamma radiation and uranium levels at spots on the Homestake property next to the residential areas. Some of those spots, located south of the LTP, are in the same area of the HMC property that was flooded in February 1977 by a spill of tailings wastewater from one of the ponds on top of the large pile and flooded in February 1979 in a major rainstorm.

Contaminated soils are not the only known or suspected sources of radon releases at the HMC site, however. Other possible sources include:

- the two tailings piles containing more than 23 million tons of uranium mill tailings;
- four open wastewater ponds used for storage and evaporation of high-salinity fluids that contain high concentrations of uranium and radium;
- periodic spraying of wastewater over the ponds to increase evaporation rates;
- a reverse osmosis (RO) plant used to treat contaminated groundwater;
- two fields covering several hundred acres where contaminated groundwater is used for irrigation; and
- the contaminated groundwater itself.

But what is causing or contributing to the elevated radon levels in and among the residences remains an open question. EPA determined in 1989 that no correlation could be made between releases from Homestake's operations and the high outdoor and indoor radon levels observed in the 1987-88 residential study. Even though the Homestake uranium mill was still operating at the time, and tailings and wastewater were being added to the LTP, EPA ruled that "no action" was needed by Homestake under EPA's Superfund authority to curb radioactive emissions (EPA, 1989). Instead, EPA recommended that owners of homes having indoor radon levels exceeding the 4 pCi/l-air action level take steps to fix their homes by increasing ventilation. Local residents and BVDA members consulted for this article said they know of no one who made any changes in their homes to lower radon levels as the result of EPA's 1989 decision and recommendations.

Homestake officials and experts asserted in the January 2010 state permit hearing that the large and small tailings piles are the source of 98.6 percent of all radon emissions from the site, and that releases from the open wastewater ponds and RO plant account for only about 1.4 percent of radon emissions. They provided results of a consultant's study conducted in Summer 2009 (Simonds et al., 2009) that indicated that very little radon is emitted from the four wastewater ponds, in large part because water has been found to attenuate radon emissions.

RESIDENTS' CONCERNS ABOUT EFFLUENT SPRAYING

The Homestake officials also said that the spraying of wastewater to increase evaporation is a minor source of radon and other radionuclides. But the spraying has long been a sore point for local residents, who on several occasions in the last two years have told regulators that mists from the sprays and salts evaporated from the high-salinity wastewater pollute the air and lands outside of Homestake's property. In 2008, Milton Head, then-president of BVDA, wrote in a letter to NMED officials that the sprays are "picked up by the wind and spread beyond the pond berms and deposited on the soils wherever the winds blow them. The mists from the sprays are depositing residue in the neighboring residential areas."

In the January hearing, two local residents, John Boomer and Mark Head, provided photos of mists clinging to the landscape around the ponds in the previous fall. In April, four different residents called SRIC to complain that Homestake was running its sprayers when winds were gusting up to 40 to 50 miles per hour, and

FIGURE 2

Average Annual Outdoor Radon Concentrations at Background Stations, in BVDA Residential Area, and at Nearest-residence Monitor (HMC #4)*, 1972–2009

*located on HMC property within 30 meters of homes

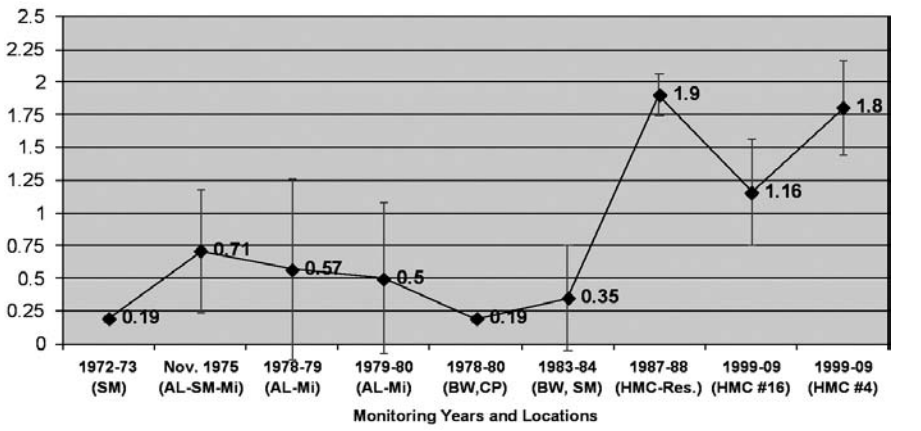


TABLE 1

Summary of Average Annual Radon Levels at Background and Non-Background Locations in Ambrosia Lake-Milan Uranium Mining District, 1972–2009

(all concentrations in picocuries per liter-air)

Year / Period	Study Area	Background		Non-background		References
		# monitors (# samples)	Average Rn (range)	# monitors (# samples)	Average Rn[a] (range)	
1972–73	San Mateo, NM	3 (135)	**.19** (.08 – .59)	None	None	GMR: NMEI, 1974
Nov. 1975	Ambrosia Lake-Milan	5 (5)	**.71 ± .47** (.11 – 1.2)	5 (5)	2.58 ± .73 (1.9 – 3.6)	USEPA: Eadie et al., 1976
1978–79	Ambrosia Lake-Milan	9 (122)	**.57 ± .69** (.10 – 1.12)	AL: 6 (110)	***3.20 ± 2.53*** (2.01– 4.23)	NMEID: Buhl et al., 1985 (17)
				HMC: 3 (53)	***1.83 ± 1.24*** (1.55 – 2.01)	
				AC: 2 (38)	***1.06 ± .75*** (.76 – 1.37)	
1979–80	Ambrosia Lake-Milan	10 (187)	**.50 ± .58** (.14 – .81)	AL: 6 (136)	***4.66±2.89*** (3.23 – 6.40)	NMEID: Buhl et al., 1985 (18, 28)
1978–80	Bluewater Lake, Cebolleta, Crownpoint, Gulf Mill Site, Nose Rock, San Mateo	6 (115)	**.19 ± .02** (.13 – .25)	HMC: 3 (67)	***1.51 ± 1.02*** (1.51–1.89)	
				AC: 2 (42)	***.87±.64*** (.78-.95)	
1983–84	San Mateo and Bluewater Village	2 (52)	**.35 ± .02** (no range)	MA and BA: 5 (130)	**1.62** (no sd or range given)	NMEID: Millard & Baggett, 1984
1987–88 (15 mo.)	Residential area south and southwest of HMC site	28 (112)	**1.9 ± .4**[b] (range of corrected Rn values, 1.2-2.7) (range of maximum Rn values, 2.8-8.2)			HMC: EPA, 1989
1999–2009*	Perimeter of HMC-licensed area	HMC #16 (21)	**1.16 ± .36** (.8 – 2.5)	HMC #4 (20)	**1.80 ± .33** (1.1 – 2.4)	HMC, 2000-2009
				HMC #5 (20)	**1.63 ± .32** (1.2 – 2.2)	
				HMC #1,2,3,6,7[d] (100)	**1.38 ± .35** (.8 – 2.8)	
2010	United States	Not given	**.4 (average outdoor Rn)**	n/a	n/a	EPA 2010

ABBREVIATIONS: AC = Anaconda Co.; AL = Ambrosia Lake Mill (Kerr-McGee Corp./Quivira Mining Co.); BA = Broadview Acres; GMR = Gulf Mineral Resources; HMC = Homestake Mining Co.; MA = Murray Acres; NMEID = New Mexico Environmental Improvement Division; sd = standard deviation; EPA = U.S. Environmental Protection Agency

TABLE 2

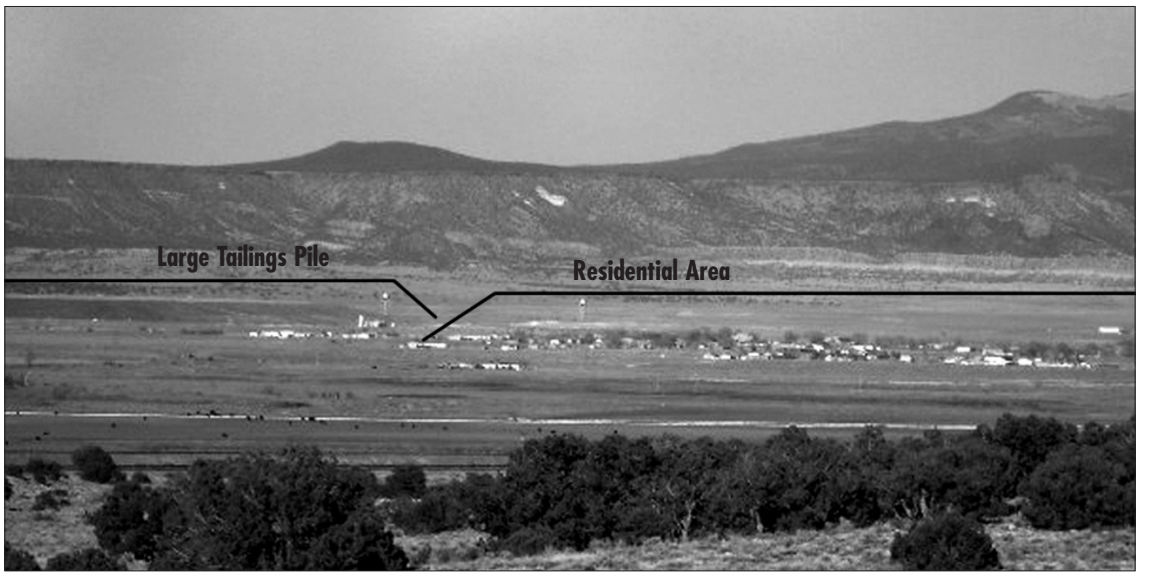
Comparison of HMC-Calculated Total Effective Dose Equivalent (TEDE) at Nearest-Residence Air Monitoring Station (HMC #4) with Doses Calculated Using Different Background Radon Values and Different Assumptions for Occupancy Factor (OF) and Radon-Radon Daughter Equilibrium Factor (EF)

(doses in italics exceed NRC's 10 CFR 20.1301(a)(1) limit of 100-mrem/y to member of the public)

Nearest Residence Radon HMC #4 (2009)	Background Radon	Background Station(s) (Year)	HMC Base Case: OF = .75 EF = .2	OF = 1.0 EF = .2	OF = .75 EF = .5	OF = 1.0 EF = .5
pCi/l	pCi/l		mrem/y			
1.8	1.3	HMC #16 (2009) NMEID #201 (1979)	46.3	58.8	*102.6*	*133.8*
1.8	1.12	(comparable with ave. Rn level of 1.16 in HMC #16)	59.8	76.8	*136.3*	*178.8*
1.8	.81	NMEID #201 (1980)	83.1	*107.8*	*194.4*	*256.3*
1.8	.53	NMEID #211, #212, #219, #220, #316, #415 (1983)	*104.1*	*135.8*	*246.9*	*326.3*
1.8	.19	San Mateo (1972-73); Bluewater Lake, Crownpoint, Gulf Mill Site, San Mateo (1978-80)	*129.6*	*169.8*	*31.7*	*411.3*

that mist from the spraying was traveling into the adjacent neighborhoods. Homestake's NRC radiation license and its NMED groundwater discharge permit do not prohibit spraying or limit spraying when atmospheric conditions are calm. Rather, the NMED permit requires only that sprays be kept inside the berms of the ponds (NMED, 2010).

A U.S. Army Corps of Engineers team assembled to review and evaluate Homestake's groundwater remediation system noted in a February 2010 draft report that the single highest ambient radon concentration measured at the Homestake property boundary was recorded at a monitor station that is used by Homestake as the background location for radioactive air particulate sampling (USACE, 2010). The USACE report suggested that this monitor station, HMC-6, which is located due west of the HMC wastewater ponds, may be influenced by sprays and deposition of particulates. A wind rose diagram provided by Homestake confirmed that the highest frequency of low-velocity winds is from the northeast to the southwest (Baker, 2010b) — that is, from the tailings piles to the neighborhoods.



View of Homestake Mill Tailings Piles in relation to nearby residential area.

THE QUESTION OF BACKGROUND

While the sources of radon in the communities are still debated, the problem of abnormally high ambient radon levels of 2 pCi/l-air or greater has been documented repeatedly since EPA's first study in November 1975 (Eadie et al, 1976). Radon concentrations of this magnitude and more were confirmed in an extensive, two-year regional study conducted by the New Mexico Environmental Improvement Division (NMEID) in 1979–1981 (Buhl et al, 1985). More data were collected by NMEID scientists in 1982–1983 at the time that many of the roughly 60 operating uranium mines in the Ambrosia Lake mining district were closing (Millard and Baggett, 1984). Both NMEID studies found that radon levels associated with uranium mining and milling facilities in the region were significantly higher than radon concentrations measured at monitor stations designated as background locations.

The question of what levels of radon accurately reflect background, or "normal," was first addressed nearly 40 years ago in a study conducted by the New Mexico Environmental Institute (NMEI) for Gulf Mineral Resources, which was proposing construction of the Mount Taylor Mine next to the village of San Mateo, New Mexico. The NMEI (1974) study is notable because it was conducted during all four seasons of the year in 1972–1973, at three ground-level monitor stations in the valley and on the side of the mountain near the proposed mine site, and by aircraft that recorded ambient radon levels at different elevations above the land. (The airborne portion of the study documented, for the first time, the effects of winter temperature inversions that hold radon close to the land surface). The study calculated an average outdoor radon level of 0.19 pCi/l-air, with a maximum of 0.58 pCi/-air, in an area that had not had previous uranium development.

Years later, the studies by EPA and NMEID scientists confirmed that average annual background levels of radon, measured in areas and communities where uranium mining and milling had not been conducted, ranged from 0.11 pCi/l-air to 0.71 pCi/l, with an overall average of between 0.4 pCi/-air and 0.5 pCi/-air. (Table 1). By comparison, EPA says the average annual ambient radon concentration in the U.S. is 0.4 pCi/l-air. And as shown in Figure 2, these background levels appear to have increased by about 1 pCi/-air between the late-1980s and 2009.

ASSESSING RADIATION DOSES

Despite clear evidence that *average* outdoor radon levels at sites *not affected* by uranium mining and milling operations rarely exceed 0.5 pCi/l-air, Homestake has consistently used average radon levels of greater than 1 pCi/l-air as the background concentration in its calculations of radiation doses to the public. Homestake derives its background radon level from monitor station HMC-16, which is located about 2.5 miles northwest of the LTP where radon levels averaged 1.16 pCi/l-air from 1999 to 2009, and in the second half of 2009 spiked to 2.5 pCi/l-air.

In calculating the total effective dose equivalent (TEDE) to members of the public pursuant to NRC regulations, Homestake adds up contributions from airborne radon, airborne particulates of uranium, thorium and radium, and direct gamma radiation measured at each of its eight perimeter monitor stations. The vast majority of the TEDE is from radon; levels of radioactive air particulates and direct gamma radiation make up only small fractions of the total dose (HMC, 2009; Attachment 4, pp. 1–2). Because the dose from each of these contributors is *reduced* by the background level for each category, the TEDE calculation is particularly sensitive to background levels of radioactive materials, especially radon. In other words, the higher the background levels of radon, the lower the TEDE. This is true even when the highest radon concentrations recorded at the two nearest-residence monitors are used in the TEDE calculation.

In reports filed with NRC in 2008 and 2009, HMC said the TEDE to the nearest resident was about 82 mrem/y in 2007 and 74 mrem/y in 2008, or up to 82 percent of NRC's annual dose limit. But calculation of the doses was based not only on high background radon levels measured at HMC-16 in 2007 and 2008, but also on two assumptions that appeared to have questionable technical bases. Those assumptions used 1) a ratio of radon levels to levels of radon daughters (called an equilibrium factor, or EF) that was lower than calculated in previous studies, and 2) a proportion of the time that local residents spend in and around their homes (called an occupancy factor, or OF) that is less than the factor recommended in NRC guidance documents and that potentially underestimates the time that local residents spend outdoors engaging in agricultural activities that are typical in the neighborhoods surrounding the HMC site.

The effects of using different assumptions for the background radon level, the radon-radon daughter equilibrium factor, and the local occupancy factor on TEDE calculations are shown in Table 2, which is taken from SRIC's May 2010 TASC report. The analysis shows that the TEDE exceeds the 100-mrem/y limit by more than four times when more conservative and area-specific background radon levels, equilibrium factors and occupancy factors are used in the calculation. A lower background radon concentration, around 0.5 pCi/l-air, is justified based on historic levels not affected by releases from uranium mines and mills. Similarly, a higher radon-radon daughter EF is reflective of equilibrium factors calculated by EPA and NMEID scientists in the studies of the 1970s and 1980s. And a higher occupancy factor better represents the time and activity patterns of local residents.

RECOMMENDATIONS OF THE TASC REPORTS

SRIC's TASC reports recommended that EPA, NRC and NMED re-examine and analyze the historic and recent radon data toward the goal of determining if Homestake's radiation dose calculations are scientifically accurate and comply with applicable regulations. The May 2010 TASC report also recommended that EPA revisit its 1989 determination that high outdoor and indoor radon levels in the communities surrounding Homestake could not be correlated with releases from HMC's operations, or with any other source of TENORM in the region. While the agencies have not responded formally to those recommendations, EPA's Region 6 Superfund office has initiated a new round of environmental monitoring in the neighborhoods next to Homestake for the purpose of conducting a new risk assessment. Local residents have requested direct participation in the new study, the results of which are not expected until mid-2011.

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