March 10, 2017

Kevin Hogg
Director of Real Estate & Business Services
Old Alumni Center
1105 Carrie Francke Drive
Columbia, MO 65211

Subject: Sinclair Farm Tract 3 Radiological Assessment Summary

Dear Mr. Hogg:

In May 2012 and March 2014, The University of Missouri - Columbia (MU) contracted Chase Environmental Group, Inc. (Chase) to conduct radiological sampling at the Environmental Trace Laboratory (ETL) Buildings 13669 and 13671 located within Tract 3 at the Sinclair Farm Site. The buildings burned in 2011 such that only the floor slabs and foundations remained. These buildings were historically used for activities involving radioactive materials as tracers for research under the MU US Nuclear Regulatory Commission (NRC) radioactive materials license.

Chase conducted independent, third party radiological measurements of the remaining building slabs and the lagoon following a survey plan based on the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) developed by the NRC, US EPA, Department of Energy, and the Department of Defense. MARSSIM provides the methodology to develop a statistically sound radiological sampling protocol to support a determination of whether or not facilities meet the NRC's radiological criteria for unrestricted use. Unrestricted use means that site can be used by members of the public for any future use without regard to radioactivity. To achieve unrestricted use, NRC regulations stipulate in 10 CFR 20.1402 that licensees must prove residual licensed radioactive materials at facilities/sites will not result in a dose greater than 25 millirem per year (mrem/yr) to members of the public. Chase used NRC screening values to determine potential future doses to members of the public. NRC screening values are radioactive materials concentrations on building surfaces or in soils that could result in a public dose equal to 25 mrem/yr based on pathway analysis using conservative assumptions. For building surfaces the pathway analysis involves a worker who occupies the impacted area for 2340 hours per year; for soils the pathway analysis involves a resident farmer that derives food and drinking water from the site. Chase's comparison of the sample results at the ETL site to the NRC screening values indicate that the potential dose to a member of the public from radioactivity at the site is less than **0.15 mrem/yr** (i.e., < 0.6 % of the NRC limit). The NRC released the ETL facility for unrestricted use in a letter to MU dated June 20, 2016.

For comparison to a property with no man-made radiological impacts, natural sources of radioactivity in the earth's soils, atmosphere, and water provide an average radiological dose to a member of the US population of approximately 310 mrem/yr. This background radiological dose from natural sources consists of radon, cosmic radiation, and food sources. An NRC Fact Sheet on this topic is attached to provide additional information on natural and man-made sources of radiation.

Chase, established in 1992, has extensive experience in planning and performing site decommissioning and MARSSIM based radiological surveys. Chase is specifically licensed by an NRC Agreement State to perform decontamination and decommissioning services and has implemented hundreds of MARSSIM based surveys throughout the US over the past seventeen years. For the past nine years, Chase has provided MU with turnkey radiological decommissioning services utilizing MARSSIM guidance to satisfy the NRC requirements for release of MU facilities for unrestricted use. If you have any questions concerning this letter, please feel free to contact me at (314) 240-0507.

Sincerely,

Dustin G. Miller, CHP
Midwest Regional Manager
Chase Environmental Group, Inc.

Att: NRC Fact Sheet, Biological Effects of Radiation

CC: Todd Houts, Director, MU EHS Department
Dave Culp, Field Services Manager, Chase Environmental Group

Biological Effects of Radiation

Radiation is all around us. It is in our environment and has been since the Earth was formed. As a result, life has evolved in the presence of significant levels of ionizing radiation. It comes from outer space (cosmic), the ground (terrestrial) and even from within our own bodies. It is in the air we breathe, the food we eat, the water we drink and the materials used to build our homes.

Some foods such as bananas and Brazil nuts naturally contain higher levels of radiation. Brick and stone homes have higher radiation levels than homes made of other materials such as wood. The U.S. Capitol, which is largely built of granite, contains more radiation than most homes. A lot of our exposure is due to radon, a gas from the Earth's crust that is present in the air we breathe.

This natural radiation that is always present is known as “background” radiation. Background levels can vary greatly from one location to the next. For example, Colorado, because of its altitude, has more cosmic radiation than the East or West Coast. It also has more terrestrial radiation from soils rich in naturally-occurring uranium. So people living in Colorado are exposed to more background radiation than residents of the coasts.

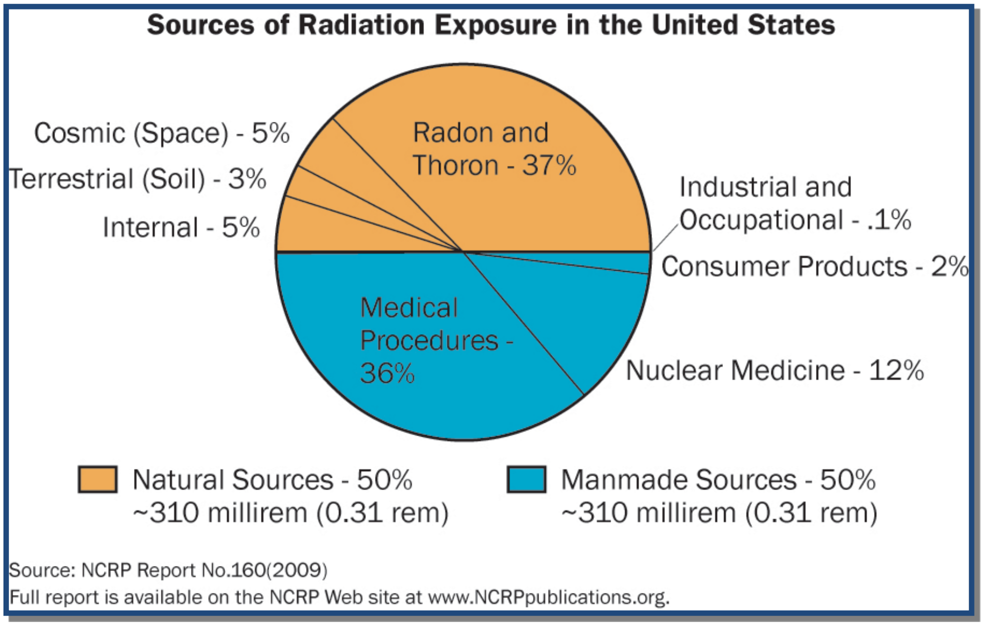
On average, a U.S. resident receives an annual radiation exposure from natural sources of about 310 millirem (3.1 millisieverts or mSv). Radon and thoron gases account for two-thirds of this exposure. Cosmic, terrestrial, and internal radiation account for the rest.

Man-made sources of radiation from medical, commercial and industrial activities contribute roughly 310 mrem more to our annual exposure. Computed tomography (CT) scans, which account for about 150 mrem, are among the largest of these sources. About another 150 mrem each year comes from other medical procedures. Some consumer products such as tobacco, fertilizer, welding rods, exit signs, luminous watch dials and smoke detectors contribute about 10 mrem per year. The pie chart below shows the radiation sources that make up the average annual U.S. radiation dose of 620 mrem.

Natural and man-made radiation may come from different sources, but both affect us in the same way. The NRC does not regulate background radiation. But the NRC does require its licensees to limit exposure to members of the public to 100 mrem (1 mSv) per year above background. Exposure to adults working with radioactive materials must be below 5,000 mrem (50 mSv) per year. NRC regulations and radiation exposure limits are contained in [Title 10 of the Code of Federal Regulations, Part 20](#).

Biological Effects of Radiation

We tend to think of the effects of radiation in terms of how it impacts living cells. For low levels of exposure, the biological effects are so small they may not be detected. The body is able to repair damage from radiation, chemicals and other hazards. Living cells exposed to radiation could: (1) repair themselves, leaving no damage; (2) die and be replaced, much like millions of body cells do every day; or (3) incorrectly repair themselves, resulting in a biophysical change.



The data on links between radiation exposure and cancer are mostly based on populations receiving high level exposures. Much of this information comes from survivors of the atomic bombs in Japan and people who have received radiation for medical tests and therapy. Cancers associated with high-dose exposure (greater than 50,000 mrem, or 500 mSv—500 times the NRC limit to the public) include leukemia, breast, bladder, colon, liver, lung, esophagus, ovarian, multiple myeloma and stomach cancers.

The time between radiation exposure and the detection of cancer is known as the latent period. This period can be many years. It is often not possible to tell exactly what causes any cancer. In fact, the National Cancer Institute says other chemical and physical hazards and lifestyle factors (e.g., smoking, alcohol consumption and diet) make significant contributions to many of these same diseases.

The data show high doses of radiation may cause cancers. But there are no data to establish a firm link between cancer and doses below about 10,000 mrem (100 mSv – 100 times the NRC limit).

Even so, the regulations assume any amount of radiation may pose some risk. They aim to minimize doses to radiation workers and the public. The international community bases standards for radiation protection on something called the linear, no-threshold (LNT) model. The idea is that risk increases as the dose increases. And there is no threshold below which radiation doses are safe. This model is a conservative basis for both international and NRC radiation dose standards. This means the model may overestimate risk.

High radiation doses (again, greater than 50,000 mrem, or 500 mSv) tend to kill cells. Low doses may damage or alter a cell's genetic code (DNA). High doses can kill so many cells that tissues and organs are damaged immediately. This in turn may cause a rapid body response often called Acute Radiation Syndrome. The higher the radiation dose, the sooner the effects of radiation will appear, and the higher the probability of death.

Many atomic bomb survivors in 1945 and emergency workers at the 1986 Chernobyl nuclear power plant accident experienced this syndrome. Among plant workers and firefighters battling the fire at Chernobyl, 134 received high radiation doses – 80,000 to 1,600,000 mrem (800 to 16,000 mSv) – and suffered from acute radiation sickness. Of these, 28 died within the first three months from their radiation injuries. Two workers died within hours of the accident from non-radiological injuries.

Because radiation affects different people in different ways, it is not possible to say what dose is going to be fatal. However, experts believe that 50 percent of people would die within thirty days after receiving a dose of 350,000 to 500,000 mrem (3,500 to 5,000 mSv) to the whole body, over a period ranging from a few minutes to a few hours. Health outcomes would vary depending on how healthy the person is before the exposure and the medical care they receive. If the exposure affects only parts of the body, such as the hands, effects will likely be more localized, such as skin burns.

Low doses spread out over a long period would not cause an immediate problem. The effects of doses less than 10,000 mrem (100 mSv) over many years, if any, would occur at the cell level. Such changes may not be seen for many years or even decades after exposure.

Genetic effects and cancer are the primary health concerns from radiation exposure. Cancer would be about five times more likely than a genetic effect. Genetic effects might include still births, congenital abnormalities, decreased birthweight, and infant and childhood mortality. These effects can result from a mutation in the cells of an exposed person that are passed on to their offspring. These effects may appear in the direct offspring if the damaged genes are dominant. Or they may appear several generations later if the genes are recessive.

While scientists have observed genetic effects in lab animals given very high doses of radiation, no evidence of genetic effects has been seen in the children born to Japanese atomic bomb survivors.

NRC regulations strictly limit the amount of radiation that can be emitted by a nuclear facility, such as a nuclear power plant. A 1991 study by the National Cancer Institute, “Cancer in Populations Living Near Nuclear Facilities,” concluded that there was no increased risk of death from cancer for people living in counties adjacent to U.S. nuclear facilities.

September 2015