

# Pervasive Presence of Plutonium Dioxide “Hot” Particles in Soils Near Rocky Flats

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Decades of studies have demonstrated that soils from the Rocky Flats National Wildlife Refuge and surroundings contain elevated levels of plutonium ( $^{239+240}\text{Pu}$ ). The plutonium originating from Rocky Flats is found in two distinct forms: a) plutonium that is dispersed relatively uniformly on the surfaces of all the soil particles, and b) “hot particles” of essentially pure plutonium dioxide. To date, studies conducted by the US Department of Energy and others have focused on measuring the first, uniformly dispersed form, while largely ignoring the latter.

Expanding upon our previous work reported in September 2019, this study performed a series of experiments specifically designed to detect small plutonium dioxide particles. We analyzed surface composite soil samples (0-5 cm, < 75-micron size fraction) collected in 2019 from the Jefferson County right-of way property immediately west of Indiana Street, in the proximity of the former east gate of the weapons plant. Also investigated were soils collected in 2000-2002 from property east of Indiana Street on City of Westminster open space. For each of the nine composite soils, we performed individual analyses of 40-50 portions of 200 milligrams. Samples were dissolved using potassium hydroxide fusions; plutonium was chemically separated, and the concentration of  $^{239}\text{Pu}$  was measured in each 200 mg portion using mass spectrometry.

The results reveal, for each of the composite samples, a consistent  $^{239}\text{Pu}$  baseline concentration resulting from 903 Pad contamination. However, all of the composites each exhibit several specific 200 mg soil portions with outlying, elevated activities. In the same manner as was interpreted by Engineering Analytics in their August 2019 discovery of an 8.8 micron  $\text{PuO}_2$  particle, the above-baseline content indicates the presence of individual  $\text{PuO}_2$  particles in some 200 mg portions of soil.

The increase in  $^{239}\text{Pu}$  concentration above baseline been used to calculate the mass of the plutonium dioxide particle, which is related to its diameter. The results show the presence of plutonium dioxide particles ranging from 0.5 to 1.9 microns in diameter, in all of the composite samples. By comparison, a micron represents one-millionth of a meter, which is considerably smaller than the diameter of a human hair. Particles in this size range are referred to as respirable, indicating that they can be inhaled and lodged in lung tissue on a long-term basis. Plutonium dioxide particles contained within the lungs will release their alpha decay energy within a small volume of affected tissue, producing localized internal doses of radioactivity.

Using these methods, we have characterized the diameters of more than 40 individual  $\text{PuO}_2$  particles. These particles are found to be pervasive in non-US Government land east of Rocky Flats, and it is reasonable to believe that ongoing wind transport is continuing to spread the contamination across open space used by the public, and toward residential areas.

We also found that all of the composite samples exhibited baseline, 903-Pad  $^{239+240}\text{Pu}$  activities well below the US Department of Energy standard of 50 pCi/gram. As the 50 pCi/g  $^{239+240}\text{Pu}$  soil standard does not preclude the presence of  $\text{PuO}_2$  “hot particles”, it cannot be considered protective of human health and the environment.