Seeking clarity in Fall 2013

D. M. Wood, September 2017

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This document is unlike others on the web site, in that it is an account of what I did *before* buying a house in Candelas and before I had time to exhaustively research the topic, to assure myself that this was a good idea. It *may* thus be of only historical interest, but it does demonstrate how much an individual can do without large resources. The small font is an indication that this document is better read offline, not as part of a web page.

Background

I have lived on the west side of Denver since 1982, in unincorporated Jefferson County, in Lakewood, and now on the south boundary of Rocky Flats in Arvada, so I have been peripherally aware of the history of the Rocky Flats plant for a very long time. After I got married in 2013 my wife and I began looking at new houses that would even out our commutes, which focused our attention on Candelas and Leyden Rock.

Parts of post-FBI raid Rocky Flats history are ugly and nasty. In the fall of 2013 I began looking carefully at what was currently known about risk to human health around the Rocky Flats National Wildlife Refuge. My customary friend Google, alas, turned up mostly posts from the Rocky Mountain Peace & Justice Center, the same statements repeated over and over in a variety of media, and Wikipedia editorial fights about whether some of the editing of the Rocky Flats entry was biased. I read about rumors that in the 90s local and state governments had been interested in developing the areas south of Rocky Flats after the plant closed, meaning they had at least some economic incentive to be less than 'squeaky clean' about certifying the area as suitable for development.

After a few weeks of reading environmental journal articles, old scanned DOE and Colorado state documents, and more diatribes about how plutonium was the "most toxic substance known to man", I realized there would be no clarity—no unimpeachable source of information from the time during and immediately after the cleanup—that would reassure me unless I invested much more time. On the other hand, neither was there a 'smoking gun' anywhere indicating coverups or clear epidemiological data from those downwind of the fires in post-fire developments. It is worth remembering that those living around Standley Lake were more directly downwind than most of what is now Candelas, and Standley Lake had been developed decades before Candelas.

The principal risk to human health from Pu is the α particles it emits, since they carry a charge $2e$ (where e is the magnitude of the electron charge) and high kinetic energy (so that they can readily ionize multiple biological molecules before coming to rest). Although α particles can be stopped simply by a piece of paper, larger radioactive dust particles, if they become somehow embedded in tissue (for example, in the lungs after inhalation) can sit still and irradiate surrounding tissue indefinitely with α particles. [Much more can be found in the document Hot particles no longer elsewhere on this web site.]

What I did

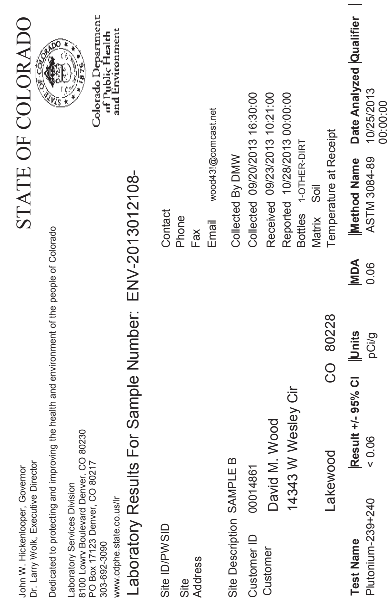
As an end run around my ignorance, I decided to find out for myself whether residual plutonium (or other sources of radiation) were an issue in the Candelas development and to educate myself on what I could measure about radiation levels in Colorado.

Figure 1: Example of sample location information

1. Soil samples
   From the lots of interest I troweled three large (1 kg or more) soil samples (two from surface dirt, one from a foot or so from the top of a dirt pile, hoping to collect buried contamination) into sealed, labeled Ziploc© bags and took them to the Laboratory Services Division of the Colorado Department of Public Health and Environment.

   This is a plutonium-in-soil testing lab with very long experience testing samples from Rocky Flats. Effectively the lab dissolves away everything that is not Pu and counts the residue. All three came back with plutonium (to be precise, the isotopes ^{239}Pu and ^{240}Pu) levels of < 0.06 pico Curies (pC) per gram of soil. In each case this number was less than the corresponding 'minimum detectable amount'. This means that the concentrations of plutonium—while nominally consistent with there being none—were really below the detection limit of the laboratory.

If I had had access to the reliable contamination maps I have now, I could have saved the money: as you will find on DOE maps, levels around our lot are between 0.04 and 0.08 pC/g, very consistent with what the state lab found.


STATE OF COLORADO

Colorado Department of Public Health and Environment

John W. Hickenlooper, Governor
Dr. Larry Wolk, Executive Director
Dedicated to protecting and improving the health and environment of the people of Colorado

Laboratory Services Division
8100 Lowry Boulevard Denver, CO 80230
PO Box 17123 Denver, CO 80217
303-692-3090
www.cdphe.state.co.us/lr

Laboratory Results For Sample Number: ENV-2013012108-

Site ID/PWSID
Site
Address

Contact
Phone
Fax
Email wood431@comcast.net

Site Description SAMPLE B
Customer ID 00014861
Customer David M. Wood
14343 W Wesley Cir
Lakewood CO 80228

Collected By DMW
Collected 09/20/2013 16:30:00
Received 09/23/2013 10:21:00
Reported 10/28/2013 00:00:00
Bottles 1-OTHER-DIRT
Matrix Soil
Temperature at Receipt

Test Name	Result +/- 95% CI	Units	MDA	Method Name	Date Analyzed	Qualifier
Plutonium-239+240	< 0.06	pCi/g	0.06	ASTM 3084-89	10/25/2013 00:00:00	

Figure 2: Example of sample Pu report (bottom of page trimmed off).

2. α particle activity on the soil surface
   The traditional way to find the concentration and identity of *atoms* in a low-density gas is by exciting the atoms (as in a high-voltage discharge in a neon tube) and measuring the color and intensity of the light its electrons emit as they fall from excited atomic states to the lower energy states. The color is a very precise indicator of the atom type and the brightness tells you how many atoms of that type there are. By analogy, the official way to identify a particular radioactive isotope is by the energy ('color') and intensity ('brightness', measuring how many light particles per second are leaving the source) of the light ('γ rays') the particles in its nucleus emit as they fall to lower energy states. However, γ ray spectrometers are both expensive and (generally) not portable.

   For these reasons I bought a 'data logging' portable Geiger-Müller counter of the 'pancake' design (the tube of gas is a flat cylinder; see Fig. 3), especially sensitive to α particles, provided the tube is fairly close to the radiation source. It seemed important to me that I be able to *log* how the radiation levels (in counts per minute) depended on time, so that I could count long enough to obtain a reliable histogram with which to identify a meaningful average radiation level.

   Geiger-Müller counters measure "ionizing radiation": α particles, high energy electrons emitted by nuclei ('β particles') and high-energy light particles (X rays or γ rays), but they cannot tell you which is which. However, if the rate increases significantly as the detector approaches the soil, either the soil's contamination is very non-uniform (not likely over a small area many years after the incidents) or the detector is now intercepting α particles. I made sure the counter was less than an inch above the surface in a repeatable position.

This is because the average distance traveled in air by an α particle before it loses its energy is 5-10 cm, depending on its initial kinetic energy.

Please refer to the document A crash course in radiation biology and health physics on this web site to see what the raw count data looks like, in order to understand that radiation levels *must* be identified by statistical analysis.

Figure 3: LND model LND 7317 pancake Geiger-Müller pancake tube.

Rationale for Geiger counting

I understood clearly that I would not be able to *identify* the particular source of excess radiation (above that due to background) with a Geiger-Müller counter, but I reasoned that if the places I measured around Candelas were 'hot' (well above background), it would likely be due to Pu, since this is the principal contaminant near Rocky Flats. By contrast, if the measured levels of radiation very close to the soil were comparable to background levels elsewhere, I could be assured that *excess risk* due to Pu would be low. (As I learned much later, this essentially defines the *low-dose* limit in the terminology of the epidemiology of cancers due to radiation exposure.)

Around sites such as Chernobyl and Fukushima Daichi there are many other sources present since the accidents involved fission reactors which produced a broad range of radionuclides.

Geiger-Müller counter measurements

I began by simply measuring background count rates at various places along the Front Range, from the Green Mountain area in southern Lakewood (where I lived at the time), Golden, and as far north as Firestone. Some were taken indoors (γ rays only) and some 2-3 cm off the soil surface (thus including α particles). It should be noted that because I was nominally trespassing on Candelas property in fall 2013, my counts on Candelas lots were limited to under 15 minutes.

When sorted by the average counts per minute (CPM) I found what is shown in Fig. 4. Counts in basements (in both cases, before radon mitigation) were among the highest measured. Over landscaping stones up in Firestone count rates were also relatively high. But the count rate I measured in my flowerbed on the south side of Green Mountain in Lakewood was higher than what I measured on Candelas lots. It should be clear that neither my Green Mountain house in Lakewood nor my wife's house in Firestone were anywhere near the Pu contamination plumes known to exist around Rocky Flats, yet their background radiation rates were higher near the soil than those in Candelas.

Geiger-Müller counters are generally calibrated using a known source of radiation, typically ^{137}Cs, an isotope common around fission reactors with the conveniently long half-life of 30.17 years. Calibration means that if all radiation were due to this isotope one could convert between counts per minute and the radiation dose, in 'rem' or sieverts (Sv), the official international unit for effective radiation dose. (Units are covered elsewhere on this web site.) Unless we know precisely the origins of radiation it is appropriate to quote only counts per minute.

This data (augmented, as you can see, by a few additional measurements in 2014) allowed me to put into perspective the background radiation levels around the Denver metro area and to conclude that no obviously high values were apparent where I measured in Candelas. This reassured me that the contamination undoubtedly present from plutonium around Rocky Flats gave rise to radiation rates quite comparable to background, which itself fluctuates by factors of more than 10 around the US and by 50% even within Colorado.

This was not clear to me in late 2013 but it is now: the soil around Candelas—like the soil in the Rocky Flats National Wildlife Refuge—was never cleaned up as part of the Superfund project. It was regarded as safe as it was.
I had no business mixing measurements taken inside a building (γ-only radiation) with those taken near soil (α + γ from whatever is in the soil, plus γ from cosmic rays), and total counts per minute with background-corrected [=total - background] CPM, but this figure was for me, not for consumption by other people.

Around the same time I made an estimate, based on the Krey-Hardy map (a cleanly redrawn version is at Kristen Iversen's web site, here, but it is now believed to suffer from grossly inadequate data sampling) of the excess count rate due to Pu around the Candelas lots of interest. The estimate, when augmented by the background rate I had measured in Lakewood, was in very reasonable agreement with what I measured with the Geiger-Müller counter. It is attached as a separate document at the end of *this* document.

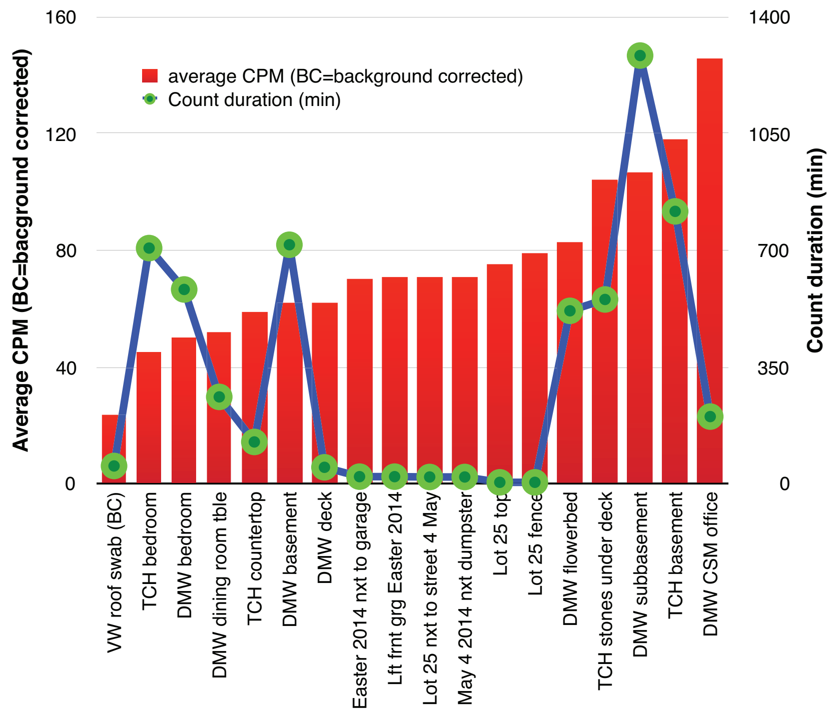


Figure 4: My count data as of spring 2014; most data is from fall 2013.

Additional key documents available in 2013

In the fall of 2013 I also examined (from the time-stamps on the documents) briefly

- From 2010, a CDC document [1] about plutonium which mentioned Rocky Flats, including a null result for excess Pu in urine among nearby residents not working at the plant. (There was considerable evidence of health impacts of Pu exposure among plant workers.)
- A position paper [2] by the Health Physics Society (adopted 1993) entitled *What about "Deadly plutonium"?* They stated,

> "The Health Physics Society believes that such inaccurate statements by the news media are at least partially responsible for much of the public anxiety and fear over issues related to radiation. The fact is that there are many people who have inhaled measurable quantities of plutonium many years ago [*Ed: That is, long enough ago that the cancer 'incubation time' is long past*] and have suffered no ill effects. The radiological hazards of plutonium are of the same types and magnitudes as those of such naturally occurring radioactive elements as radium and thorium, which are now and always have been present in the food we eat, in the water we drink, and in trace amounts in our bodies. ... As scientists who are professionally responsible for radiation protection of workers and the public, we

believe that journalists, wire services and news broadcasters should be completely factual in news stories involving radiation. When it becomes obvious that a story has been distorted, and we know the facts, we become skeptical of your honesty in all stories."

- A 2000 document [3] from Los Alamos entitled *Plutonium and Health* which reviews the radiological risks of Pu but observes that in terms of chemical toxicity, "Although dangerous, plutonium is not "the most toxic substance known to man." On a weight-by-weight basis, plutonium is less toxic than the unforgiving bacterial toxins that cause botulism, tetanus, and anthrax."
- The ATSDR (a subdivision of the US Department of Health and Human Services) Public Health Assessment for the Rocky Flats Environmental Technology Site [4] dated 2005, evidently written before the cleanup was complete. I learned that the highest off-site radiation levels were measured about 1 mile east Rocky Flats, near the Great Western Reservoir. The report flagged no risks to those choosing to move in nearby and no evidence (apart from Carl Johnson's 1981 report [5]) of elevated cancer risks for those already living nearby: "ATSDR's review of the environmental data strongly suggests that the epidemiological studies failed to detect increased cancer incidence primarily because the estimated increased theoretical cancer risk is extremely low...". (I have not been able to examine the Johnson article myself since it requires a large document charge.)
- The "Third Five-Year Report for the Rocky Flats Site, Jefferson and Boulder Counties, Colorado" (2012) [6].
- The Health Physics Society's Environmental Radiation fact sheet [7]
- The peer-reviewed 2002 journal article *Risks to the public from historical releases of radionuclides and chemicals at the Rocky Flats Environmental Technology Site* [8, 9], which introduced me to revised maps of the smoke plumes associated with the fires at the plant. This work was carried out in direct communication with a number of citizen's groups. [In 2017 this is important to remember: there was no DOE cover-up of this data.] It was my first exposure to contour plots of lifetime cancer risk attributable to Pu contamination levels, as predicted by careful modeling. They quoted values of around (0.01 to 125) $\times 10^{-6}$ for the worst-case scenario *assuming* that exposure was from direct inhalation of Pu. (In 2017 this scenario is considered extremely unlikely.) They concluded "At the 5th percentile level, the maximum cancer risk was about 10^{-7} (1 chance in 10 million) for developing cancer during a lifetime. Estimated

cancer risks at the 95th percentile level are within the range of for acceptable risks established by the US Environmental Protection Agency of 10^{-6} to 10^{-4}." I had not realized that a great deal of

FINAL REPORT, Technical Summary Report for the Historical Public Exposures Studies for Rocky Flats Phase II, Part of Task 6: Technical Support for Public Involvement, September 1999, Radiological Assessment Corporation, RAC Report No. 14-CDPHE-RFP-1999-FINAL

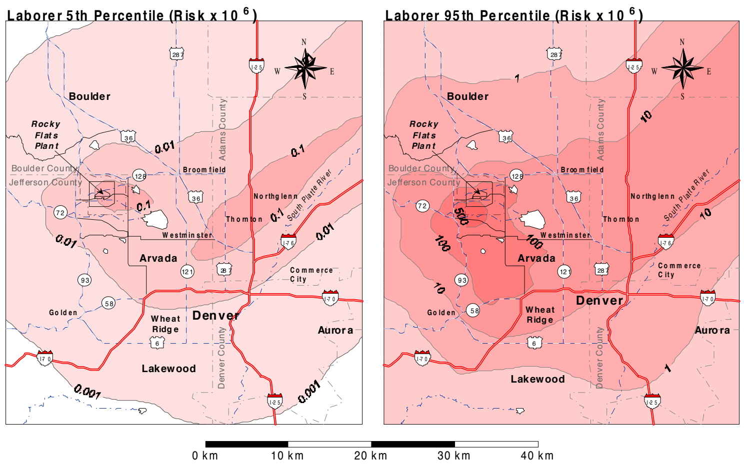


Figure 8. Lifetime cancer incidence risk from plutonium inhalation for the laborer scenario; 5th percentile (left plot) and 95th percentile (right plot). Risk values have been multiplied by 10^6 so a value of 1.0 in the plot represents a cancer risk of 1×10^{-6} or 1 chance in 1 million of developing cancer.

Figure 5: Figure from the 1999 Radiological Assessment Corporation report carried out on behalf of the Colorado Department of Public Health and Environment.[9]. This is a clearer version of the figures published in 2002 [8]

the risks due to the plant before its closure came from beryllium and volatile organic compounds (VOCs), most especially carbon tetrachloride.

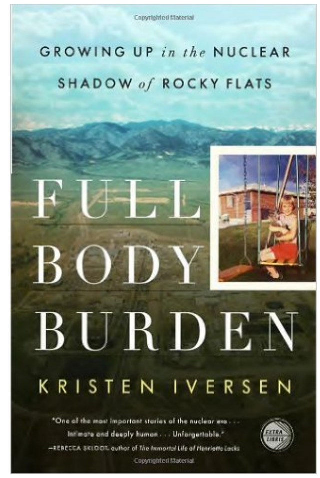
This was the single most influential document I read.

- I examined a follow-up peer-reviewed journal article *A comparative study of ^{239,240}Pu in soil near the former Rocky Flats Nuclear Weapons Facility, Golden, CO* [10] The abstract stated

> A dose reconstruction study for the Rocky Flats facilities, begun in 1990, provided a unique opportunity for concerned citizens to design and implement field studies without participation of the DOE, its contractors, or other government agencies. The Citizens Environmental Sampling Committee was formed in late 1992 and conducted a field sampling program in 1994. Over 60 soil samples, including both surface and core samples, were collected from 28 locations where past human activities would have minimal influence on contaminant distributions in soil. . . The distribution of plutonium (as ^{239,240}Pu) in soil was consistent with past sampling conducted by DOE, the Colorado Department of Public Health and Environment, and others. Elevated levels of ^{239,240}Pu were found immediately east of the Rocky Flats Plant, with concentrations falling rapidly

> with distance from the plant to levels consistent with background from fallout. Samples collected in areas south, west, and north of the plant were generally consistent with background from fallout. No biases in past sampling due to choice of sampling locations or sampling methodology were evident. The study shows that local citizens, when provided sufficient resources, can design and implement technical studies that directly address community concerns where trust in the regulated community and/or regulators is low.

Note: [2017] This means that citizen groups suspicious of DOE results had *already* done their own, independent measurements and *confirmed* DOE and Colorado Department of Public Health and Environment data.



- I bought and skimmed through Kristen Iversen's book *Full Body Burden*.

  It was a personal history of what it was like to live around Rocky Flats through the fires and with many friends who worked at the plant itself. I found no compelling evidence that areas around Rocky Flats were unsafe for newcomers who had not been exposed to radiation during plant operations.

- The 1992 peer-reviewed journal article *Is there a large risk of radiation? A critical review of pessimistic claims* [11] which explicitly reviewed a number of US and British 'cancer clusters' claims, statistical fallacies to which such claims are vulnerable, and the terminology of epidemiology. One section of the paper, entitled *Does plutonium from Rocky Flats cause excess cancers?*. It reviewed previous work on cancer epidemiological studies around Rocky Flats and rejects the Carl Johnson work (spoken of reverentially by long-time opponents of the wildlife preserve but unavailable without purchasing the article) as incomplete and unsatisfactory.

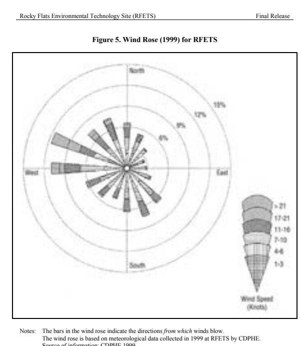


Figure 6: Typical 'wind rose' for what was termed the Rocky Flats Environmental Test Site at the time (2005); from [4]

- Because at the time I did not know what to make of claims of possible wind-borne radioactive particulates, I also examined wind patterns around the plant site.

  The lots we examined were southeast of the cleaned-up plant site area; prevailing winds from the diagram are mostly from the west or west northwest.

- As would any prospective house buyer, I examined city records for tax base concerns, details about the Candelas water supply (from the city of Arvada), looked at flood plain maps for the city of Arvada, and verified that drainage for the lots of interest was *toward* the wildlife preserve and not from it.

I wrote in the log I kept about the run-up to moving in "Anyone who claims there is an ongoing coverup is dissembling or is a conspiracy theorist. Careful, thoughtful reports which do plausible estimates of cancer rate scenarios are chockablock on the Colorado state website."

What I concluded

By late November 2013 I had concluded that (i) my own data was consistent with what had been *measured* by others; (ii) radiation levels around Rocky Flats were, in fact, comparable to background levels; (iii) there was no compelling epidemiological evidence of excess cancers around Rocky Flats, and (iv) independent estimates of cancer risks were well below risks that to me would provoke alarms (they were in the range of 1 in one million in terms of *excess* risk–the risk over and beyond that due to background radiation, which I could not control at all).

I thus concluded (with input from my wife) that it was safe for us to buy a lot in Candelas, and we did so. The only concession we made to the presence of Rocky Flats (the *possibility* of windblown radioactive dust) was to have an electrostatic precipitation air cleaning system installed in our furnace. (My wife and I also have some pollen allergies, so this was a good idea in any case.)

The opinions I formed in late 2013 have since then been reinforced by the reading and additional measurements I have made, as reported in other documents on this web site.

For completeness, I include as separate documents the estimate I made of expected count rates based on the Krey-Hardy map, and a second summarizing the locations and results of soil samples.

References

[1] Agency for Toxic Substances and Disease Registry. *Toxicological Profile for Plutonium*. Tech. rep. U.S. DEPARTMENT OF HEALTH and HUMAN SERVICES, 2010. URL: https://www.atsdr.cdc.gov/toxprofiles/tp143.pdf.

[2] Health Physics Society. *WHAT ABOUT "DEADLY PLUTONIUM"?* Tech. rep. Health Physics Society, 1993. URL: http://hps.org/documents/plutonium2.pdf.

[3] George L Voelz and Ileana G Buican. *Plutonium and Health*. Tech. rep. 26. Department of Energy, Los Alamos National Laboratory, 2000. URL: http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-00-1613.

[4] Agency for Toxic Substances and Disease Registry. *Rocky Flats Environmental Technology Site U.S. Department of Energy Golden , Colorado EPA Facility Id : CO7890010526*. Tech. rep. US Department of Health and Human Services (Public Health Service), 2005. URL: https://www.atsdr.cdc.gov/hac/pha/RockyFlats(DOE)/RockyFlatsPHA051305a.pdf.

[5] Carl J. Johnson. "Cancer incidence in an area contaminated with radionuclides near a nuclear installation". In: *Ambio* 10.4 (1981), pp. 176–182. ISSN: 0044-7447.

[6] Legacy Management) US (DOE. *Third Five-Year Review Report for the Rocky Flats Site Jefferson and Boulder Counties, Colorado*. Tech. rep. 2012. URL: https://www.lm.doe.gov/Rocky_Flats/Third_Five-Year_Review_Report.pdf.

[7] Health Physics Society. "Background Radiation Fact Sheet". In: June (2012), pp. 2–5. URL: http://hps.org/documents/background_radiation_fact_sheet.pdf.

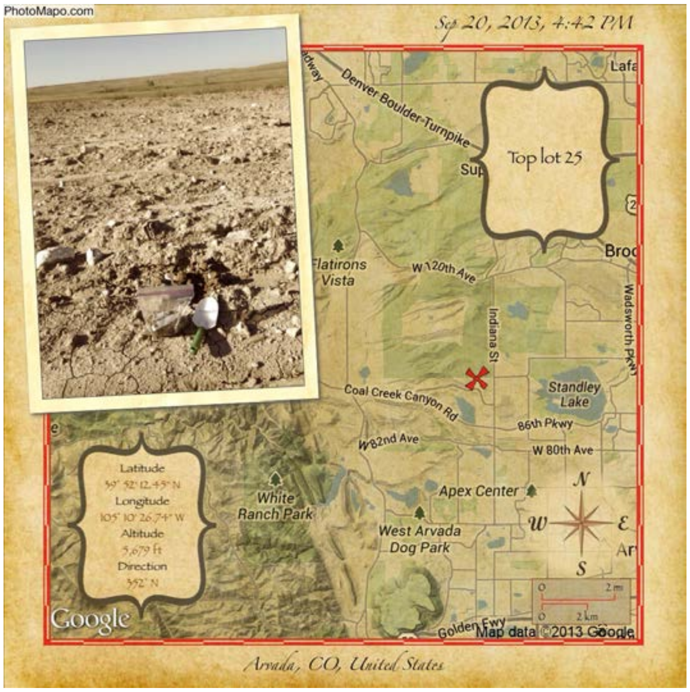
[8] John E Till et al. "Risks to the public from historical releases of radionuclides and chemicals at the Rocky Flats Environmental Technology Site". In: *Journal of Exposure Analysis and Environmental Epidemiology* 12.5 (2002), pp. 355–372. ISSN: 10534245. DOI: 10.1038/sj.jea.7500237. URL: http://www.nature.com/doifinder/10.1038/sj.jea.7500237.

[9] Jill M. Weber Helen A. Grogan, Patricia D. McGavran, Kathleen R. Meyer, H. Robert Meyer, Justin Mohler, Arthur S. Rood, Warren K. Sinclair, Paul G. VoillequeÌĄ. *Technical Summary Report for the Historical Public Exposures Studies for Rocky Flats Phase II; Part of Task 6: Technical Support for Public Involvement*. Tech. rep. 1999. URL: http://s197420.gridserver.com/wp-content/uploads/2014/12/Rocky_Flats_Technical_Summary.pdf.

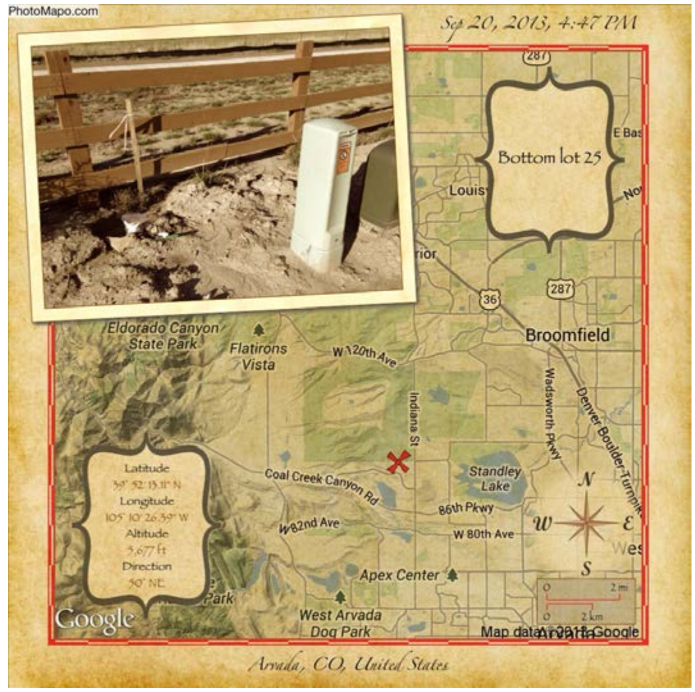
[10] Todd D. Margulies et al. "A comparative study of 239,240Pu in soil near the former Rocky Flats Nuclear Weapons Facility, Golden, CO". In: *Journal of Environmental Radioactivity* 75.2 (2004), pp. 143–157. ISSN: 0265931X. DOI: 10.1016/j.jenvrad.2003.12.005.

[11] Adnan Shihab-Eldin, Alexander Shlyakhter, and Richard Wilson. "Is there a large risk of radiation? A critical review of pessimistic claims". In: *Environment International* 18.2 (1992), pp. 117–151. ISSN: 01604120. DOI: 10.1016/0160-4120(92)90002-L.

These bibliographic entries above reflect access in Fall 2017, not in 2013. *Reminders:* (i) Just click on a reference in the text to reposition the cursor in the bibliography; (ii) generally by simply clicking on the URL field or the DOI field in a bibliographic entry will fire up your Web browser and take you to where the original file is available.

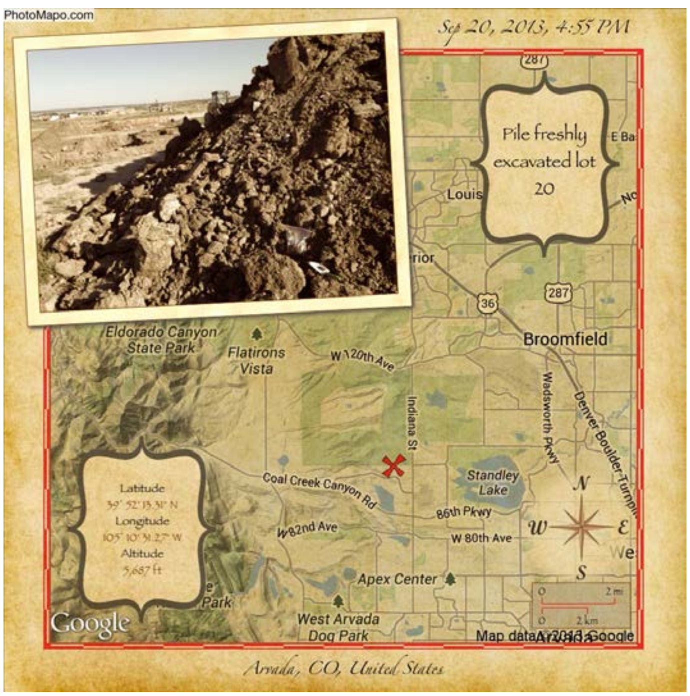


Lot 25: Top; sample A
39 52 12.45 N, 105 10 26.74 W



ENV-2013012107-
<0.04 ± 95% CI; MDA 0.04 pCi/g

Lot 25: Bottom; sample B
39 52 13.11 N, 105 10 26.39 W
ENV-2013012108-
<0.06 ± 95% CI; MDA 0.06 pCi/g



Lot 20: sample C
39 52 13.31 N, 105 10 31.27 W
ENV-2013012109-
<0.07 ± 95% CI; MDA 0.07 pCi/g

Mazur Instruments 5-minute timed measurements, 20 Nov 2013
My back yard: 0.022 mR/hr = milliRoentgens/hr
Top lot 25, just down from street sidewalk: 75 CPM
Below lot 25, shallow ditch between barbed wire Rocky Flats boundary and running path sidewalk: 79 CPM

Q bq/m^2 = 0.04771 Q cnts/min (2Pi steradians, given detector geom)
59-85 CPM (lowest 2 zones of Krey/Hardy map)

Standard Pacific/Candelas estimates as of 21 November, 2013

Many maps display radioactive contamination in Bq/m^2 (Becquerels per square meter). Since 1 Bq ≡ 1 disintegration per second, we can estimate the number of particles we expect to count per minute with the Mazur Instruments Geiger counter via

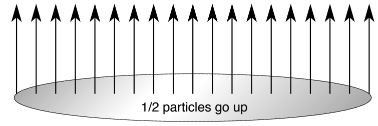


Figure 1: Assumed geometry and emission assuming *uniform* contamination

$$\begin{aligned} \text{CPM} &= Q\left[\frac{\text{Bq}}{\text{m}^2}\right]\times \pi \text{R}^2\left[\text{m}^2\right]\times\frac{1\ \text{particle/second}}{1\text{Bq}}\times 60\frac{\text{seconds}}{\text{minute}}\times\frac{1}{2} \\ &\simeq 0.04771\ Q. \end{aligned}$$

Here CPM is the average number of counts per minute, Q is the surface radioactivity in Bq/m^2, R is the Geiger-Müller pancake tube radius (half its effective diameter of 4.5 cm, neglecting transmission losses through the bottom grid), and we multiply by a trailing factor of $\frac{1}{2}$ because for uniform surface contamination half the radiation goes up (into the detector). The Geiger counter was placed less than 1 cm from the soil, less than the range of 5.3 MeV α particles in air. This geometrical estimate is crude but reasonable.

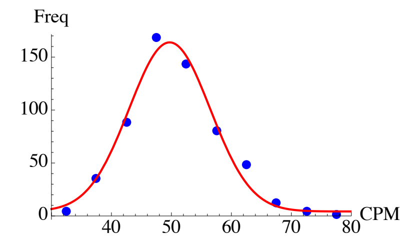


Figure 2: Background in my bedroom

Example: Standard Pacific lots, Candelas Assume a background count rate of 50 CPM, based on my data taken at home away from the ground.

The frequently-replotted Krey Hardy map shows contours of Pu contamination of from 185-740 Bq/m^2 in the two least-contaminated zones around Rocky Flats.

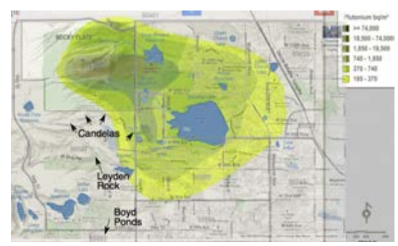


Figure 3: Krey-Hardy map, redrawn, superimposed on locations and streets

The expression above would predict a *total* CPM in the range

$$\begin{aligned} \text{CPM}_{tot} &\simeq 50 + 0.04771\times(185-740) \\ &= 59-85 \end{aligned}$$

The Standard Pacific lots lie very near the boundary between the first and second zones on the crude contour map, suggesting about 370 Bq/m^2 and hence about 68 CPM. I measured 5-minute averaged values of 75 and 79 at two locations.

Notes: The estimate count rate is in reasonable agreement with what we'd expect, but remain dominated just by background radiation. The agreement is almost definitely fortuitous:

Figure 4: Soil tests and locations

1. Background rates can vary easily by a factor of 2 or 3 and I don't have data (yet) on the background levels on the lots.

2. I cannot readily verify that what I was measuring was from ^{239}Pu (the worrisome one at Rocky Flats), which emits 5.25 MeV α particles, for which the detector efficiency should be at least 80%.