

## *Quick estimate of radiation dose from visiting the Wildlife Refuge*

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Although I will prepare a more careful analysis later, note that we have already estimated (using both my own calculations and a RESRAD run with identical input) the annual radiation dose and a 50-year excess risk of cancer for a homeowner spending 100% of his/her time on land with a  $^{239}\text{Pu}$  contamination level of 0.08 pCi/g (typical of regions near the external boundary of the Wildlife Refuge).

As we have seen, the radiation dose (and, using the 'linear no-threshold' dose-response description, thus the net excess cancer risk) is directly proportional both to the radiation *level* and to the exposure *time*. Thus to make a conservative (health-protective) estimate of the radiation dose during one year from five, 4-hour visits we can write

$$\begin{aligned} [\text{1-yr dose from visits}] \simeq & \quad [\text{1-yr dose living} \\ & \text{just outside RFNWR 100\% of time}] \\ & \times [\text{fraction of yr spent visiting}] \\ & \times \frac{[\text{rad level in Refuge}]}{[\text{rad level just outside RFNWR}]} \end{aligned}$$

Notice that (i) radiation levels within the Refuge are higher (in some areas) than they are outside, but (ii) a visitor spends far less than 100% of his time within the Refuge.

Let's look at the measurements. The 'preliminary remediation goal' (PRG) for the site was 9.8 pCi/g (substantially higher than outside the Refuge but, as we have seen in the Executive Summary, comparable to worldwide levels of radioactive thorium and potassium isotopes. Thus this level of radiation is already in the range of *background* radiation in the Rocky Mountains.

If we examine the 2006 DOE map we see that light green dots indicate regions which meet the PRG while

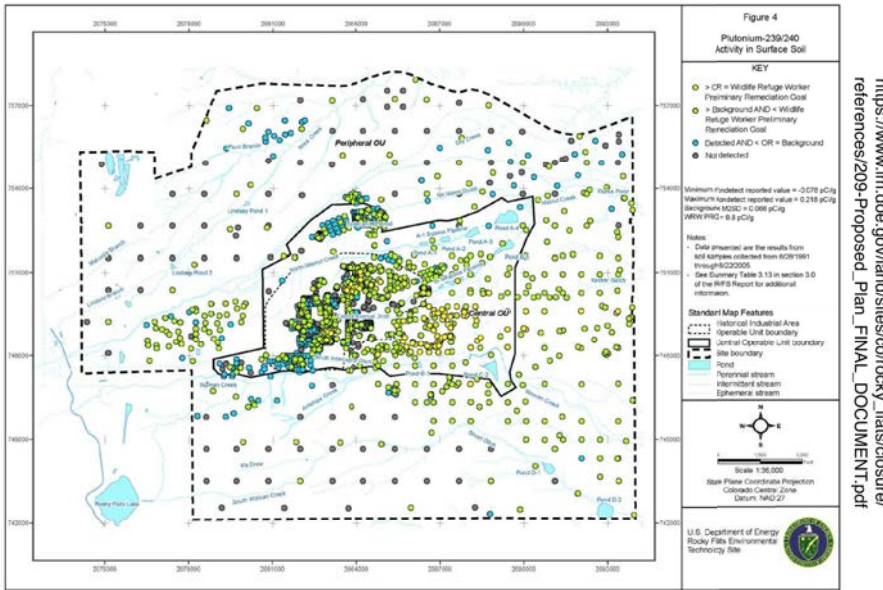


Figure 1: 2006 DOE map indicating radiation level measurements within the Wildlife Refuge and within the 'central operating unit' (COU). From [1]

[Legend: Yellow dots exceed the PRG, light green dots exceed background but meet the PRG, blue dots are less than or equal to background. Gray dots indicate 'not detected': see the original document.]

yellow dots exceed this. Almost all of the Wildlife Refuge, with the exception of a corridor on its east side, meets the requirement.

Let's assume a very conservative (high) estimate for soil radiation levels with the Wildlife Refuge of 20 pCi/g, 250 times bigger than on the Wildlife boundary. This means that the ratio of radiation level inside the Refuge to that just outside is about 250. In the document [Rocky Flats, radiation, and risk](#) we found for someone spending 100% of their time on soil contaminated with 0.08 pCi/g of  $^{239}\text{Pu}$  (a value reasonable just outside the Refuge boundaries) a yearly dose of 0.25  $\mu\text{Sv}$  and a 50-year excessive relative risk (ERR) of cancer of  $9.4 \times 10^{-7}$  as reported by RESRAD.

The five yearly visits above account for 20 hours of exposure, or 0.01282 years. Plugging into the equation

above, we find a 1-year dose from visits of

$$\approx \underbrace{250}_{\text{rad ratio}} \times \underbrace{0.01282}_{\text{fraction of year}} \times \underbrace{0.25 \mu\text{Sv}}_{\text{0.08 pCi/g 100\% of time dose}} \approx 0.14 \mu\text{Sv}.$$

(1)

Bear in mind (as usual) that in Colorado the typical annual dose from *background* radiation is about 3800  $\mu\text{Sv}$ ; see [Radiation doses: large, small, and unavoidable](#). If the visitor kept visiting for 50 years he or she would have a 'lifetime' ERR of  $7.1 \times 10^{-7}$ .

So: this estimate indicates that despite the higher radiation levels inside the Refuge, the net extra dose is immensely smaller than what a visitor *already* gets from living in Colorado.

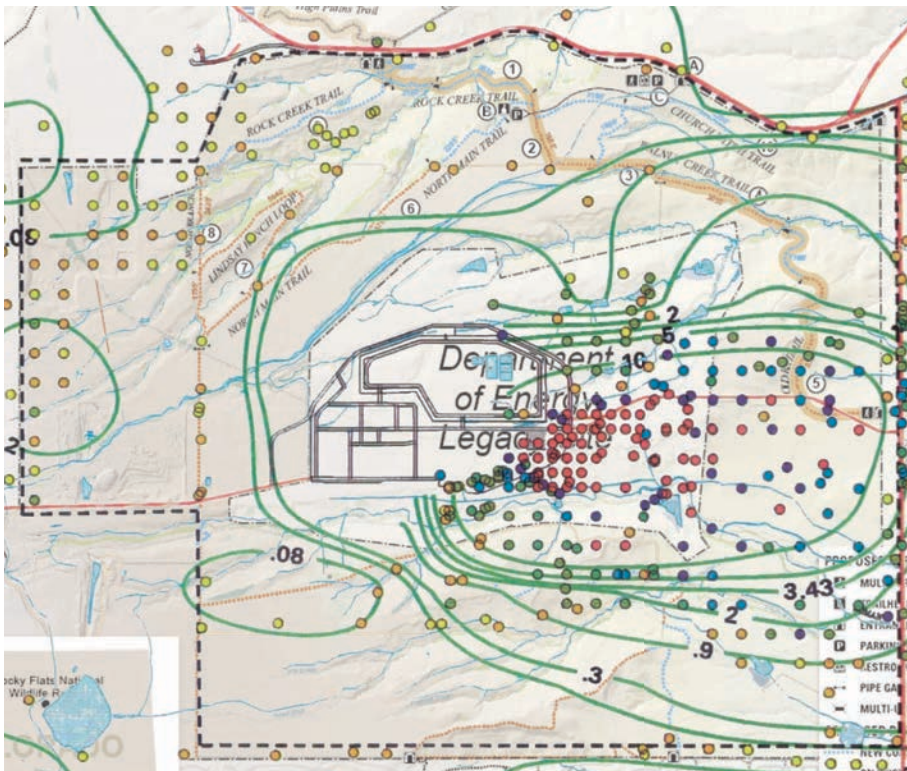


Figure 2: Radiation level contour map from 2006 superimposed on recent map of proposed trails.

In fact, when one hastily superimposes the 2006 map of radiation contours on top of a reasonably current trail map of the Refuge one sees what is shown in Fig. 2. (As you have seen elsewhere, the contour map of radiation levels shows markers inside the 'central operating unit'

that I believe are now longer there.) One finds the following for some of the proposed trails:

1. The Lindsay Gulch Loop is confined to an area where contours are between 0.08 and 0.02 pCi/g;
2. The North Main Trail has levels which range between 0.2 and 0.3 pCi/g;
3. the Walnut Creek Trail ranges from 0.2 to 2. pCi/g except in the easternmost part, where there are sections over 10 pCi/g;

### *References*

- [1] U.S. (Department of Energy). "Rocky Flats Environmental Technology Site Proposed Plan DOE Announces the Proposed Plan for the Rocky Flats Environmental Technology Site". In: (2006), pp. 0-9. URL: <https://www.lm.doe.gov/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=2982>.