14503

Army Anagnostopoulos Exh. # 1-B

[Originally Attached As EXHIBIT HWA # 3 to Witness Anagostopoulos' pre-filed testimony]

U.S. NUCLEAR REGULATORY COMMISSION
In the Matter of U.S. Army (Jefferson Proving Ground)
Docket No. 40-8838-MLA Official Exhibit No. Army Exh. # 1-B
OFFERED by (A[illegible]ensee) Intervenor ______
NRC Staff Other ______
IDENTIFIED on ______ Witness/Panel ______
Action Taken: ADMITTED REJECTED WITHDRAWN
Reporter/Clerk ______

Environmental Radioactivity Form Natural, Industrial, and Military Sources, Fourth Edition, Esenbud and Gesell, Academic Press, 1997,

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Docket No. 40-8838-ML

TEMPLATE=SECY-028

SECY-02

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From Natural, Industri... Military Sources

FOURTH EDITION

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TABLE 6-5

Average Uranium Concentration in [illegible]arious Rocks[a]

Rock type	Uranium concentration		
	ppm	[illegible] g⁻¹	Bq kg⁻¹
Acid igneous	3.0	[illegible]	37
Intermediate igneous	1.5	[illegible]	18
Basic igneous	0.6	[illegible]	7.3
Ultrabasic igneous	0.03	[illegible]	0.37
Meteorites	0.003	[illegible]	0.037
Phosphate rock (Florida)	120	[illegible]	1500
Phosphate rock (N. Africa)	20–30	[illegible]	240–370
Bituminous shale (Tennessee)	50–80	[illegible]	610–980
Normal granite	4	[illegible]	49
Limestones	1.3	0.43	16
Other sedimentary rocks	1.2	0.40	15

[a]From Lowder and Solon (1956).

TABLE 6-6

Ranges[a,b] and Averages of the Concentrations of ^{40}K, ^{232}Th, and ^{238}U in Typical Rocks and Soils[c]

Material	Potassium-40		Thorium-232		Uranium-238	
	% total K	Bq kg⁻¹	ppm	Bq kg⁻¹	ppm	Bq kg⁻¹
Igneous rocks						
Basalt (crustal ave.)	0.8	[illegible]	[illegible]	[illegible]		
Mafic	0.3–1.1	70–400	1.6, 2.7[c]	7, 10[c]	0.5, 0.9[c]	7, 10[c]
Salic	4.5	1100–1500	16, 20[c]	60, 80[c]	3.9, 4.7[c]	50, 60[c]
Granite (crustal ave)	>4	>1000	17	70	3	40
Sedimentary rocks						
Shale sandstones	2.7	800	12	[illegible]0	3.7	40
Clean quartz	<1	<300	<2	[illegible]8	<1	<10
Dirty quartz	2?	400?	3–6?	0–25?	2–3?	40?
Arkose	2–3	600–900	2?	[illegible]8	1–2?	10–25?
Beach sands	<1	<300	6	[illegible]5	3	40
Carbonate rocks	0.3	70	2	8	2	25
All rock (range)[d]	0.3–4.5	70–1500	1.6–20	7–80	0.5–4.7	7–60
Continental crust (ave.)	2.8	850	10.7	41	2.8	36
Soil (ave.)	1.5	400	9	3[illegible]	1.8	22

[a]Examples of materials outside the ranges can be found, but quantities are relatively small.

[b]One Bq kg⁻¹ = 0.027 pCi g⁻¹ [illegible]

[illegible]iba, 1949). Uranium in commercial p[illegible]
[illegible] Chapter 7.
[illegible]ause uranium occurs in soils and ferti[illegible]
[illegible] and human tissues. The daily intake [illegible]
[illegible]g radionuclides in a sample New [illegible]
[illegible]6-7 (Fisenne *et al.*, 1987). These data [illegible]
[illegible] (Fisenne and Keller, 1970; Holtzma[illegible]
[illegible], the annual intake of uranium from a[illegible]
[illegible]20 pCi) (NCRP, 1987a).
The intake of uranium from tap water ca[illegible]
[illegible] total intake depending on concentrat[illegible]
[illegible] *et al.* (1985) reported population-averag[illegible]
[illegible] in the United States that range typicall[illegible]
[illegible] in many eastern states, to 13 Bq m⁻³ ([illegible]

TABLE 6-7

Radionuclides in a New Yor[illegible]

Type of food	Annual intake (kg y⁻¹)	[illegible]	[illegible]
[illegible]sh vegetables	48	3.0	3.[illegible]
[illegible]nned vegetables	22	0.27	0.[illegible]
[illegible]ot vegetables	10	0.34	0.[illegible]
[illegible]otatoes	38	0.11	0.[illegible]
Dry beans	3	0.25	[illegible]
[illegible]	50	[illegible]	
Canned fruit	11	0.08	0.[illegible]
Fruit juice	28	0.04	0.[illegible]
Bakery products	44	3.5	2.[illegible]
Flour	34	0.43	0.[illegible]
Whole-grain products	11	0.75	0.[illegible]
Macaroni	3	0.03	0.[illegible]
Rice	3	0.02	0.[illegible]
Meat	79	0.40	0.[illegible]
Poultry	20	0.04	0.[illegible]
Eggs	15	0.04	0.[illegible]
Fresh fish	8	0.38	0.[illegible]
Shellfish	1	6.0	5.[illegible]
Dairy products	200	0.54	[illegible]
Rounded total		[illegible]	[illegible]

potassium content of the body is under strict homeostatic control and is not influenced by variations in environmental levels. For this reason, the dose from ^{40}K within the body is constant.

Rubidium-87

Of the two rubidium isotopes found in nature, ^{85}Rb and ^{87}Rb, only the latter is radioactive, with a half-life of 4.8×10^{10} years. Rubidium-87 is a pure β emitter, and it is present in elemental rubidium in the amount of 27.8%, which endows this element with a specific activity of 0.02 μCi g^{-1} (0.74 kBq g^{-1}). Pertsov (1964) quotes Vinogradov in listing the rubidium content of all but highly humic soils as about 0.01%. The ^{87}Rb content of ocean water has been reported to be 2.8 pCi L^{-1} (104 Bq m^{-3}), with marine fish and invertebrates ranging from 0.008 to 0.08 pCi g^{-1} (0.3 to 3 Bq kg^{-1}) wet weight (Mauchline and Templeton, 1964). It is estimated (NCRP, 1987a) that the whole-body dose from ^{87}Rb is 0.3 mrem y^{-1} (3 μSv y^{-1}) on average.

NATURAL RADIOACTIVITY IN PHOSPHATE FERTILIZERS

Phosphate fertilizers are used in huge amounts around the world and are essential for food production. The natural resource from which agricultural phosphorus is obtained is phosphate rock, found in sedimentary formations, usually interbedded with marine shales or limestones. The United States is a major phosphate user, with extensive mines located in Florida, North Carolina, Tennessee, Idaho, Montana, Utah, and Wyoming. In recent years, more than 90% of the phosphate rock mined in the United States has come from Florida. The location of the Florida phosphate deposits is shown in Fig. 6-6. They average 4 m in thickness and lie under sand and clay overburdens that vary from about 1 to 10 m in thickness (Roessler *et al.*, 1980). As the surface mining operations proceed, the overburdens, sand tailings, and other waste products are returned to the land.

It has been known since early in this century that the phosphate rocks contain relatively high concentrations of uranium. Depending on the economics of the uranium industry, uranium has periodically been extracted as a sidestream of phosphoric acid production (NCRP, 1993b). The concentration of uranium in U.S. phosphate ores ranges from 8 to 400 ppm. The phosphate rocks from the important Florida deposits average 41 ppm with ^{226}Ra in secular equilibrium. Phosphate rock is mined in huge quantities: it is reported that in 1974, about 26 million tons of ore were sold for fertilizer production in the United States, and that the ore contained about 1000 Ci

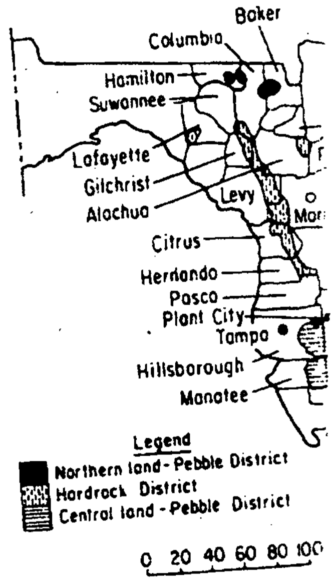

FIGURE 6-6 Phosphate deposits in Florida.

(37 TBq) of ^{226}Ra in equilibrium with ^{238}U
tons of ore had been removed from
Several types of phosphate fertilize
ally blended for application in the fiel
separate in the process of producing p
fertilizer manufacture (Roessler *et al.*,
The radium passes to the gypsum p
fraction of the radioactivity is reject
mounds of stored waste products.
Elevated concentrations of ^{222}Rn
on land reclaimed from phosphate m
Roessler *et al.*, 1983). A survey of indo
sures in buildings on or near the Flori
by Guimond and Windham, who foun
land contained more than 0.01 WL a
High levels were also found in structu

not been mined, but relatively few measurements were made. Although these ^{222}Rn concentrations are above the average concentrations found in U.S. homes, it is noteworthy that many homes in areas of the United States contained higher concentrations than are found in the phosphate regions.

The high concentrations of ^{226}Ra also result in increased γ-radiation exposure in homes built on reclaimed land. Johnson and Bailey (1983) found excess γ dose to average 17 mrem y^{-1} (0.17 mSv y^{-1}), with values ranging as high as 166 mrem y^{-1} (1.66 mSv y^{-1}).

The radioactivity associated with the land reclaimed prior to the 1940s tends to be higher than that in land reclaimed more recently, because methods have been developed for separating the phosphate-rich clay fraction of the deposit. A major fraction of the radium and uranium associated with the phosphate minerals was formerly returned to reclaimed land (Roessler *et al.*, 1980). In 1978, the Florida Department of Health and Rehabilitation Services ruled that some sort of rehabilitation would have to be applied to homes in which the ^{222}Rn decay product concentrations exceeded 0.029 WL. This is about three times the remedial action level suggested by the Surgeon General for application to homes constructed over uranium mill tailings in Grand Junction, Colorado (see Chapters 7 and 15). It has been estimated that of the approximately 4000 buildings on reclaimed land in 1978, 6–10% would require some kind of corrective action. Roessler *et al.* (1980) found that most of these structures were located on land reclaimed prior to the 1940s. The radium and radon contents of water supplies from the phosphate rock region of North Carolina were investigated by Watson and Mitsch (1987), who found the levels to be well within acceptable limits.

The contribution of uranium and radium to agricultural lands owing to the application of phosphate fertilizers does not significantly affect the dose received from the general population (Kirchmann *et al.*, 1980; Ryan, 1981). However, phosphorus, in the form of mineral phosphate rock, is sometimes added to cattle feed and this practice can result in increased levels of uranium and radium in cows' milk (Reid *et al.*, 1977). However, continued application of phosphate fertilizers to soil over a period of many years could eventually double the radium and uranium content of the soil, which would result in a corresponding doubling of the dose to bone from this source. Spalding and Sackett (1972) found that the uranium content of North American rivers is higher than in the past, which they attribute to increased runoff of phosphate fertilizers.

NATURAL RADIOACTIVITY IN BUILDING MATERIALS

The Federal Republic of Germany conducted a survey of 30,000 dwellings and found that, on average, the external radiation exposure was 33% higher

within the dwellings than outdo
absorb the radiation that origi
the building is more than comp
the materials of construction (K
ity in selected building materials
spend 90% of their time indoors.
radiation is increased somewhat
sorbed dose to the population of
from 40 to 80 mrad y^{-1} (0.4–0.8
compared to 30 to 60 mrad y^{-1} (
exposure. The natural radioactiv
studied by Chang *et al.* (1974).

Wood-frame residences on th
ity and provide some shielding a
underlying soil. The NCRP (1987
and Canada, indoor dose rates t
outdoor rates in the vicinity, on av
Indoor dose rates can vary conside

Two important by-products fro
gypsum and calcium silicate slag, bo
industry. Use of these products in
dose (EPA, 1990b; Laiche and Scot
a source of indoor ^{222}Rn, as was dis
usually much less important than in

NATURAL RADIOACTIVITY

Coal contains radionuclides of the u
^{40}K. The uranium and thorium conc
assembled from various sou
Table 6.7, which includes data on mo
States. The mean value for all coals sa
4.5 μg g^{-1} for natural thorium, which is
found in soils and rocks, also shown i
estimated slightly lower average conce
3.2 ppm for thorium based on 5000 sam
areas (EPA, 1984a). Most investigators
clides of the uranium and thorium se
et al. (1980) noted that there have be
the evidence for disequilibria to be co

The quantity of radionuclides disc
coal consumed depends on the conce