ENERGY FACILITY SITING COUNCIL

RADIOACTIVE WASTE MATERIALS RULEMAKING ADVISORY COMMITTEE

Partial Rulemaking Record for EFSC 9-1978

INDEX

BEFORE THE

ENERGY FACILITY SITING COUNCIL

In the Matter of the Adoption of a rule defining "Radioactive Material" as it relates to ORS 469.525.	NOTICE OF PROPOSED ADOPTION OF A RULE DEFINING "RADIOACTIVE MATERIAL"

1. On June 27, 1978 at 10:00 A.M. a public hearing will be held in Room 122, State Highway Building, Salem to consider adoption by the Energy Facility Siting Council of a proposed rule which defines "radioactive material" for the purpose of clarifying what materials can and cannot be disposed of in Oregon consistent with ORS 469.525. In addition, Rule 345-50-005, related to radioactive waste disposal sites, is proposed to be deleted.

2.. The proposed rule provides as follows:

For the purposes of ORS 469.525, "radioactive material" is defined as:

a. Man-Made Radioisotopes in excess of those concentrations listed in OAR 333-22-150, Oregon Regulations for the Control of Radiation, dated June 1977, Part B, Schedule A, Column II.

b. Naturally Occurring Radioisotopes that, if accumulated over a 40-year period at one location, would exceed the criteria contained in OAR 333-22-150, Oregon Regulations for the Control of Radiation, dated June 1977, Part C, Sections C104, C104.1, C105(a) and C106(a). In determining whether naturally occurring radioisotopes exceed the criteria in a particular circumstance, the EFSC will take into consideration:

i the present or anticipated rate of accumulation; and,

ii the extent to which such isotopes will be mixed with other materials and the nature of such materials.

c. This definition applies to material as it exists on the date this rule is adopted, or the time at which disposal is proposed, whichever is most recent.

3. Rule 345-50-005, which was adopted in 1972, appears to have been rendered obsolete by ORS 469.525. Rule 345-50-005 provides for storage or disposal of radioactive materials only at sites licensed by the Department of Environmental Quality with the exception of wastes under the authority of the USAEC which require site approval by EFSC. By contrast, ORS 469.525 prohibits disposal facilities for radioactive materials.

4. Among the issues to be considered at the hearing are:

a. The extent to which the proposed rule fulfills the intent of the Legislature to prohibit, under ORS 469.525, the establishment, operation, or licensing of radioactive waste disposal facilities;

b. The extent to which alternative wording of the proposed rule would promote more effective state regulation;

c. the compatability of the proposed rule with other statutes and ORS Chapter 453 in particular;

d. the impact of the proposed rule on existing and future accumulations of radioactive materials in the State of Oregon; and

e. any consequences of deleting Rule 345-50-005.

5. Interested persons may present their views or arguments orally or in writing at the hearing. Written testimony submitted to the Energy Facility Siting Council in care of Mr. Don Godard, Oregon Department of Energy, Room 111, Labor and Industries Building, Salem, Oregon 97310 prior to June 27, 1978 will be considered by the Energy Facility Siting Council in their deliberations.

6. Dr. W. Kelly Woods has been designated by the Council to preside over and conduct the hearing.

7. A copy of the "Statement of Need" supporting the proposed rule can be obtained from Don Godard at the Department of Energy, Labor and Industries Building, Room 111, Salem, Oregon 97310.

Dated May 19, 1978

Don Godard

Donald W. Godard, Administrator
Siting and Regulation

BEFORE THE

ENERGY FACILITY SITING COUNCIL

In the Matter of the Adoption of a rule defining "Radioactive Material" as it relates to ORS 469.525	STATEMENT OF NEED

The Energy Facility Siting Council proposes to adopt a rule to define "Radioactive Material" for the purpose of clarifying what materials can and cannot be disposed of in Oregon consistent with ORS 469.525.

(a) Legal Authority: ORS 469.470 and 469.510

(b) Need for the Rule:

The 1977 Oregon Legislature assigned to the Energy Facility Siting Council the responsibility for radioactive "waste disposal facilities" and prohibited the issuance of site certificates for any such facilities. Several sites currently exist in Oregon where waste materials containing low-levels of naturally occurring radioactive contamination have been or are being generated. According to the Attorney General's opinion No. 7611 dated April 25, 1978, it is the responsibility of the Energy Facility Siting Council to define which of these materials constitute "radio-active materials", the disposal of which is prohibited by ORS 469.525.

(c) Documents Relied Upon:

(1) Attorney General's opinion No. 7611 issued April 25, 1978.

(2) OAR 333-22-150 commonly referred to as "State of Oregon Regulations for Control of Radiation".

JMP:sa
5/18/78

PRESENTATION BY DOE
TO THE
ENERGY FACILITY SITING COUNCIL
HEARING RELATING TO THE DEFINITION OF
"RADIOACTIVE MATERIALS"

INTRODUCTION

The rule as published in the "Notice of Proposed Adoption of a Rule" was drafted with the intent that the Energy Facility Siting Council would prohibit the disposal of any radioactive materials which present a sufficient risk to public health that their possession and use is required to be licensed by the Health Division. Today, I would like to focus on the extent to which the proposed rule accomplishes that purpose and the effect that such a rule would have on the existing waste disposal practices in Oregon.

For the sake of simplicity, my presentation is separated into two parts - first the general subject of man-made radioisotopes, and second, the more difficult problem of naturally occurring isotopes.

MAN-MADE RADIOACTIVE MATERIALS

As proposed, the definition references only the levels of radioactivity considered as "exempt concentrations" in the regulations of the Health Division. Through discussions with Health Division and others, it has come to the attention of the Department staff that this definition may not be completely adequate. We have prepared a revised wording (Option 2) which I would like to present at this time as the Department's recommendation.

There are basically three reasons for the proposed modification. First of all, it is more precise in that it specifies that man-made materials include by-product, special nuclear, and accelerator produced materials and incorporates existing, accepted definitions for these. Second, by referencing the entire Section B.4 of the Oregon Regulations for the Control of Radiation, this modification incorporates both the "exempt concentrations" and also the "exempt quantities" provisions of the Health Division regulations. This modification is important because situations exist where materials are present in high concentration when viewed in terms of activity per gram; however, the total amount is so low that it is almost non-existent. Conversely, material in extremely low concentration, if accumulated in large quantity, could exceed a preset "exempt quantity" without presenting any risk. Third, it also adopts by reference exemptions for certain consumer products in which man-made radioactivity have been incorporated. These products are

manufactured either under an NRC license or a license from a compatible regulatory body which determined that unregulated distribution to the public does not pose any hazard to the public health and safety. Among these products are such items as watches, electron tubes, compasses, and smoke detectors.

With these modifications, the proposed rule should be fully compatible with Health Division regulations. The staff does not see any rationale for adopting a rule either more or less stringent than this proposal. All "radioactive material", exceeding these levels, currently disposed of by individuals and corporations in the state is packaged and shipped to licensed out-of-state disposal facilities (primarily to the low level disposal facility at Hanford Washington). Materials which would be exempt from the definition are currently exempt from regulation as far as possession and use are concerned. Enforcing regulation on the disposal of them would, therefore, be virtually impossible and even if successful, would have little, if any, impact on public health and safety.

As there are currently no known disposal sites in Oregon for man-made radioactive materials as defined in the proposal presented today, the effect of its adoption would be to maintain the status quo. It would effectively forbid the Health Division from licensing a radioactive waste disposal site for such material in the state at any time in the future.

Before leaving the topic of man-made radioactive waste, I wish to emphasize that this proposed rule does not, nor is it intended to deal with the question of the definition of temporary storage as it relates to spent fuel at Trojan. There is no question but that it would prohibit off-site disposal of spent fuel.

NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM)

A definition identical to that proposed for man-made radioactive materials could be adopted for the naturally occurring materials and a proposed wording for this has been prepared (Option 3). The Department staff does not believe, however, that such a rule complies with the statuatory mandate or the Attorney General's opinion. Specifically, Section C.105(b) and C.106(b) of the Oregon Regulations for the Control of Radiation (which are referenced in Section B.4(a)(2)) allow for either restricting access to the area where the material is possessed or used, or limiting the time individuals are present as ways to limit exposures of members of the public. While this procedure is appropriate for active users of NORM, consideration of waste disposal requirements must assume that, at some time in the future, the ability to impose such restrictions will be lost.

The Department feels that any disposal site where long term maintenance or permanent land use restriction is the only method of preventing exposure of individuals to radiation in excess the defined limits, in effect, constitutes a radioactive "waste disposal facility" under the statutes, and is prohibited by ORS 469.525. Again, as there have been

several problems raised with the ability of the proposed wording in the announcement to meet the intent, we are submitting a revised version (Option 2) of this portion of the definition for consideration.

For those who have not had the benefit of extended discussion, I would like to take a few minutes at this point to present some background on the problem which the Council faces. Naturally occurring radioactivity exists and has existed since the beginning of time in small quantities in every ounce of matter in the universe. In some areas, mineral veins, rock formations, sands, or underground waters contain considerably higher than average amounts of radioactivity. Although there are places in the world where an individual could be exposed to these higher levels of natural radioactivity, they don't represent a significant widespread concern for public health. However, if man alters this situation by removing materials to more populated areas and particularly if the radioactive materials are then concentrated, either intentionally or unintentionally, significant exposures are possible.

In 1966, when it was discovered that as much as 200,000 tons of uranium mill tailings (the waste material left behind when uranium is removed from the ore) had been used as fill material under and around homes built in Grand Junction, Colorado, studies were begun to determine the health impact of this waste. These studies have concluded that radiation

exposure resulting from this material is significant and remedial action has been initiated to reduce the exposure. Tailings have been removed from houses, and tailings piles have been fenced, covered with topsoil, and planted with vegetation to eliminate windblown distribution of the material.

Concern for repeating the mistakes which occurred in Grand Junction is widespread and the legislature has expressed that concern by incorporating NORM into the statutory definition of radioactive waste. Unfortunately, the problem is not limited to the uranium mining and milling industry.

Significant concentrations of uranium and radium have been found to exist in phosphate rock, particularly in Florida where the wastes from the production of phosphate fertilizers have been incorporated into building materials and houses have been built on lands reclaimed from mining. Resulting radiation exposures are essentially identical to those from the use of uranium mill wastes.

Concern among radiological health experts about exposures to NORM and Technologically Enhanced Natural Radioactivity, in particular, has increased considerably in the last few years. The Environmental Protection Agency estimates that, for individuals in the general population who reside near such materials, the largest radiation doses from any source may be derived from Technologically Enhanced Natural Radioactivity. Primary components of this dose in addition to uranium and phosphate processing are the burning of fossil fuels, radon in water supplies, other mining, milling, and smelting operations and construction materials

manufactured from the by-products of these operations. It is inevitable that further evaluations by the Conference of Radiation Control Program Directors and the EPA will identify other sources of radiation exposure. In particular, sources of waste containing naturally occurring radioactivity will be identified which will require proper disposal and isolation from the environment to maintain the extremely low levels of environmental contamination which are currently required.

The Health Division has identified several locations in Oregon which use NORM materials and which may or may not be affected by adoption of this rule. It is not possible, at this time, to identify for the Council exact locations which currently exceed or may in the future exceed levels set by the proposed rule; however, the possibilities requiring further evaluation include:

1) Abandoned uranium mill tailings pile at Lakeview.
2) Wah Chang rare earth processing plant in Albany
3) Approximately 20 foundries using zircon sands
4) Ash from the coal fired power plant at Boardman

In short, the situation which faces the Siting Council in this deliberation is that several sites have been identified in Oregon where the disposal of quantities of NORM may require permanent maintenance and/or land use restrictions to insure that individuals are not exposed to radiation in excess of currently accepted levels. Since the Attorney General has indicated that there is no "grandfather" provision in the law, adoption of this proposed rule would require their removal.

Submission of this proposal to the Council is with the full knowledge on the part of the staff that the economic impact on some industries may be great. There is also the realization that, even if a company were to decide that it is financially able to comply, it may be impossible to do so. This results from the fact that the existing low level radioactive waste disposal sites in other states are not designed to handle the type or quantity of NORM materials involved. The staff is also aware that the removal of the uranium mill talings pile at Lakeview, which is well stablized and fenced, could create a risk to public health and safety greater than leaving it where it is.

The Council should be aware of an additional problem which may result from adoption of the rule. ORS 469.300 (20) which defines "waste disposal facilities" exempts "a site at which the radioactive waste was used or generated pursuant to a license granted under ORS 453.635" (i.e., a Health Division licensee). The Health Division has begun issuing licenses to foundries and other industries using zircon sands. The effect of this action combined with the prohibition of off-site disposal may result in the permanent disposal of zircon sands in heavily populated areas rather than allowing their removal to a disposal site located in a remote area.

There are alternatives available to the Council:

1) It could adopt a looser definition of the radioactive materials which constitute prohibited radioactive waste. Adequate protection of

the public health would still be assured by the Health Division's imposition of disposal requirements including isolation, stabilization, permanent maintenance and land use restrictions. This alternative, the staff believes, would be inconsistent with the intent of the statutes.

2) It could delay decision until the EPA, which is currently working on proposals for defining hazardous radioactive waste, adopts their regulations. The EPA regulations will probably be expressed in terms of concentrations and quantities of individual isotopes. Unfortunately, it is unlikely that the EPA will include any other isotopes besides radium-226 in the foreseeable future. In addition, the EPA is basing their rule on radon emanation from waste containing radium and will most likely set the level identical to that obtained from application of this proposed rule. Material which exceeds that level would merely require, under EPA's rules, consideration of certain disposal techniques which have not yet been specified.

3) It could adopt the rule as proposed, evaluate the existing sites over which it then has jurisdiction, and issue orders for removal of the material. If it is the decision of the Council to follow this third alternative, the staff of the Department of Energy is prepared to recommend to the Legislature modifications to the existing statutes. These modifications would give the Legislature an alternative to imposing costly and possibly impossible remedial actions on existing locations of NORM waste by allowing the EFSC to site a limited number of waste disposal locations for low level naturally occurring radioactivity. The changes would also allow, and in fact require, the Siting Council to determine that any such sites meet all the requirements currently specified in ORS 469.375. They would allow the Health Division to require their

licensees to dispose of wastes at an approved off-site disposal location or to apply to the Siting Council for a site certificate for disposal at the point of generation, and they would allow the Council to impose disposal restrictions other than shipping out-of-state on the ash from the Boardman Coal plant and any future locations where NORM is generated. No modifications are proposed which would allow establishment of waste disposal facilities for any man-made radioactive materials.

MP:kp
6/26/78

PROPOSED REPEAL OF OAR 345-50-055

This existing rule relates to the approvals required for the disposal of radioactive waste materials in Oregon. Since the 1977 legislature prohibited such disposal, this rule is effectively null and void. Even if the statutes were to be modified in the future, the provisions of the existing rule are obsolete and would need to be completely revised.

OPTION 1 (AS PRESENTED IN NOTICE OF PROPOSED RULEMAKING)

For the purposes of ORS 469.525, "radioactive material" is defined as:

1. Man-Made Radioisotopes in excess of those concentrations listed in OAR 333-22-150, Oregon Regulations for the Control of Radiation, dated June 1977, Part B, Schedule A, Column II.

2. Naturally Occurring Radioisotopes that, if accumulated over a 40-year period at one location, would exceed the criteria contained in OAR 333-22-150, Oregon Regulations for the Control of Radiation, dated June 1977, Pact C, Sections C104, C104.1, C105(a) and C106(a). In determining whether naturally occurring radioisotopes exceed the criteria in a particular circumstance, the EFSC will take into consideration:

   a. the present or anticipated rate of accumulation; and,

   b. the extent to which such isotopes will be mixed with other materials and the nature of such materials.

3. This definition applies to material as it exists on the date this rule is adopted, or the time at which disposal is proposed, whichever is most recent.

OPTION 2

For the purpose of ORS 469.525, "Radioactive Material" shall be defined as follows:

1. Man-Made Radioactive Materials shall be defined as any material containing "by-product" or "special nuclear materials" (as defined in ORS 453.605) or "accelerator produced materials" (as defined in OAR 333-22-150, Oregon Regulation for the Control of Radiation). Any man-made radioactive materials, the possession and use of which is exempt from regulation by the Oregon Regulations for the Control of Radiation, Sec. B.4, shall be considered to be exempt from this definition.

2. Naturally Occurring Radioactive Materials (NORM) shall be defined as any nuclide found in nature as a radioactive material (i.e., radioactive but no by-product, special nuclear, or accelerator produced). Any "naturally occurring radioactive material" exempt from regulation by OAR 333-22-150, Oregon Regulations for the Control of Radiation, Part B, Sections 3, 4(b), and 4(d) shall be considered exempt from this definition. Other NORM shall be exempt from this regulation only if it can be demonstrated that a 40 year accumulation of material (generated at a rate based on the current or anticipated annual average

production), if disposed of at one location, would not result in the exposure of any individual to external gamma radiation in excess of 0.5 REM in any one year or result in the release of effluents to the air or any river or stream in annual average concentrations exceeding the values in the Oregon Regulations for the Control of Radiation, Part C, Appendix A, Table II. In calculating doses and releases, no consideration shall be given to land use restrictions or to permanent, periodic maintenance operations. Further, for the purposes of waste disposal, the material shall be considered in the form it exists when it is removed from the users equipment, systems, or settling ponds prior to any dilution or remedial action.

OPTION 3

For the purpose of ORS 469.525, "Radioactive Material" shall be defined as any substance containing "by-product material" or "special nuclear material" (as defined in ORS 453.605) or "accelerator produced material", "naturally-occurring radioactive material", or "source material" (as defined in OAR 333-22-150, Oregon Regulations for the Control of Radiation, Part A). Any "radioactive material", the possession and use of which is exempt from regulation by the "Oregon Regulations for the Control of Radiation, Part B, Sections 3 and 4, shall be considered to be exempt from this definition.

RADIOACTIVE WASTE MATERIALS

DISCUSSION OF HEARING OFFICER'S RECOMMENDATIONS

I. Introduction

On June 27, 1978 the Energy Facility Siting Council (EFSC, or "the Council") held a public hearing on proposed rules to define "radioactive material" for the purpose of clarifying what materials can and cannot be disposed of in Oregon consistent with ORS 469.525, and on proposed repeal of OAR 345-50-005. I, W. Kelly Woods, the Hearings Officer, recommend that any new rules be codified under the existing OAR 345, Division 50, Radioactive Waste Materials.

The key document in this rule-making procedure is the Attorney General's Opinion No. 7611 which I have appended to the hearing record as Exhibit 11. This opinion establishes clearly that the 1977 Legislature prohibited nuclear waste disposal in Oregon and gave the Energy Facility Siting Council and the Department of Energy responsibility for enforcing the prohibition. This prohibition is stated in ORS 469.525.

Opinion No. 7611 goes on to say, in a footnote, that the 1977 Legislature did not really mean to prohibit the disposal of all radioactive wastes in Oregon, but only those wastes consisting of radioactive material of concern

to public health. Hence, the purpose of the proposed rules is to attempt to identify those radioactive materials which, if discarded or unwanted, would have such marginal health concern that they would not be subject to the provision of ORS 469.525.

II. Pertinent Findings

1. Difficulty of the Task

Assessment of the dangers to health from radioactive materials is a very complex procedure. Variables include the hazards from eating or drinking contaminated material, from potential pathways for radioactive species to get into the food chain, from breathing contaminated air, from external radiation, from the kind of radiation (alpha, beta, gamma, or neutrons), from the half-life of the radioactive species, and from the biologic behavior of different kinds of materials within the body. Organizations such as the International Commission on Radiological Protection (ICRP) and the U. S. National Committee on Radiation Protection and Measurements (NCRP) have been studying these problems for decades. It is unreasonable to expect the Council to make an independent determination of the health hazards of various amounts of radioactivity. Instead, the

only rational course for the Council to take is to declare that those materials having such low levels of radioactivity that no license is needed for their use should be considered suitable for disposal. Normally, people should be free to dispose of materials for which they do not need a license to possess.

2. Health Division Licensing Regulations

Except as radioactive material is associated with energy facilities under the regulatory responsibility of the Council, no person in Oregon can use radioactive material unless he has a license issued by Health Division or unless he is exempted from Health Division licensing requirements.

Health Division has published Regulations for the Control of Radiation. Pertinent parts for our purposes are Parts B, C, and (letter) I. Part B spells out licensing requirements, Part C sets standards for protection against radiation, and Part I concerns radiation safety requirements for radioactive tailings.

Part C comes primarily from standards developed by ICRP and concerns all kinds of radioisotopes. A particular exception is potassium-40 for which there is no standard, since potassium-40 occurs in nature at levels substantially greater than ordinary ICRP standards would allow.

Part B is based on Part C and comes from regulations adopted by the former Atomic Energy Commission (AEC).

A trouble with Part B is that there is limited reference to naturally occurring radioisotopes since AEC did not issue licenses for use of radioactive material that occurred in nature.

Part I is procedural. It has no specific standards for naturally occurring radioisotopes but applies to material "which the Radiation Control Agency has determined to present a biological hazard to the occupational or public health and safety." Unstabilized tailings piles subject to Part I must be fenced and posted to restrict public access, there can be no unauthorized removal of material, and there are restrictions on future use of the land. By any criteria this has to be considered a waste disposal facility for radioactive material.

There is no way in which Health Division can assert that tailings piles resulting from use of zircon sands are free of biological hazard. It is out of the question to consider packaging ten million cubic feet of tailings into 50-gallon barrels and transporting them out of the state.

3. Legal and Legislative Aspects

Associated Oregon Industries argues that the Legislature only intended to prohibit in-state disposal of radioactive wastes from facilities under the regulatory

authority of the Council. This is contrary to the Attorney General's opinion as expressed in Opinion No. 7611. The Council must either reject this argument or brazenly return to the Attorney General and ask him if he really meant what he said.

Regardless of what rules the Council adopts, as long as ORS 469.525 is on the books it appears to me that at least Wah Chang in Albany and casting companies such as ESCO must go out of business and leave the state. The impact on other installations is discussed in the following section on "Rationale for the Recommended Rules". It is very probable that the Legislature did not recognize the economic implications which could result from passage of ORS 469.525 and that they might wish to reconsider in light of further information, as was done with regulations prohibiting field burning. In view of this possibility, the Council should search for legal methods to defer enforcement of any rules adopted pursuant to ORS 469.525 until after the Legislature has reconvened.

The original proposed rules set for hearing were substantially modified by the time of the hearing on June 27, to the dismay of some of the participants. I recommend another major modification, attached hereto. I propose that the Council prepare for the next Legislative session by scheduling another hearing on the rules which I have recommended with the objective of determining (1) any technical

objection to the rules, (2) any legal objection to the rules, and (3) the full impact of the rules on the economic well-being and health of the citizens of Oregon.

III. Rationale for the Recommended Rules

Repeal of Rule 345-50-005
Disposal Sites for Radioactive Waste Materials

This rule was adopted in 1972. It is rendered obsolete by ORS 469.525, and there was no testimony in the hearing record arguing for retention of the rule.

If a future legislature were to repeal ORS 469.525 it would then be necessary for the Council to adopt a rule similar to OAR 345-50-005, but the present rule is also obsolete in its reference to the role of DEQ in siting disposal grounds for radioactive wastes.

Rule 345-50-010 Purpose and Applicability

It has proven to be easier to identify radioactive materials which are declared to be exempt from ORS 469.525 than to describe materials which are subject to the statute.

Rule 345-50-015 Referenced Regulations

This rule is advisable for clarity since the Health Division Regulations do not specifically state the authority under which they were adopted.

Rules 345-50-020, 345-50-025, and 345 50-030 (1) Exempt Quantities and Concentrations

These rules could be simplified by saying instead that any material subject to licensing by Health Division is considered radioactive material for purposes of ORS 469.525. Considering the nebulous nature of Health Division regulations for naturally radioactive material, I believe the Council has an obligation to be more specific rather than delegate all decision-making to Health Division.

Rule 345-50-020 Exempt Quantities

In almost all cases the exempt quantities shown for radioisotopes in the table in Part B are repeated exactly the same in the table in Part C. Some of the gaps in Part B are filled by referencing radioisotopes listed only in Part C.

It should be recognized that the exempt quantities proposed in Rule 345-50-020 are extremely small. The rule covers minute quantities of research materials which may be relatively highly concentrated. Radioactive industrial wastes, if exempt at all from ORS 469.525, will generally find their exemption because of low concentration rather than low quantity.

Rule 345-50-025 Exempt Concentrations

The table in Part B lists for 153 radioisotopes those concentrations in air, liquids, and solids which are exempt from the need for licensing fees under Health Division regulations. However, there is no guidance for other radioisotopes.

The referenced table in Part C lists permissible concentrations of 247 radioisotopes in air and water, based upon the human body suffering insignificant effects from breathing contaminated air or drinking contaminated water at these levels. There is no guidance here regarding permissible radioactivity in solids.

We note, however, that with few exceptions the exempt concentrations (microcuries per gram of solids) in Part B are exactly ten times the concentrations (microcuries per milliliter of water) shown in Table II of Part C for soluble forms. An empirical approach is to work backwards and say that for all radioisotopic concentrations shown in Table II of Part C for water a concentration ten times greater in solids is exempt from the provisions of ORS 469.525. The rule does not appear to be excessively liberal as evidenced by the discussion of Rule 345-50-030(2) below.

If this simplifying rule should have small errors the consequences are not great. It could mean that some licensed material might be disposed of in the state, and

that some unlicensed material might still have to be shipped out of state.

Rule 345-50-030 Specific Exemptions Part (1)

Health Division has many instances where radioisotopes are exempt from the need for licensing by specific rule even though licensing would be required under a general rule. For example, Schedule C of Part B says that quantities of tritium no greater than one millicurie are exempt from licensing. It then goes on to say in Section B.4(b)(1)(i) that a watch or a clock can contain up to 25 millicuries of tritium without needing to be licensed.

The purpose of Part (1) of Rule 345-50-030 is to avoid a situation where the Council might declare it illegal to dispose of unlicensed material.

Section B.4(a)(2) exempts some radioactive materials from licensing if it can be shown that there will be limited human occupancy in "unrestricted" areas contaminated with these materials. Making a judgment that such an area is not a waste disposal facility because of limited human occupancy appears to violate legislative intent in adopting ORS 469.525.

Rule 345-50-030 Specific Exemption Part (2)

Application of proposed rules 345-50-020 and 345-50-025 would lead to the conclusion that exempt quantities

of radium-226 are limited to less than 0.1 microcurie and exempt concentrations of radium-226 are limited to less than 0.3 picocuries per gram of solids. However, on March 24, 1978 the U. S. Environmental Protection Agency (EPA) issued draft regulations stating that for radium-226 quantities and concentrations of radium-226 qualifying as radioactive wastes should be greater than 10 microcuries and 5 picocuries per gram, respectively. This increase by factors of about ten suggests that my proposed rules are adequately conservative. Since at least some people in EPA endorse the more liberal concentrations shown in their draft regulations, I believe the Council should also adopt them, subject to future revision whenever EPA comes out with final regulations regarding radium-226.

Note that this special exemption does little to alleviate the problem discussed above under "Pertinent Findings". The radium-226 content of zircon sands and uranium mill tailings runs about 100 picocuries per gram, and preliminary estimates are that ash from the Boardman coal plant will contain about 10 picocuries per gram, in contrast to only 5 picocuries per gram permitted under this rule.

Rule 345-50-030 Specific Exemption Part (3)

It is futile to permit certain concentrations or quantities of thorium-232 if this results in violating

permissible concentrations or quantities of the daughter radium-228. As long as the radium-228 is tied up in rocks with the thorium it should not present a health hazard. The more restrictive limits on radium-228 apply to separated radium which could get into ground water.

Proposed Rule 345-50-030 Specific Exemption Part (4)

In an earlier draft of this report I proposed the following additional exemption:

> (4) Abandoned piles of uranium mill tailings which have been stabilized against wind and water erosion prior to July 1, 1977, under plans approved by the Radiation Control Section.

To my dismay I have been advised by the Department of Justice that adoption of such an exemption would exceed the authority of the Council, though I have no idea who would challenge such a rule.

The only purpose of the proposed rule was to address the problem of stabilized mill tailings in Lake County. Under the preceding rules it could be illegal in the future to dispose of mill tailings in Oregon if they were sufficiently radioactive. However, the hearing record is convincing (refer Exhibit 7) that the Lakeview mill tailings are not a current health menace and that any attempt at this time to remove them from the state could present a hazard to public health and safety.

Proposed Rule 345-50-030 Specific Exemptions Part (5)

In an earlier draft of this report I also proposed the following additional exemption:

(5) Ash from coal-fired power plants for which a site certificate has been issued by the state prior to July 1, 1977.

Unfortunately I have been advised by the Department of Justice that adoption of this exemption would also exceed the authority of the Council.

The Boardman site certificate is a binding agreement between the State of Oregon and the utility. To impose unilaterally such a major change in conditions of the permit at this time would undoubtedly result in litigation and the prospect that the state would have to pick up the cost of moving the ash out of state. Alternatively, it could cause cessation of the Boardman project, loss of power to the citizens of Oregon, and state liability for construction costs incurred to date in accordance with the site certificate.

Analysis of Hearing Record

Department of Energy (Exhibit 1)

The rules originally noticed for hearing contained major gaps as well as some provisions which would have been extremely difficult to enforce. By the time of the hearing

the Department had commendably changed its mind and submitted a substantial revision to its proposed rules, identified as Option 2 in Exhibit 1.

Option 2, while superior to Option 1, still has notable defects. First, I am unsympathetic with the attempt to distinguish between man-made and naturally occurring radioactive materials. Second, it seems improper to base the hazard of naturally occurring radioactive material on the potential for receiving an external dose of gamma radiation; in this case we merely need some shielding. The prospects for release to air or river appear to be extremely subjective and difficult to quantify. I believe we need more specific standards than proposed by DOE.

Associated Oregon Industries (Exhibit 2)

AOI's first suggestion, regarding legislative intent; has already been dealt with. Their second suggestion regards delaying any action until the federal Environmental Protection Agency has "finalized guidelines and levels for the disposal of low level radioactive materials". I do not believe it is consistent with legislative intent for us to wait on EPA guidelines. However, it appears appropriate to incorporate current EPA draft limits for radium-226 into our rules.

AOI had worthwhile alterations to suggest to DOE's original rule proposal. When DOE abandoned their original

proposal and went to "Option 2" these alterations became somewhat moot.

State of Washington (Exhibits 3 & 4)

The State of Washington advises against the export from Oregon of materials which in their opinion do not represent a radiation hazard. Specifically they consider that the chlorinator residue from Wah Chang was a potential hazard only because of its location over a water table close to the Willamette River. They suggest that such potential hazards can be abated more economically by means other than shipment to Washington in the future. I believe that their attitude could change for materials which are reported by EPA to constitute a radiation hazard.

Precision Pine (Exhibit 5)

Precision Pine advises of their problems with abandoned mill tailings at Lakeview which they bought incidental to old uranium mill buildings which they wish to convert into a sawmill. Their problems are insurmountable if the Council can not adopt proposed rule 345-50-030(4).

Health Division (p. 21 of transcript)

As it stands right now the mill tailings at Lakeview do not constitute a radiation hazard to the public.

Portland General Electric (Exhibit 6)

This testimony was based on Option 1 of DOE testimony which DOE no longer recommends. PGE recommended inclusion of material from Part C of Health Division Regulations in order to address strontium and cesium as well as naturally occurring isotopes which are not defined in Part B. There was tentative concurrence that Option 2 of DOE testimony satisfied many of PGE concerns.

Sharon McKeel

Ms. McKeel urged that we continue to work with EPA in defining radioactive wastes. We are at least partially responsive in proposed rule 345-50-030(2).

Health Division (Exhibit 7)

Health Division essentially recommends that the Council turn over to Health Division the responsibility for determining whether or not "Lakeview tailings, foundry sands, Wah Chang sludge, coal fly ash, and other such low specific activity materials may be disposed of in Oregon", i.e., the determination as to whether or not these materials are exempt from ORS 469.525. In the absence of criteria I don't see how the Council can shirk a legislatively assigned responsibility.

Health Division urges a change in the law so that low specific activity radioactive materials can be disposed of within the state.

Heike M. Eubanks (Exhibit 8)

H. M. Eubanks urges immediate removal of radioactive sludge from farms and landfills, evidently in relation to Wah Chang residues.

Oregon Environmental Council (Exhibit 9)

OEC appears to use the letters EPA when they mean DOE. With this understanding OEC supports DOE's Option 2 but objects to any suggestion by DOE that low level disposal sites be permitted in Oregon.

ESCO Corporation (Exhibit 10)

The ESCO submittal is clear and comprehensive and warrants close attention by every member of the Council. It constitutes by itself a good report on the hearing.

ESCO testimony is very helpful in explaining the problems which exist in any attempt to switch to casting sands other than zircon sand. They go on to address five topics as listed in the following paragraphs.

They urge that the Council refrain from promulgating any rule until all interested parties have had ample time to understand the meaning of the rule and to assess the technological and economic impacts. I agree. The original hearing was held on Option 1 of DOE testimony. Option 2 was presented

at the hearing. And now I have come up with a third option. Many people have been unaware that they were working with potentially radioactive materials. We have not heard from Wah Chang or other casting companies, presumably in the belief that AOI was representing their interests. I am not sympathetic that we should wait for EPA to promulgate rules, for this could conceivably take years. I note in passing that the ESCO quote of EPA draft rules on page 8 of Exhibit 10 is correct and comes from Section 250.12(e) of a draft release dated March 24, 1978. The lead-in portion of the EPA release is: "Radioactive wastes - A waste is radioactive waste if it is not source, special nuclear or byproduct material as defined by the Atomic Energy Act of 1954, as amended, and if a representative sample of the waste has either of the following properties:" (Paragraphs (1) and (2) follow as quoted by ESCO.)

ESCO urges that the effective date of any rule adopted should be after the Legislature has had an opportunity to define certain statutory words and phrases and has had an opportunity to consider the human, technical and economic impacts of the rule proposed under the statutes -- with which I agree.

ESCO has a number of specific criticisms of DOE's Option 2 which are somewhat moot if the Council were to consider instead my recommended rules. I strongly disagree

with ESCO and with EPA in any attempt to say that natural radioactivity is in some way more acceptable than radioactivity of human manufacture.

ESCO points out certain ambiguities between statutes, at least one of which is along the line presented by AOI questioning the scope of ORS 469.525.

Finally, ESCO raises the question of comity between the states as a result of, and constitutionality of, ORS 469.525. These matters, I believe, should be considered by the Legislature.

WKW:sj
8/22/78

8-6-8

(RECOMMENDED)

BEFORE THE ENERGY FACILITY SITING COUNCIL

RADIOACTIVE WASTE MATERIALS

Rule 345-50-005 Disposal Sites for Radioactive Waste Materials is repealed.

Rule 345-50-010 Purpose and Applicability: Since virtually all materials contain some measure of radioactivity, it is the purpose of these rules to identify those materials which present such small health hazards that they are exempt from the provisions of ORS 469.525 (1977 Replacement Part) and may be disposed of within the state.

Rule 345-50-015 Referenced Regulations: Reference to OAR 333-22-150 means "State of Oregon Regulations for the Control of Radiation" issued by the Radiation Control Section of the State Health Division in June 1977.

Rule 345-50-020 Exempt Quantities: Materials are exempt from the provisions of ORS 469.525 if the total curies of contained radioactivity are less than the quantities listed in Schedule C., Part B of OAR 333-22-150, or in the case of americium-241, plutonium-239, thorium, or uranium are less than the quantities listed in Appendix B, Part C of OAR 333-22-150.

Rule 345-50-025 Exempt Concentrations: Materials are exempt from the provisions of ORS 469.525 if the concentration of contained radioactivity in microcuries per gram of solids is less than ten times as large as the concentration in microcuries per milliliter of water for soluble species listed in Column 2, Table II, Appendix A, Part C of OAR 333-22-150.

Rule 345-50-030 Specific Exemptions: In addition to exemptions under rules 345-50-020 and 345-50-025, the following materials are exempt from the provisions of ORS 469.525:

(1) Excluding the exemption found in Section B.4(a)(2), any material identified in Section B.3 Source Material or Section B.4 Radioactive Material Other Than Source Material of OAR 333-22-150 as being exempt from requirements for licensing and fees for radioactive material.

(2) Radium-bearing materials containing less than 5 picocuries of radium-226 per gram of solid or containing a total radium-226 activity of less than 10 microcuries.

(3) Thorium-bearing materials containing less than 20 picocuries of radium-228 per gram of solid or containing a total radium-228 activity of less than 100 microcuries, provided that the radium-228 is present with the parent thorium-232.

-0-

WKW:sj
8/22/78

BEFORE THE
ENERGY FACILITY SITING COUNCIL

In the Matter of the Adoption of a Rule Defining "Radioactive Material" as it Relates to ORS 469.525	))))	NOTICE OF PROPOSED ADOPTION OF A RULE DEFINING "RADIOACTIVE MATERIAL"

1. On October 18, 1978 at 1:00 p.m. a second public hearing will be held in the State Capitol Building, Hearing Room C, to consider adoption of a rule which defines "radioactive material" for the purpose of clarifying what materials can and cannot be disposed of in Oregon consistent with ORS 469.525.

2. Two separate proposed rules are under consideration. One rule is "Option 2" presented by the Department of Energy during the initial hearing on June 27, 1978. An alternative rule has been proposed by the hearings officer for the June 27 hearing in his recommendation to the Council by memorandum dated August 23, 1978.

3. Copies of either or both of these proposed rules may be obtained from Mr. Don Godard at the Department of Energy, Labor and Industries Building, Room 111, Salem, OR 97310.

4. Among the issues to be considered at the hearing are:

   a. The extent to which either of the proposed rules fulfills the intent of the Legislature to prohibit, under ORS 469.525, the establishment, operation or licensing of radioactive waste disposal facilities;

b. The extent to which a different rule, or alternate wording of either of the proposed rules would minimize any problems of interpretation and implementation and would promote more effective state regulation;

c. The compatibility of proposed rules with other statutes and ORS Chapter 453 in particular; and

d. The identification of specific materials which would be prohibited upon the adoption of either of the proposed rules.

5. Dr. W. Kelly Woods has been designated by the Council to preside over and conduct the hearing.

6. The "Statement of Need" filed with the "Notice of Proposed Adoption of a Rule" announcing the June 27, 1978 hearing remains in effect for this "Notice". Copies of this "Statement of Need" (including legal authority) may be obtained from Mr. Don Godard at the Department of Energy, Labor and Industries Building, Room 111, Salem, OR 97310.

Dated 9/14/78

Fred D. Miller

Fred D. Miller
Director
Department of Energy

BEFORE THE

ENERGY FACILITY SITING COUNCIL

In the Matter of the Adoption of a rule defining "Radioactive Material" as it relates to ORS 469.525	STATEMENT OF NEED

The Energy Facility Siting Council proposes to adopt a rule to define "Radioactive Material" for the purpose of clarifying what materials can and cannot be disposed of in Oregon consistent with ORS 469.525.

(a) Legal Authority: ORS 469.470 and 469.510

(b) Need for the Rule:

The 1977 Oregon Legislature assigned to the Energy Facility Siting Council the responsibility for radioactive "waste disposal facilities" and prohibited the issuance of site certificates for any such facilities. Several sites currently exist in Oregon where waste materials containing low-levels of naturally occurring radioactive contamination have been or are being generated. According to the Attorney General's opinion No. 7611 dated April 25, 1978, it is the responsibility of the Energy Facility Siting Council to define which of these materials constitute "radio-active materials", the disposal of which is prohibited by ORS 469.525.

(c) Documents Relied Upon:

(1) Attorney General's opinion No. 7611 issued April 25, 1978.

(2) OAR 333-22-150 commonly referred to as "State of Oregon Regulations for Control of Radiation".

JMP:sa
5/18/78

PRESENTATION TO A HEARING ON

DEFINITION OF RADIOACTIVE MATERIALS

November 3, 1978

The staff of the Department of Energy has reviewed the hearing record, including testimony, presented at the previous hearing, as well as the report of Dr. Woods, Hearings Officer, and subsequent submissions by various interested parties. Based on that review, we are returning to this hearing and appear again in support of our Option 2 as presented at the previous hearing.

In this presentation, we wish to begin by reviewing and emphasizing the assumptions which were used in the preparation of this option. We have distinguished between those assumptions which we feel are "givens" based on the Attorney General's interpretation of the statute and those which, though perhaps not "givens", we feel are important in this rulemaking.

Following this review of the assumptions, we want to briefly review the procedures which would be used in applying Option 2 to real cases. Attached to the document is a more complete evaluation of one specific situation. Finally we want to summarize the strengths and weaknesses we see with the approach in Option 2 and the approach adopted by Dr. Woods.

GIVENS:

1. The Council must adopt a rule.

2. Any rule adopted by the Council must apply to any source of radioactive waste; not simply that waste generated by another energy facility. This is discussed in more detail in response to a question in the Appendix.

3. Naturally-occurring radioactive materials (NORM) are included in the definition of radioactive waste (ORS 469.300(12)) and must be provided for in the Council rulemaking.

4.. The Legislature never intended to ban the disposal of all NORM. It is the Council's responsibility to define "threshold" levels.

5. The rule must define the material, not how it is disposed; that is, the definition can not be written such that the material changes from radioactive to non-radioactive by placing a fence around it, covering it with dirt, or moving it from one place to another.

ASSUMPTIONS USED IN REACHING OPTION 2:

1. The rule should be based on current regulatory practices; i.e., if it requires a Health Division License or if it presents a health hazard due to the presence of radioactive materials, it meets the threshold criteria.

2. In considering potential health hazards resulting from the disposal of radioactive materials, the Council should rely on currently-accepted dose and effluent limits rather than debate the merits of higher or lower limits. If accepted dose limits are changed in the future, this, as well as other Council rules, would require reconsideration.

3. "Man-made" radioactive materials, the use of which are exempt from Health Division (and NRC) regulation should be exempt from the definition of radioactive materials for the purpose of disposal. This serves as an adequate and complete definition of radioactive materials in these categories.

4. Health Division regulations are not intended to "define" NORM and, hence, are not adequate by themselves. In particular, they are designed to protect public health and consequently allow administrative controls to restrict exposures. The staff has assumed that if the only way to insure against elevated population exposures following abandonment of materials is to maintain a fence or "clean" cover over a material, that material must be considered radioactive.

In Appendix I, we have given an example of how Option 2 might be applied to the disposal of waste tailings from a hypothetical uranium mill. It should be emphasized that the selection of uranium mill tailings for this evaluation is based, not on its uniqueness in terms of potential hazard, but rather on the fact that it is essentially the only source of NORM exposure in the environment to have received adequate treatment in the literature to allow a complete evaluation.

To summarize the calculations in Appendix I, we have assumed the following:

1. The waste generated by the mill and proposed for disposal consists of "typical" uranium mill tailings as defined by Keith J. Schiager ("Analysis of Radiation Exposures on or Near Uranium Mill Tailings Piles," Radiation Data and Reports, July 1974). This material has the properties:

    a. Radium-226 concentration of 250 pCi/gm average

    b. Thorium-230, Radium-266, and its progeny (daughters) in appropriate equilibrium

    c. Density of 1.6 gm/cm^3

    d. Diffusion coefficient of 5×10^{-2} cm^2/sec

    e. Porosity of 0.36 (fraction void space)

2. The amount of material to be generated will exceed a depth of two feet when distributed over a surface area of 100 square meters (approximately 1000 sq. ft.)

3. A postulated house built on top of the material would have the following characteristics:

    a. Floor area not exceeding the size of the waste pile

    b. an eight (8) foot high ceiling

    c. A ventilation rate of one air change per hour.

Using these assumptions, we have calculated the radiation doses and concentrations resulting from two potential exposure pathways -- direct, external, "whole body" gamma dose and the inhalation of the gaseous radium progeny (radon and its daughters) which could be expected to affect the health of an individual who constructed his home on the disposal site. These two pathways are known to be the most critical

pathways leading to exposure from abandoned tailings. The staff believes that, with the exception of special cases such as a manufacturing process which leaves one or more of the radioactive species considerably more mobile in the environment than its natural state, these will also be the most critical pathways for any radium bearing wastes.

The calculations performed are, of necessity, approximate and are based on empirical data rather than strict first principal calculations. References are included for those who wish to pursue the specific calculations.

As a result of these calculations, the estimated external, whole body, gamma dose rate over the pile is 5.5 REM per year. According to Option 2, "NORM shall be exempt from this regulation only if it can be demonstrated that * * * (the material) * * * would not result in the exposure of any individual to external gamma radiation in excess of 0.5 REM in any one year * * *"; consequently the uranium mill tailings in this example are not exempt from ORS 469.525 and their disposal in Oregon is prohibited.

In addition, the calculations estimate that the radon-222 concentration in the air of a house constructed on the pile would be 37.5 pCi/l compared to a maximum permissible concentration in air of 3 pCi/l. Even allowing a reduction in the concentration by considering the degree of equilibrium between radon and its daughters (as permitted by footnote 3, Part C Appendix A, Table II of the Oregon Regulations for the Control of Radiation) yields a concentration of 0.25 working levels -- still almost

an order of magnitude greater than the allowable one-thirtieth of a working level.

The previous example assumed a uranium ore with ony the uranium removed and the rest of the decay series present essentially in equilibrium. For materials other than uranium mill tailings, similar evaluations will have to be made and, under Option 2 these will have to be done on a case-by-case basis. Assumptions used in projecting doses could, in some cases, be based on first principle calculations, however, most will probably require generation of the type of empirical data used in the demonstration of Appendix I.

We recognize that these requirements for a case-by-case evaluation and for some actual measurements performed on the waste material before determining whether it is or is not radioactive is a weakness in Option 2. Dr. Woods' report calls it "subjective and difficult to quantify" and we do not disagree. Upon careful examination, the staff has concluded that the solution proposed by Dr. Woods, apparently in response to this problem, may cause more problems than it solves.

We wish to note first of all that Dr. Woods' extension of the Part B Exempt Quantities Table by using a factor of 10 increase over the soluble effluent release limits in water of Part C, Appendix A of OAR 333-22-150, as it relates to man-made radioactive materials is reasonable and would, at the most, result in only very minor enforcement problems. One problem which has been pointed out to us is that Health Division

(and NRC) Regulation (B.4(f)(1)) allow an individual to possess up to 10 individual exempt quantities without any controls and consistency with existing licensing practices would require this to be reflected in any EFSC rule. As was pointed out by ESCO, this use of a factor of 10 is not based directly on the health effects to be expected from a contaminated solid but rather on existing regulatory practices.

Because of the fact that this is not based on health effects, extending it to NORM is more risky. Obviously it would include as prohibited radioactive disposal of many wastes which have not been identified and we feel uncomfortable with any speculation as to the impact because there is really very little data available. Since the origin of this proposal is not based on health effects we are concerned that some prohibited materials might present little or no potential health hazards even under the worst conditions.

The additional exemption in Dr. Woods' presentation for materials containing less that 5 pCi/gm of Ra-226 warrants some discussion. Dr. Woods obtained this number from preliminary drafts of EPA's definition of radium bearing radioactive waste to be controlled under the national Resource Conservation and Recovery Act (RCRA). EPA, in turn, based their proposal on actual measurements of radon activity in houses constructed on lands reclaimed from phosphate processing and an extrapolation back to the soil concentration which would result in exceeding 3 pCi/l of Radon-222 in the air in these homes. It should also be noted that if one begins with 3 pCi/l maximum Radon-222 level in the theoretical

house discussed in Appendix I and calculates backwards through the same procedure, it is found that a soil concentration in the range of 4-6 pCi/gm of Radium (depending on equilibrium assumed) in uranium mill tailings will also exceed the limits referenced in Option 2.

EPA has since dropped its 5 pCi/gm definition under pressure from those who claim, and correctly so, that some materials containing radium-226 may not release radon to the environment as rapidly as uranium mill tailings or phospate waste. Recognizing the fact that radon emanation rates from most materials including zircon sands and coal ash are not well documented, the staff finds that it must agree with critics of the 5 pCi/gm Radium-226 definition. We do feel, however, that the disposal of waste materials exceeding 5 pCi/gm of Radium-226 should be subjected to an evaluation to determine if there are radiological health problems associated with them. We would support a recommendation to amend Option 2 to exclude NORM wastes below 5 pCi/gm <u>if</u> the uranium decay series is the primary source of radioactivity; however, we recognize that low radon emanation rates from some wastes above this level may mitigate this pathway as a potential health hazard and if this is the case, these materials should not be subject to ORS 469.525.

In conclusion, we recognize that Option 2 is not without potential problems. We do feel, however, that it is the best proposal we can make at this time and we urge its adoption by the Council.

APPENDIX I DRAFT

What about water contamination

Sample Calculations for Use of Option 2

Uranium mill tailings are the wastes remaining after the extraction of uranium from uranium ore. These tailings consist of sands and clays (commonly called slimes) whose volume is very nearly the same as the volume of ore processed in the plant. Contained in this waste are essentially all of the radioactive daughters of uranium listed on Table 1. The length of time required for the decay of this waste is generally controlled by the first radioactive species in the chain (Thorium -230) which has a half life of 80,000 years. As can be seen in Table 1, the radioactive species in the waste decay either by the emission of beta or alpha particles and many have associated emissions of gamma radiation. Each of these types of radiation has a different range (or penetrating power) and even the gamma radiations of different energies will have significantly differet ranges. In addition, a complete evaluation would require consideration of the physical and chemical form of each one of these species in determining potential human exposures. Consequently, it would be an incredible job to begin with first principles and derive the whole body and organ doses resulting from exposure to the material. At the least, this would require a very large computer and may well be an unsolvable problem even given that assistance. The approach to be taken here is based on empirical data available in the literature. References used are listed at the end.

Experiences with uranium mill tailings piles and the use of these tailings for fill around residential structures have shown that there are basically

TABLE I

Uranium Series (4n + 2)* DRAFT

Nuclide	Historical name	Half-life	Major radiations energies (MeV) and intensities†		
			α	β	γ
$^{238}_{92}U$	Uranium I	4.51×10^{9}y	4.15 (25%) 4.20 (75%)	---	---
$^{234}_{90}Th$	Uranium X_1	24.1d	---	0.103 (21%) 0.193 (79%)	0.063c‡ (3.5%) 0.093c (4%)
$^{234}_{91}Pa^{m}$	Uranium X_2	1.17m	---	2.29 (98%)	0.765 (0.30%) 1.001 (0.60%)
99.87% | 0.13%					
$^{234}_{91}Pa$	Uranium Z	6.75h	---	0.53 (66%) 1.13 (13%)	0.100 (50%) 0.70 (24%) 0.90 (70%)
$^{234}_{92}U$	Uranium II	2.47×10^{5}y	4.72 (28%) 4.77 (72%)	---	0.053 (0.2%)
$^{230}_{90}Th$	Ionium	8.0×10^{4}y	4.62 (24%) 4.68 (76%)	---	0.068 (0.6%) 0.147 (0.07%)
$^{226}_{88}Ra$	Radium	1602y	4.60 (6%) 4.78 (95%)	---	0.186 (4%)
$^{222}_{86}Rn$	Emanation Radon (Rn)	3.823d	5.49 (100%)	---	0.510 (0.07%)
$^{218}_{84}Po$	Radium A	3.05m	6.00 (~100%)	0.33 (~0.019%)	---
99.98% | 0.02%					
$^{214}_{82}Pb$	Radium B	26.8m	---	0.65 (50%) 0.71 (40%) 0.99 (6%)	0.295 (19%) 0.352 (36%)
$^{218}_{85}At$	Astatine	~2s	6.65 (6%) 6.70 (94%)	? (~0.1%)	---
$^{214}_{83}Bi$	Radium C	19.7m	5.45 (0.012%) 5.51 (0.008%)	1.0 (23%) 1.51 (40%) 3.26 (19%)	0.609 (47%) 1.120 (17%) 1.764 (17%)
99.98% | 0.02%					
$^{214}_{84}Po$	Radium C'	164μs	7.69 (100%)	---	0.799 (0.014%)
$^{210}_{81}Tl$	Radium C''	1.3m	---	1.3 (25%) 1.9 (56%) 2.3 (19%)	0.296 (80%) 0.795 (100%) 1.31 (21%)
$^{210}_{82}Pb$	Radium D	21y	3.72 (.0000002%)	0.016 (85%) 0.061 (15%)	0.047 (4%)
$^{210}_{83}Bi$	Radium E	5.01d	4.65 (.00007%) 4.69 (.00005%)	1.161 (~100%)	---
-100% | .00013%					
$^{210}_{84}Po$	Radium F	138.4d	5.305 (100%)	---	0.803 (0.0011%)
$^{206}_{81}Tl$	Radium E''	4.19m	---	1.533 (100%)	---
$^{206}_{82}Pb$	Radium G	Stable	---	---	---

*This expression describes the mass number of any member in this series, where n is an integer.
Example: $^{206}_{82}Pb$ (4n + 2) n = 51 + 206

†Numbers refer to percentage of disintegrations of the nuclide itself, not to original parent of series.

‡Complex energy peak which would be incompletely resolved by instruments of moderately low resolving power such as scintillators.

two concerns from the standpoint of population exposure--whole body gamma exposure from the pile itself and alpha irradiation of lung tissues resulting from the inhalation of the radioactive progeny of the gaseous species Radon -222.

Initially, consider an "infinite source of material emitting gamma radiation from its surface. We find in the literature the following expression:

$$X(\text{ R/hr}) = 2.5\ C_{Ra}\ (\text{PCi/g}) \qquad \text{(Schiager, 1974)}$$

where X is the gamma exposure rate (external) in microroentgen per hour determined empirically and including all gamma emitting species in the uranium decay chain and C_{Ra} is the radium concentration in soil or tailings expressed in picocuries per gram.

To what extent does this expression accurately reflect exposures for real situations involving uranium mill tailings; and specifically:

What about a pile which is not infinitely thick?

a. For a source whose thickness is not infinite the correction factor may be derived from the graph of Figure 1. It can be seen that a depth of tailings of only two feet will yield approximately 90% of the gamma exposures to be expected from a pile infinitely thick. This is a function of self absorption in the waste itself.

b. Is this exposure to a person lying prone on the pile or standing up? Exposures received by a person in either position are essentially identical! It is important to remember that the basic rule that radiation exposure decreases with the square of the distance from source applies only to point sources. The situation is much more complex where the size of the source is large compared to the receptor. In this case, if the person being exposed to gamma irradiation from a pile is close compared to the horizontal size of the pile, it does not matter particularly how close. Perhaps a diagram will help illustrate:

First - why is this important?

Second - Does this rule hold only when the receptor is at a distance which is small compared to the largest dimension of the source?

A person lying prone on the pile at position A will be exposed only to gamma radiation emanating from material within a small radius around his body (see a. above). A person at point B (representing a standing person) will be farther from the material at point C and will receive less exposure from it, however, he will be exposed also to radiation emanating from point D.

c. What surface area must the pile have to be essentially infinite? For the reasons given in b, the size must be "large" compared to the distance a person is from the pile. A standard height for measuring gamma radiation levels above a pile is one meter (about

DRAFT

3 feet) because this represents the approximate midpoint of a human adult. While a precise calculation of the required pile size has not been done due to its complexity, the exponential nature of the decrease with distance will yield an exposure at a height of one meter which is a large percentage of the exposure from an infinite pile on a pile only a few yards in radius.

d. What effect would building a house on such a pile have on the gamma levels? Again this is a complex question. Construction materials placed between an individual and the pile could reduce the gamma exposure. Conversely, construction materials above a person could increase the effective radiation exposure through a phenomena known as "sky-shine". It should be a conservative (but not overly conservative) assumption that a house built without special consideration for potential radiation effects may not significantly change the external gamma levels.

e. What contribution, if any, does alpha and beta radiation add to the whole body dose? Beta and alpha radiations are low in the penetrating power. Consequently, their effect is to expose only small localized areas of the body and they are not included in considerations of "whole body dose". Alpha and beta exposures only become significant when the material is introduced into the human body and exposes particular organs from the inside, as will be shown when considering exposures to radon progeny.

To conclude the evaluation of gamma exposure, we have shown from published empirical information that uranium mill tailings in sufficient quantity

DRAFT

to yeild a waste pile a couple of feet thick with a radius of several yards will yield a gamma exposure above the pile very nearly that of an infinite amount of material and the expression

$$X = 2.5\ C_{Ra}$$

presented earlier may be used.

From the literature, we can also obtain concentration values for Radium -226 in uranium mill tailings and find these values to range from about 100 pCi/gm to around 1,000 pCi/gm (in some slimes). Adopting an average value of 250 pCi/gm for such a pile results in an estimated gamma exposure of 625 micro REM per hour or almost 5.5 REM per year.

The second pathway which is known to cause significant human exposures from uranium mill tailings is the inhalation of radon progeny. When Radium -226 decays it produces radon -222, a gaseous radioactive material with a half life of 3.8 days. During its life, some of this radon is released from the tailings, diffuses through the material in the pile and is subsequently released into the air. This radon undergoes, through a period of a couple of hours, decay through a chain of short half life radioactive materials until it eventually becomes a form of lead with a relatively long half-life (30 years). It is these short half-life radon prodgeny (or daughters), including a couple decaying by alpha emission, which result in a radiation exposure to human lungs. Numerous studies of lung cancer in miners have demonstrated conclusively that there is a statistically significant increase in the rate of cancer incidence to workers exposed to elevated levels of these daughters.

DRAFT

This evaluation will proceed with a discussion of the considerations which ~~must proceed with a discussion of the considerations which~~ must precede ~~proceed~~ an estimation of potential radiation exposures.

The amount of radon released from the surface of the pile is refereed to as the "radon emanation rate" and in an "infinite" pile can be approximated, in relation to the concentration of radium -226 in the pile, by the expression:

$$J = 1.6\ C_{Ra}$$

where J is the emanation rate in picocuries of radon -222 per square meter per second and C_{Ra} is, again, the radium concentration in the tailings in picocuries per gram. The emanation rate is graphed in Figure 2 for future reference.

Again, as before, it is necessary to examine whether sufficient material is present to consider the pile "inifinite" and the how do you convert this rate into a concentration or a dose.

a. What if the pile is not infinitely thick? Figure 3 is a graphical representation of the amount of radon emanating from a "thin" pile compared to the amount which would be released if the pile were, in fact, infinitely thick. Since radon diffuses through tailings relatively fast, it will be necessary to examine this graph in the final calculation also.

FIGURE 2

DRAFT

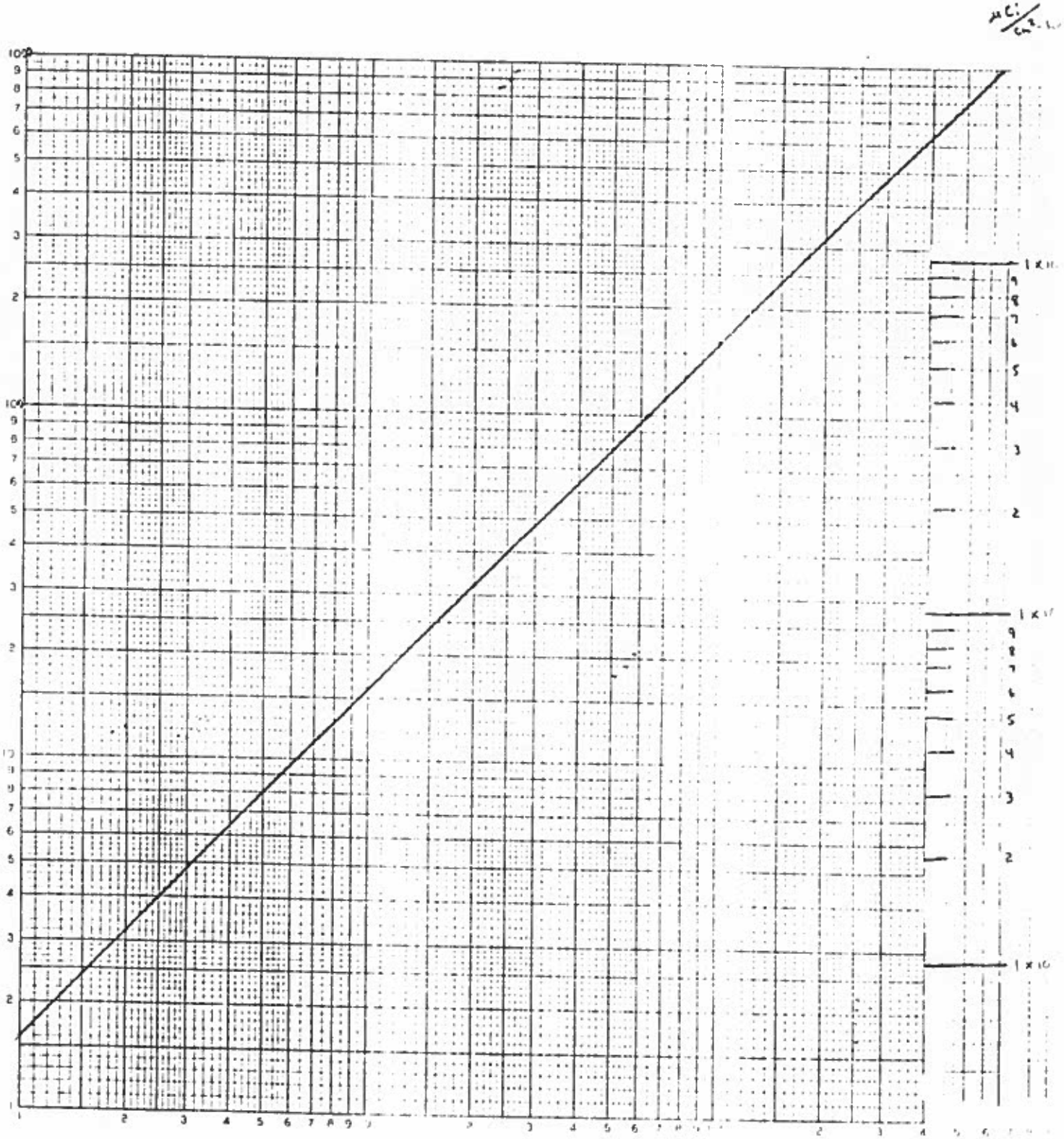
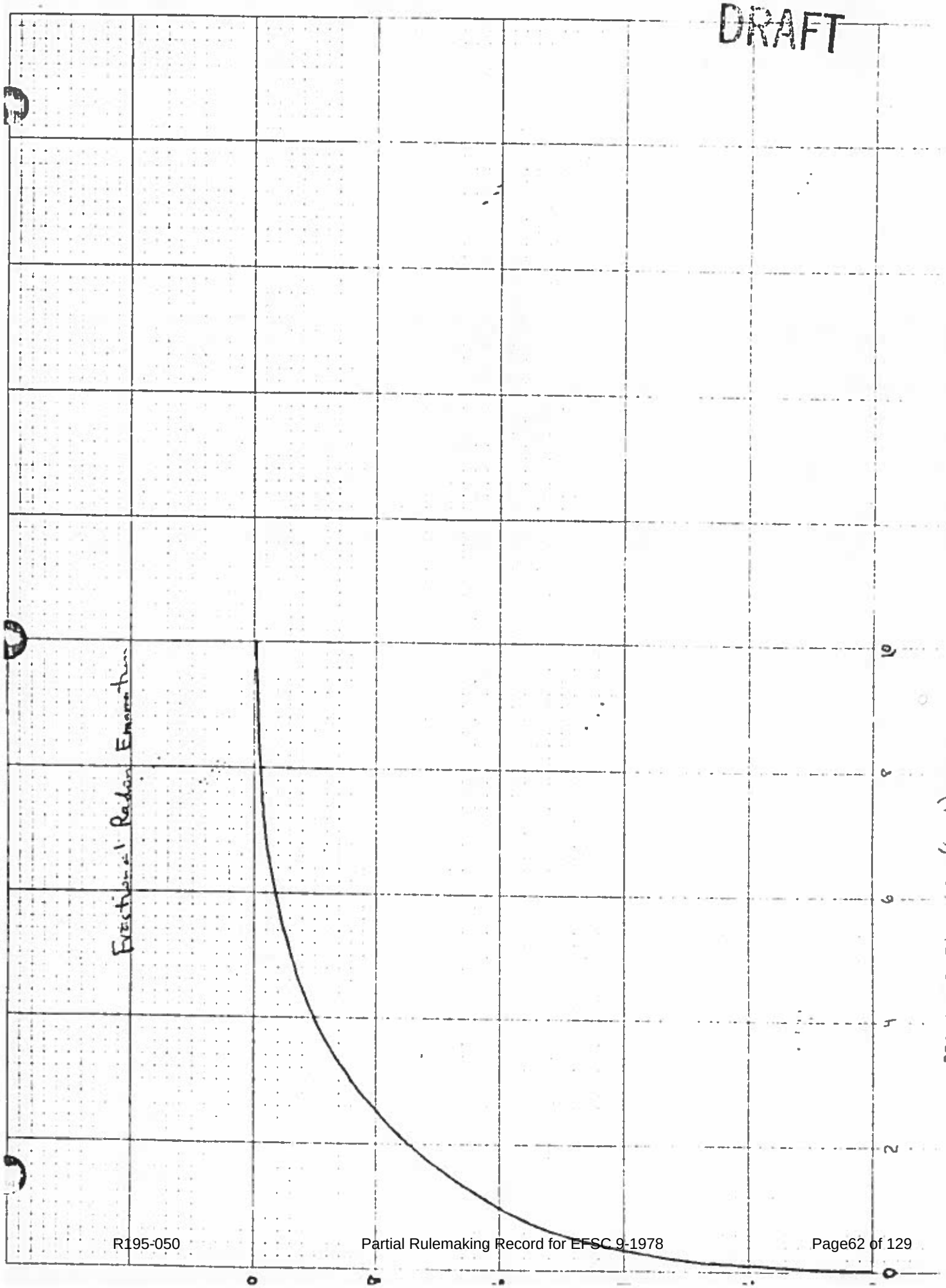


FIGURE 3

DRAFT



DRAFT

what surface area can be considered infinite?

b. How large does the pile have to be? As was noted earlier, the radiation exposure to an individual is primarily due to the alpha emitting daughters of the radon. An evaluation of the buildup of these progeny reveals that, even in the case of a large (several acre) pile, normal air movements across a pile outdoors will remove the radon from the pile and dilute it and its daughters considerably before there is time for the daughter activity to increase. This is not the case, however, where air flow is restricted such as in a house. Here, the radon may accumulate and the radioactive daughters buildup to considerable activity. It is necessary, therefore, to have sufficient material present to cover a major portion of the floor area of a house.

c. How do you calculate the radon and progeny activity in a house? The steady state radon concentration in a structure may be expressed by the equation:

$$C_{Rn} = 3.6 \frac{JA}{V\lambda} \qquad \text{(USNRC 1974)}$$

where C_{Rn} = radon concentration in pCi/l

J = radon emanation rate into the house in pCi/m^2-sec

A = the area of the house

λ = effective loss by decay and exchange

explain what major assumptions go into

V = volume of the house

It should be noted that this equation really only depends on three factors--J, λ, and the height of the ceiling in the house $(\frac{A}{V})$.

The percentage of radon daughter activity is again dependent on the air exchange rate in the house and is graphically represented in Figure 4.

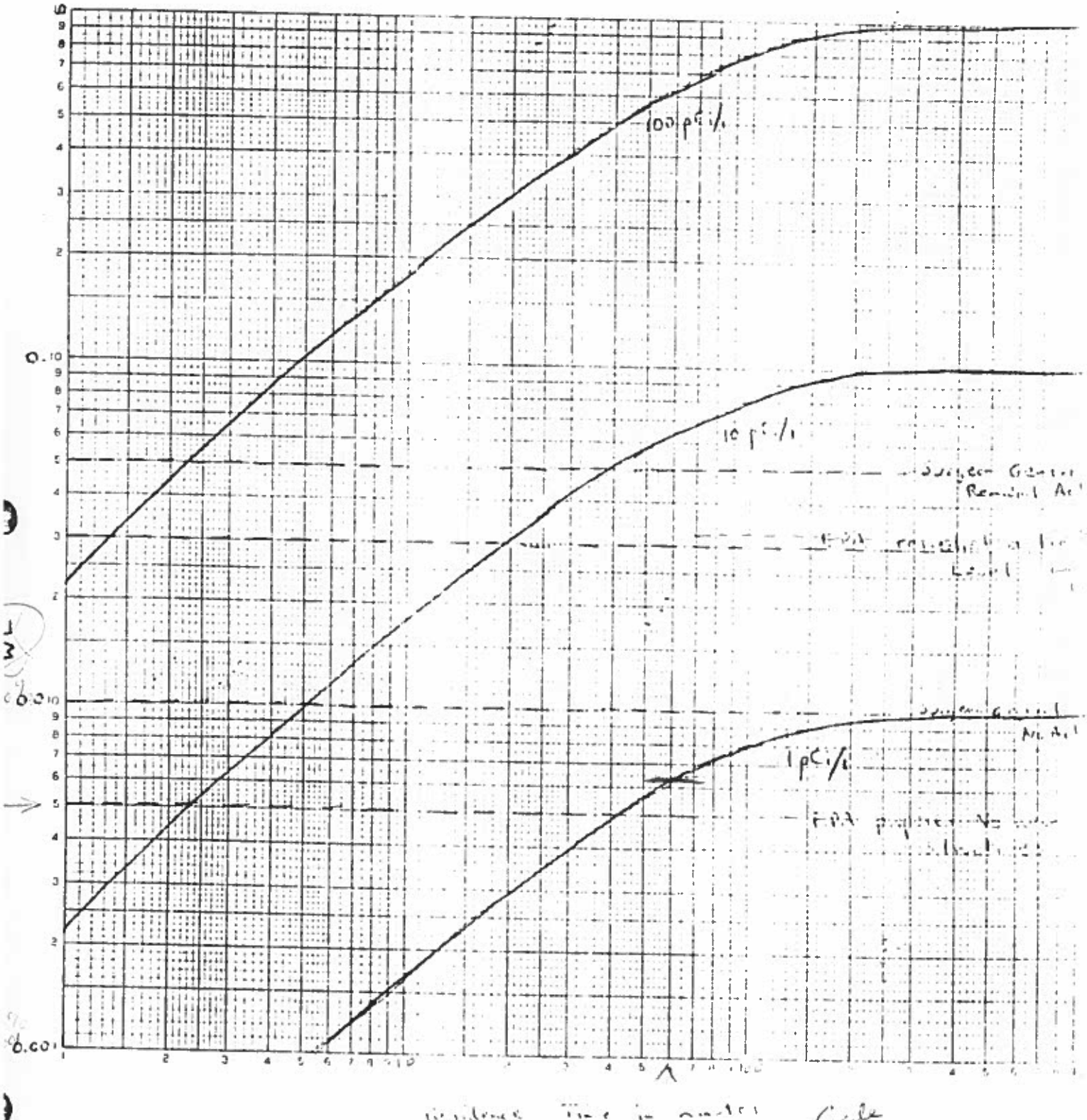
d. Won't a concrete foundation reduct this level significantly? A concrete foundation will restrict, to some extent, the passage of radon into a structure. Our assumptions include the fact that no land use restrictions could apply and, hence, we feel that any consideration for a reduction in radon levels by assuming that a house built on the site will have such a foundation would not be allowed under Option 2.

e. How would a concentration of 3×10^{-9} Ci/ml (0.03 WL assuming equilibrium) be translated into a dose? At equilibrium 1 pCi/l of Radon -222 in equilibrium with its daughter activities will deliver a dose due primarily to the alpha activity of daughters of approximately 1 REM to the small airways of the lung. (It must be remembered that this dose is highly localized and cannot be directly added or compared to any "whole body" doses.) Hence 3×10^{-9} Ci/ml is approximately equal to 3 REM of alpha exposure to small areas of the lung.

To conclude the evaluation of the exposure to radon emanating from the pile, we will assume that sufficient mill tailing waste will be generated

DRAFT

FIGURE 4



Residence Time in months Scale

to form a pile 100 m^2 and 2 feet thick containing 250 pCi/gm of Ra -226.

We have shown that the exposure will depend on the amount of radon emanating from an infinite pile which is related to radium -226 concentration by:

$$J = 1.6\ C_{Ra}$$

Hence, the radon emanation from our theoretical pile will be about 75 percent (see figure 3) of 400 pCi/m^2-sec or 300 pCi/m^2-sec.

As we have stated, it is necessary to assume that a house could be built on this pile and we will assume a house with an 8 foot (2.4m) ceiling and one complete air change per hour and assume that a negligible percentage of the radon decays in one hour.

From the expression for radon concentration:

$$C_{Rn} = 3.6\ \frac{JA}{V\lambda} = 3.6\ \frac{300}{8}$$

we calculate a radon concentration of 37.5 pCi/l in the house. From Figure 4 we find that the radon daughter activity reaches approximately 65 percent of its equilibrium activity in one hour and, thus, will result in a radon progeny dose to residents of the house equal to an equilibrium dose of approximately 25 pCi/l or about 10 times the limit of 3×10^{-9} μCi/ml allowed by Health Division REgulations referenced in Option 2.

In summary, using the assumptions which appear on the summary sheet, we have demonstrated that a theoretical uranium mill tailings pile fails two of the tests required by Option 2 to be exempt from the prohibition in ORS 469.525.

DRAFT

SUMMARY

Waste Material:	Uranium Mill Tailings (typical)
Concentration:	250 pCi/gm of Th-230, Ra-226, and daughters
Amount:	Resulting pile at least 2 feet thick and 1000 square feet (100 m^2) in area.
Postulated House:	Floor area the same size or smaller than the pile Ceiling height--8 feet Ventilation rate--one air change per hour
Estimated Gamma Dose Rate:	5.5 REM per year
Maximum Gamma Dose Rate:	allowable 0.5 REM per year
Estimated Radon Concentration:	37.5 ~~25~~ pCi/l
Maximum Rad~~o~~on Concentration:	allowable 3 pCi/l

APPENDIX II

Responses to questions and comments received as part of June 27, 1978 hearing:

Q. Is there any scientific basis for converting the levels which may be hazardous in the air or water to hazardous levels in the soil by simply multiplying by 10 (or any other number)?

A. The response to this question must be given in two parts.

1. As the hearings officer noted in his report, the exempt concentrations in Part B, Oregon Regulations for the Control of Radiation, are exactly 10 times the concentrations for the soluble form of the same isotopes listed in Part C, Table II, Column 2 (with minor exceptions). For the "man-made" radioactive materials, the staff believes this to be a reasonable extension of the Part B table. It is <u>not</u>, however, based directly on health effects but rather on current NRC agreement state licensing practices (i.e., material in excess of those amounts require a license from Health Division for possession and use).

2. The staff is somewhat more concerned where this factor of 10 has been extended to naturally occurring isotopes and this is discussed in detail in the body of this presentation.

Q. What health hazard is presented by accumulating more than 10 microcuries of radium 226 in an area without regard to the size of the area?

A. The recommendation of the hearings officer exempts radium bearing materials which meet either one of the following criteria: a total quantity less than 10 microcuries or a concentration of less than 5 picocuries per gram. Hence, if a material were to contain, say, 10 picocuries per gram of Ra-226, it would still be exempt from the definition if the quantity did not exceed 1,000 kg (about 1 ton). Below 5 picocuries per gram, the material would be exempt from the regulation regardless of how much material is disposed of. Discussion of the potential radiation exposure from these materials is contained in other sections of this presentation.

While the staff recognizes that the use of an either-or regulation may cause confusion, we recognize that if the rule adopted is based on a direct definition of the material rather than the radiation exposure levels, a minimum concentration as well as a minimum quantity must be incorporated into rule in order to avoid including all waste in the definition.

Q. Where are the proposed threshold levels to be applied -- to the material at the site of origin or at the disposal site?

A. The staff recognizes that this question was not addressed adequately in its previous discussion of proposed Option 2. The hearings officer's proposal resolves this problem by defining the material rather than radiation exposures resulting from the material. Consequently, a relatively simple chemical analysis could be performed and the location of the material would not affect whether or not it exceeded the threshold levels. If the Council choses to adopt Option 2, as we propose, it will be necessary to make some assumptions

and calculations in order to estimate potential exposure levels. We have presented an example of this in another section of this presentation.

Q. How are the proposed threshold levels to be measured?

A. In order to insure that adequate analytical techniques are used, the staff is proposing an additional rule adopting "standard methods: of analysis for radioactive materials. In recognition of the fact that additional refinements in procedures are common, we have attempted to make this requirement as flexible as possible.

Q. Will it be permissible to process waste material so as to extract and concentrate any radioactive material, thereby reducing the residual material below the threshold concentration?

A. This would certainly not be prohibited by either proposed rule. It must be remembered that this proposed rulemaking is only to define radioactive materials for the purpose of disposal. Additional questions related to the meaning of "temporary" storage and "discarded or unwanted" radioactive material are not being specifically addressed at this time. It is the feeling of the staff that a material which is still being processed for the purpose of recycling all or portions of it, preparing secondary products, and preparing waste for disposal is not yet "discarded or unwanted". A warning is in order, however, that use of materials which exceed the levels in any of the proposed rules including products produced from them may be subject to the regulations of the Oregon State Health Division, Radiation Control Section.

Q. Did the Legislature intend to place jurisdiction over all radioactive waste disposal facilities with EFSC or only those for disposal of wastes from other facilities under the Council's jurisdiction?

A. The Department of Energy agrees with the opinion expressed by Dr. Woods that the statutes and the Attorney General's Opinion #7611 clearly place the responsibility for radioactive waste disposal with the Council and do not limit this authority to wastes generated by other facilities under Council jurisdiction. We do not feel that an additional Attorney General's opinion is appropriate at this time.

MP:sh

10-27-78

ROBERT W STRAUB
GOVERNOR

Department of Energy

LABOR & INDUSTRIES BUILDING, ROOM 111, SALEM, OREGON 97310 PHONE 378- 6469

TO: EFSC Members DATE: December 7, 1978

FROM: DOE Staff

SUBJECT: DOE Exceptions to Dr. Woods' Definition for Radioactive Material

1. DOE agrees with the concepts contained in Dr. Woods' recommended rule to the extent that this rule is derived from Health Division rules rather than adopting new and possibly contradictory rules. Dr. Woods has recommended quantitative limits of naturally occurring radioactivity below which material would not be considered radioactive. Such a value is needed to fill a gap in existing Health Division rules. The value proposed by Dr. Woods for radium-226 (5 pCi/gm), is based on values under consideration by EPA. The other values for thorium bearing materials and for total radium-226 are based on NRC recommendations.

2. DOE believes the quantitative limits adopted for these materials are to be appropriately conservative. Generally, they are based on assumptions that are applicable to phosphate processing wastes and uranium mill tailings (Appendix C). DOE knows of no material that can be reasonably expected in Oregon that would require lower acceptable quantities. However, some materials in Oregon could have characteristics that would permit greater acceptable values. Therefore, DOE recommends that Dr. Woods' alternative recommendation, which allows a case-by-case evaluation, be incorporated into his primary recommendation. Such a case-by-case evaluation would, in essence, declare any material that would result in exposures in excess of 500 mr/yr or could result in exceeding effluent release limits would be defined as radioactive material.

3. DOE recommends the following specific technical changes to Dr. Woods' rule. The bases for these changes are in Appendix A.

   a. Rule 345-50-020 should be revised to recognize that Health Division distinguishes between radioactive material contained in one discrete quantity versus several individual quantities. The

Council should not attempt to define exempt quantities for americium, plutonium, uranium, or thorium, or other isotopes which do not currently have accepted exempt quantity limits.

b. Rule 345-50-025 should reference the Health Division activity concentrations in solid materials rather than values derived from tables for concentrations in air or water.

c. Rule 345-50-030(1) should be revised to exempt all consumer products that have been evaluated for potential hazards by the Health Division. It should not, however, exempt ores.

d. Alternate Rule 345-50-021(2) should be revised to delete premises used in the case-by-case evaluation that are not generally applicable to all potential sources of activity.

4. DOE believes the following non-technical changes should be made; the bases are contained in Appendix B.

   a. The rule should become effective upon adoption rather than delaying until August 1979; this would be more responsive to the Legislature.

   b. The rule adopted by the Council should incorporate Health Division rules rather than simply referencing them; this is at the request of the EFSC committee.

5. DOE believes the Legislature should be informed of the potential consequences of this rule. The DOE will recommend to the Council an appropriate approach at the January meeting.

6. The above comments are incorporated in the attached rule, which is recommended by DOE. The DOE believes the only difference from Dr. Woods' proposal is that a case-by-case determination of hazards is permitted for naturally occurring radioactivity and several technical corrections have been made.

DWG:sj
1313A

DR. WOODS' RULE OF NOVEMBER 1978

AS MODIFIED BY DOE COMMENTS

DEFINITION OF RADIOACTIVE MATERIALS

Rule 345-50-055 Disposal Sites for Radioactive Materials is repealed.

Rule 345-50-010 Purpose of Applicability: Since virtually all materials contain some measure of radioactivity, it is the purpose of these rules to identify those materials which present such small health hazards that they are exempt from the provisions of ORS 469.525 (1977 Replacement Part) and may be disposed of within the state.

Rule 345-50-020 Exempt Quantities: The disposal of products or materials is exempt from provisions of ORS 469.525 provided that such products or materials contain radioactive materials in individual quantities, none of which exceeds, the applicable quantity set forth in Table II and provided that the number of individual quantities does not exceed 10.

Rule 345-50-025 Exempt Concentrations: The disposal of products or materials is exempt from the provisions of ORS 469.525 provided that such products or materials contain radioactive materials in concentrations not in excess of those in Table I.

Rule 345-50-030 Specific Exemptions: In addition to the exemptions under Rules 345-50-020 and 345-50-025, disposal of the following materials are exempt from the provisions of ORS 469.525:

(1) The radioactive material is incorporated into a consumer product approved by the Oregon Health Division.

(2) Radium-bearing materials containing less than 5 picocuries of radium-226 per gram of solid, or containing a total radium-226 activitiy of less than 10 microcuries.

(3) Thorium-bearing materials containing less than 20 picocuries of radium-228 per gram of solid, or containing a total radium-228 activity of less than 100 microcuries providing that the radium-228 is present with the parent thorium-232.

Rule 345-50-030 Pathway Exemption: Except for materials specifically listed in Rules 345-50-020 and 345-50-025, the disposal of products and materials containing radioactive materials shall be exempt from the provisions of ORS 469.525 if it can be demonstrated that accumulation of material will not result in exposures exceeding 500 millirem of external gamma radiation per year, nor in the release of effluents to air and water an annual concentrations exceeding the values in Table III. An evaluation of potential radiation exposures and effluent releases shall be performed using the following premises:

(1) The material shall be considered in the form it exists when it is removed from the users' equipment, systems, or settling ponds prior to any dilution or remedial action designed to reduce radiation levels.

(2) No consideration shall be given to land use restrictions, maintenance operations, or overburden at the disposal site.

ie may no be fenced guarded buried

(3) Accumulations of material over the reasonably projected period of waste generation shall be evaluated.

(4) External gamma radiation exposures shall be based on actual measurements and allowance may be made for the degree of equilibrium and for self-shielding.

(5) In computing radon concentrations in the air above a disposal site containing radium-226, the following additional premises shall be used:

(a) Any house built on ground contaminated with radium-226 is assumed to have an 8-feet high ceiling on the first floor, to have one complete air change per hour, and to have a foundation constructed so as to meet the Uniform Building Codes effective at the time of adoption of these rules. No consideration will be allowed for any special construction or treatments designed to reduce radon diffusion into the structure.

(b) The relation between radon-emanation rate and radium concentration will be based upon experimental measurements on material intended for disposal.

DWG:sj
12/7/78
1320A

TABLE I

EXEMPT CONCENTRATIONS

(See notes at end of Table I)

Element (atomic number)	Isotope	Liquid and Solid Concentration (μCi/ml)*
Antimony (51)	Sb-122	$3X10^{-4}$
	Sb-124	$2X10^{-4}$
	Sb-125	$1X10^{-3}$
Argon (18)	Ar-37	
	Ar-41	
Arsenic (33)	As-73	$5X10^{-3}$
	As-74	$5X10^{-4}$
	As-76	$2X10^{-4}$
	As-77	$8X10^{-4}$
Barium (56)	Ba-131	$2X10^{-3}$
	Ba-140	$3X10^{-4}$
Beryllium (4)	Be-7	$2X10^{-2}$
Bismuth (83)	Bi-206	$4X10^{-4}$
Bromine (35)	Br-82	$3X10^{-3}$
Cadmium (48)	Cd-109	$2X10^{-3}$
	Cd-115m	$3X10^{-4}$
	Cd-115	$3X10^{-4}$
Calcium (20)	Ca-45	$9X10^{-5}$
	Ca-47	$5X10^{-4}$
Carbon (6)	C-14	$8X10^{-3}$
Cerium (58)	Ce-141	$9X10^{-4}$
	Ce-143	$4X10^{-4}$
	Ce-144	$1X10^{-4}$
Cesium (55)	Cs-131	$2X10^{-2}$
	Cs-134m	$6X10^{-2}$
	Cs-134	$9X10^{-5}$
Chlorine (17)	Cl-38	$4X10^{-3}$
Chromium (24)	Cr-51	$2X10^{-2}$
Cobalt (27)	Co-57	$5X10^{-3}$
	Co-58	$1X10^{-3}$
	Co-60	$5X10^{-4}$
Copper (29)	Cu-64	$3X10^{-3}$
Dysprosium (66)	Dy-165	$4X10^{-3}$
	Dy-166	$4X10^{-4}$
Erbium (68)	Er-169	$9X10^{-4}$
	Er-171	$1X10^{-3}$

Element (atomic number)	Isotope	Liquid and Solid Concentration (μCi/ml)
Europium (63)	Eu-152 (T =9.2 h)	$6X10^{-4}$
	Eu-155	$2X10^{-3}$
Fluorine (9)	F-18	$8X10^{-3}$
Gadolinium (64)	Gd-153	$2X10^{-3}$
	Gd-159	$8X10^{-4}$
Gallium (31)	Ga-72	$4X10^{-4}$
Germanium (32)	Ge-71	$2X10^{-2}$
Gold (79)	Au-196	$2X10^{-3}$
	Au-198	$5X10^{-4}$
	Au-199	$2X10^{-3}$
Hafnium (72)	Hf-181	$7X10^{-4}$
Hydrogen (1)	H-3	$3X10^{-2}$
Indium (49)	In-113m	$1X10^{-2}$
	In-114m	$2X10^{-4}$
Iodine (53)	I-126	$2X10^{-5}$
	I-131	$2X10^{-5}$
	I-132	$6X10^{-4}$
	I-133	$7X10^{-5}$
	I-134	$1X10^{-3}$
Iridium (77)	Ir-190	$2X10^{-3}$
	Ir-192	$4X10^{-4}$
	Ir-194	$3X10^{-4}$
Iron (26)	Fe-55	$8X10^{-3}$
	Fe-59	$6X10^{-4}$
Krypton (36)	Kr-85m	
	Kr-85	
Lanthanum (57)	La-140	$2X10^{-4}$
Lead (82)	Pb-203	$4X10^{-3}$
Lutetium (71)	Lu-177	$1X10^{-3}$
Manganese (25)	Mn-52	$3X10^{-4}$
	Mn-54	$1X10^{-3}$
	Mn-56	$1X10^{-3}$
Mercury (80)	Hg-197m	$2X10^{-3}$
	Hg-197	$3X10^{-3}$
	Hg-203	$2X10^{-4}$
Molybdenum (42)	Mo-99	$2X10^{-3}$
Neodymium (60)	Nd-147	$6X10^{-4}$
	Nd-149	$3X10^{-3}$
Nickel (28)	Ni-65	$1X10^{-3}$
Niobium (Columbium)(41)	Nb-95	$1X10^{-3}$
	Nb-97	$9X10^{-3}$

Element (atomic number)	Isotope	Liquid and Solid Concentration (μCi/ml)
Osmium (76)	Os-185	$7X10^{-4}$
	Os-191m	$3X10^{-2}$
	Os-191	$2X10^{-3}$
	Os-193	$6X10^{-4}$
Palladium (46)	Pd-103	$3X10^{-3}$
	Pd-109	$9X10^{-4}$
Phosphorus (15)	P-32	$2X10^{-4}$
Platinum (78)	Pt-191	$1X10^{-3}$
	Pt-193m	$1X10^{-2}$
	Pt-197m	$1X10^{-2}$
	Pt-197	$1X10^{-3}$
Potassium (19)	K-42	$3X10^{-3}$
Praseodymium (59)	Pr-142	$3X10^{-4}$
	Pr-143	$5X10^{-4}$
Promethium (61)	Pm-147	$2X10^{-3}$
	Pm-149	$4X10^{-4}$
Rhenium (75)	Re-183	$6X10^{-3}$
	Re-186	$9X10^{-4}$
	Re-188	$6X10^{-4}$
Rhodium (45)	Rh-103m	$1X10^{-1}$
	Rh-105	$1X10^{-3}$
Rubidium (37)	Rb-86	$7X10^{-4}$
Ruthenium (44)	Ru-97	$4X10^{-3}$
	Ru-103	$8X10^{-4}$
	Ru-105	$1X10^{-3}$
	Ru-106	$1X10^{-4}$
Samarium (62)	Sm-153	$8X10^{-4}$
Scandium (21)	Sc-46	$4X10^{-4}$
	Sc-47	$9X10^{-4}$
	Sc-48	$3X10^{-4}$
Selenium (34)	Se-75	$3X10^{-3}$
Silicon (14)	Si-31	$9X10^{-3}$
Silver (47)	Ag-105	$1X10^{-3}$
	Ag-110m	$3X10^{-4}$
	Ag-111	$4X10^{-4}$
Sodium (11)	Na-24	$2X10^{-3}$
Strontium (38)	Sr-85	$1X10^{-3}$
	Sr-89	$1X10^{-4}$
	Sr-91	$7X10^{-4}$
	Sr-92	$7X10^{-4}$

Element (atomic number)	Isotope	Liquid and Solid Concentration (μCi/ml)
Sulfur (16)	S-35	$6X10^{-4}$
Tantalum (73)	Ta-182	$4X10^{-4}$
Technetium (43)	Tc-96m	$1X10^{-1}$
	Tc-96	$1X10^{-3}$
Tellurium (52)	Te-125m	$2X10^{-3}$
	Te-127m	$6X10^{-4}$
	Te-127	$3X10^{-3}$
	Te-129m	$3X10^{-4}$
	Te-131m	$6X10^{-4}$
	Te-132	$3X10^{-4}$
Terbium (65)	Tb-160	$4X10^{-4}$
Thallium (81)	Tl-200	$4X10^{-3}$
	Tl-201	$3X10^{-3}$
	Tl-202	$1X10^{-3}$
	Tl-204	$1X10^{-3}$
Thulium (69)	Tm-170	$5X10^{-4}$
	Tm-171	$5X10^{-3}$
Tin (50)	Sn-113	$9X10^{-4}$
	Sn-125	$2X10^{-4}$
Tungsten (Wolfram)(74)	W-181	$4X10^{-3}$
	W-187	$7X10^{-4}$
Vanadium (23)	V-48	$3X10^{-4}$
Xenon (54)	Xe-131m	
	Xe-133	
	Xe-135	
Ytterbium (70)	Yb-175	$1X10^{-3}$
Yttrium (39)	Y-90	$2X10^{-4}$
	Y-91m	$3X10^{-2}$
	Y-91	$3X10^{-4}$
	Y-92	$6X10^{-4}$
	Y-93	$3X10^{-4}$
Zinc (30)	Zn-65	$1X10^{-3}$
	Zn-69m	$7X10^{-4}$
	Zn-69	$2X10^{-2}$
Zirconium (40)	Zr-95	$6X10^{-4}$
	Zr-97	$2X10^{-4}$
Beta and/or gamma emitting radioactive material not listed above with half-life less than 3 years.		$1X10^{-6}$

NOTE 1. Many radioisotopes disintegrate into isotopes which are also radioactive. In expressing the concentrations in Schedule A the activity stated is that of the parent isotope and takes into account the daughters.

NOTE 2. For purposes of Sec. B.4 where there is involved a combination of isotopes, the limit for the combination should be derived as follows: Determine for each isotope in the product the ratio between the concentration present in the product and the exempt concentration established in Schedule A for the specific isotope when not in combination. The sum of such ratios may not exceed "1" (i.e., unity).

EXAMPLE:

$$\frac{\text{Concentration of Isotope A in Product}}{\text{Exempt concentration of Isotope A}} + \frac{\text{Concentration of Isotope B in Product}}{\text{Exempt concentration of Isotope B}} \leq 1$$

---

* μCi/gm for solids

TABLE II

EXEMPT QUANTITIES

Radioactive Material	Microcuries	Radioactive Material	Microcuries
Antimony-122 (Sb-122)	100	Europium-152 (Eu-152) 9.2h	100
Antimony-124 (Sb-124)	10	Europium-152 (Eu-152) 13 yr	1
Antimony-125 (Sb-125)	10	Europium-154 (Eu-154)	1
Arsenic-73 (As-73)	100	Europium-155 (Eu-155)	10
Arsenic-74 (As-74)	10	Fluorine-18 (F-18)	1,000
Arsenic-76 (As-76)	10	Gadolinium-153 (Gd-153)	10
Arsenic-77 (As-77)	100	Gadolinium-159 (Gd-159)	100
Barium-131 (Ba-131)	10	Gallium-67 (Ga-67)	100
Barium-133 (Ba-133)	10	Gallium-72 (Ga-72)	10
Barium-140 (Ba-140)	10	Germanium-71 (Ge-71)	100
Bismuth-210 (Bi-210)	1	Gold-198 (Au-198)	100
Bromine-82 (Br-82)	10	Gold-199 (Au-199)	100
Cadmium-109 (Cd-109)	10	Hafnium-181 (Hf-181)	10
Cadmium-115m (Cd-115m)	10	Holmium-166 (Ho-166)	100
Cadmium-115 (Cd-115)	100	Hydrogen-3 (H-3)	1,000
Calcium-45 (Ca-45)	10	Indium-111 (In-111)	100
Calcium-47 (Ca-47)	10	Indium-113m (In-113m)	100
Carbon-14 (C-14)	100	Indium-114m (In-114m)	10
Cerium-141 (Ce-141)	100	Indium-115m (In-115m)	100
Cerium-143 (Ce-143)	100	Indium-115 (In-115)	10
Cerium-144 (Ce-144)	1	Iodine-123 (I-123)	100
Cesium-129 (Cs-129)	100	Iodine-125 (I-125)	1
Cesium-131 (Cs-131)	1,000	Iodine-126 (I-126)	1
Cesium-134m (Cs-134m)	100	Iodine-129 (I-129)	0.1
Cesium-134 (Cs-134)	1	Iodine-131 (I-131)	1
Cesium-135 (Cs-135)	10	Iodine-132 (I-132)	10
Cesium-136 (Cs-136)	10	Iodine-133 (I-133)	1
Cesium-137 (Cs-137)	10	Iodine-134 (I-134)	10
Chlorine-36 (Cl-36)	10	Iodine-135 (I-135)	10
Chlorine-38 (Cl-38)	10	Iridium-192 (Ir-192)	10
Chromium-51 (Cr-51)	1,000	Iridium-194 (Ir-194)	100
Cobalt-57 (Co-57)	100	Iron-52 (Fe-52)	10
Cobalt 58m (Co-58m)	10	Iron-55 (Fe-55)	100
Cobalt-58 (Co-58)	10	Iron-59 (Fe-59)	10
Cobalt-60 (Co-60)	1	Krypton-85 (Kr-85)	100
Copper-64 (Cu-64)	100	Krypton-87 (Kr-87)	10
Dysprosium-165(Dy-165)	10	Lanthanum-140 (La-140)	10
Dysprosium-166 (Dy-166)	100	Lutetium-177 (Lu-177)	100
Erbium-169 (Er-169)	100	Manganese-52 (Mn-52)	10
Erbium-171 (Er-171)	100	Manganese-54 (Mn-54)	10

Radioactive Material	Microcuries	Radioactive Material	Microcuries
Manganese-56 (Mn-56	10	Silver-110m (Ag-110m)	1
Mercury-197m (Hg-197m)	100	Silver-111 (Ag-111)	100
Mercury-197 (Hg-197)	100	Sodium-22 (Na-22)	10
Mercury-203 (Hg-203)	10	Sodium-24 (Na-24)	10
Molybdenum-99 (Mo-99)	100	Strontium-85 (Sr-85)	10
Neodymium-147 (Nd-147)	100	Strontium-89 (Sr-89)	1
Neodymium-149 (Nd-149)	100	Strontium-90 (Sr-90)	0.1
Nickel-59 (Ni-59)	100	Strontium-91 (Sr-91)	10
Nickel-63 (Ni-63)	10	Strontium-92 (Sr-92)	10
Nickel-65 (Ni-65)	100	Sulphur-35 (S-35)	100
Niobium-93m (Nb-93m)	10	Tantalum-182 (Ta-182)	10
Niobium-95 (Nb-95)	10	Technetium-96 (Tc-96)	10
Niobium-97 (Nb-97)	10	Technetium-97m (Tc-97m)	100
Osmium-185 (Os-185)	10	Technetium-97 (Tc-97)	100
Osmium-191m (Os-191m)	100	Technetium-99m (Tc-99m)	100
Osmium-191 (Os-191)	100	Technetium-99 (Tc-99)	10
Osmium-193 (Os-193)	100	Tellurium-125m (Te-125m)	10
Palladium-103 (Pd-103)	100	Tellurium-127m (Te-127m)	10
Palladium-109 (Pd-109)	100	Tellurium-127 (Te-127)	100
Phosphorus-32 (P-32)	10	Tellurium-129m (Te-129m)	10
Platinum-191 (Pt-191)	100	Tellurium-129 (Te-129)	100
Platinum-193m (Pt-193m)	100	Tellurium-131m (Te-131m)	10
Platinum-193 (Pt-193)	100	Tellurium-132 (Te-132)	10
Platinum-197m (Pt-197m)	100	Terbium-160 (Tb-160)	10
Platinum-197 (Pt-197)	100	Thallium-200 (Tl-200)	100
Polonium-210 (Po-210)	0.1	Thallium-201 (Tl-201)	100
Potassium-42 (K-42)	10	Thallium-202 (Tl-202)	100
Potassium-43 (K-43)	10	Thallium-204 (Tl-204)	10
Praseodymium-142 (Pr-142)	100	Thulium-170 (Tm-170)	10
Praseodymium-143 (Pr-143)	100	Thulium-171 (Tm-171)	10
Promethium-147 (Pm-147)	10	Tin-113 (Sn-113)	10
Promethium-149 (Pm-149)	10	Tin-125 (Sn-125)	10
Rhenium-186 (Re-186)	100	Tungsten-181 (W-181)	10
Rhenium-188 (Re-188)	100	Tungsten-185 (W-185)	10
Rhodium-103m (Rh-103m)	100	Tungsten-187 (W-187)	100
Rhodium-105 (Rh-105)	100	Vanadium-48 (V-48)	10
Rubidium-81 (Rb-81)	10	Xenon-131m (Xe-131m)	1,000
Rubidium-86 (Rb-86)	10	Xenon-133 (Xe-133)	100
Rubidium-87 (Rb-87)	10	Xenon-135 (Xe-135)	100
Ruthenium-97 (Ru-97)	100	Ytterbium-175 (Yb-175)	100
Ruthenium-103 (Ru-103)	10	Yttrium-87 (Y-87)	10
Ruthenium-105 (Ru-105)	10	Yttrium-90 (Y-90)	10
Ruthenium-106 (Ru-106)	1	Yttrium-91 (Y-91)	10
Samarium-151 (Sm-151)	10	Yttrium-92 (Y-92)	100
Samarium-153 (Sm-153)	100	Yttrium-93 (Y-93)	100
Scandium-46 (Sc-46)	10	Zinc-65 (Zn-65)	10
Scandium-47 (Sc-47)	100	Zinc-69m (Zn-69m)	100
Scandium-48 (Sc-48)	10	Zinc-69 (Zn-69)	1,000
Selenium-75 (Se-75)	10	Zirconium-93 (Zr-93)	10
Silicon-31 (Si-31)	100	Zirconium-95 (Zr-95)	10
Silver-105 (Ag-105)	10	Zirconium-97 (Zr-97)	10

Any radioactive material not listed above other than alpha emitting radioactive material 0.1

TABLE III

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

(See notes at end of Table III)

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
Actinium (89)	Ac-227	S	$8X10^{-14}$	$2X10^{-6}$
		I	$9X10^{-13}$	$3X10^{-4}$
	Ac-228	S	$3X10^{-9}$	$9X10^{-5}$
		I	$6X10^{-10}$	$9X10^{-5}$
Americium (95)	Am-241	S	$2X10^{-13}$	$4X10^{-6}$
		I	$4X10^{-12}$	$3X10^{-5}$
	Am-242m	S	$2X10^{-13}$	$4X10^{-6}$
		I	$9X10^{-12}$	$9X10^{-5}$
	Am-242	S	$1X10^{-9}$	$1X10^{-4}$
		I	$2X10^{-9}$	$1X10^{-4}$
	Am-243	S	$2X10^{-13}$	$4X10^{-6}$
		I	$4X10^{-12}$	$3X10^{-5}$
	Am-244	S	$1X10^{-7}$	$5X10^{-3}$
		I	$8X10^{-7}$	$5X10^{-3}$
Antimony (51)	Sb-122	S	$6X10^{-9}$	$3X10^{-5}$
		I	$5X10^{-9}$	$3X10^{-5}$
	Sb-124	S	$5X10^{-9}$	$2X10^{-5}$
		I	$7X10^{-10}$	$2X10^{-5}$
	Sb-125	S	$2X10^{-8}$	$1X10^{-4}$
		I	$9X10^{-10}$	$1X10^{-4}$
Argon (18)	Ar-37	Sub[2]	$1X10^{-4}$	------
	Ar-41	Sub	$4X10^{-8}$	------
Arsenic (33)	As-73	S	$7X10^{-8}$	$5X10^{-4}$
		I	$1X10^{-8}$	$5X10^{-4}$
	As-74	S	$1X10^{-8}$	$5X10^{-5}$
		I	$4X10^{-9}$	$5X10^{-5}$
	As-76	S	$4X10^{-9}$	$2X10^{-5}$
		I	$3X10^{-9}$	$2X10^{-5}$
	As-77	S	$2X10^{-8}$	$8X10^{-5}$
		I	$1X10^{-8}$	$8X10^{-5}$

Element (Atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
Astatine (85)	At-211	S	$2X10^{-10}$	$2X10^{-6}$
		I	$1X10^{-9}$	$7X10^{-5}$
Barium (56)	Ba-131	S	$4X10^{-8}$	$2X10^{-4}$
		I	$1X10^{-8}$	$2X10^{-4}$
	Ba-140	S	$4X10^{-9}$	$3X10^{-5}$
		I	$1X10^{-9}$	$2X10^{-5}$
Berkelium (97)	Bk-249	S	$3X10^{-11}$	$6X10^{-4}$
		I	$4X10^{-9}$	$6X10^{-4}$
	Bk-250	S	$5X10^{-9}$	$2X10^{-4}$
		I	$4X10^{-8}$	$2X10^{-4}$
Beryllium (4)	^{7}Be-7	S	$2X10^{-7}$	$2X10^{-3}$
		I	$4X10^{-8}$	$2X10^{-3}$
Bismuth (83)	Bi-206	S	$6X10^{-9}$	$4X10^{-5}$
		I	$5X10^{-9}$	$4X10^{-5}$
	Bi-207	S	$6X10^{-9}$	$6X10^{-5}$
		I	$5X10^{-10}$	$6X10^{-5}$
	Bi-210	S	$2X10^{-10}$	$4X10^{-5}$
		I	$2X10^{-10}$	$4X10^{-5}$
	Bi-212	S	$3X10^{-9}$	$4X10^{-4}$
		I	$7X10^{-9}$	$4X10^{-4}$
Bromine (35)	Br-82	S	$4X10^{-8}$	$3X10^{-4}$
		I	$6X10^{-9}$	$4X10^{-5}$
Cadmium (48)	Cd-109	S	$2X10^{-9}$	$2X10^{-4}$
		I	$3X10^{-9}$	$2X10^{-4}$
	Cd-115m	S	$1X10^{-9}$	$3X10^{-5}$
		I	$1X10^{-9}$	$3X10^{-5}$
	Cd-115	S	$8X10^{-9}$	$3X10^{-5}$
		I	$6X10^{-9}$	$4X10^{-5}$
Calcium (20)	Ca-45	S	$1X10^{-9}$	$9X10^{-6}$
		I	$4X10^{-9}$	$2X10^{-4}$
	Ca-47	S	$6X10^{-9}$	$5X10^{-5}$
		I	$6X10^{-9}$	$3X10^{-5}$
Californium (98)	Cf-249	S	$5X10^{-14}$	$4X10^{-6}$
		I	$3X10^{-12}$	$2X10^{-5}$

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
	Cf-250	S	$2X10^{-13}$	$1X10^{-5}$
		I	$3X10^{-12}$	$3X10^{-5}$
	Cf-251	S	$6X10^{-14}$	$4X10^{-6}$
		I	$3X10^{-12}$	$3X10^{-5}$
	Cf-252	S	$2X10^{-13}$	$7X10^{-6}$
		I	$1X10^{-12}$	$7X10^{-6}$
	Cf-253	S	$3X10^{-11}$	$1X10^{-4}$
		I	$3X10^{-11}$	$1X10^{-4}$
	Cf-254	S	$2X10^{-13}$	$1X10^{-7}$
		I	$2X10^{-13}$	$1X10^{-7}$
Carbon (6)	C-14	S	$1X10^{-7}$	$8X10^{-4}$
	(CO_2)	Sub[2]	$1X10^{-6}$	------
Cerium (58)	Ce-141	S	$2X10^{-8}$	$9X10^{-5}$
		I	$5X10^{-9}$	$9X10^{-5}$
	Ce-143	S	$9X10^{-9}$	$4X10^{-5}$
		I	$7X10^{-9}$	$4X10^{-5}$
	Ce-144	S	$3X10^{-10}$	$1X10^{-5}$
		I	$2X10^{-10}$	$1X10^{-5}$
Cesium (55)	Cs-131	S	$4X10^{-7}$	$2X10^{-3}$
		I	$1X10^{-7}$	$9X10^{-4}$
	Cs-134m	S	$1X10^{-6}$	$6X10^{-3}$
		I	$2X10^{-7}$	$1X10^{-3}$
	Cs-134	S	$1X10^{-9}$	$9X10^{-6}$
		I	$4X10^{-10}$	$4X10^{-5}$
	Cs-135	S	$2X10^{-8}$	$1X10^{-4}$
		I	$3X10^{-9}$	$2X10^{-4}$
	Cs-136	S	$1X10^{-8}$	$9X10^{-5}$
		I	$6X10^{-9}$	$6X10^{-5}$
	Cs-137	S	$2X10^{-9}$	$2X10^{-5}$
		I	$5X10^{-10}$	$4X10^{-5}$
Chlorine (17)	Cl-36	S	$1X10^{-8}$	$8X10^{-5}$
		I	$8X10^{-10}$	$6X10^{-5}$
	Cl-38	S	$9X10^{-8}$	$4X10^{-4}$
		I	$7X10^{-8}$	$4X10^{-4}$
Chromium (24)	Cr-51	S	$4X10^{-7}$	$2X10^{-3}$
		I	$8X10^{-8}$	$2X10^{-3}$

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
Cobalt (27)	Co-57	S	$1X10^{-7}$	$5X10^{-4}$
		I	$6X10^{-9}$	$4X10^{-4}$
	Co-58m	S	$6X10^{-7}$	$3X10^{-3}$
		I	$3X10^{-7}$	$2X10^{-3}$
	Co-58	S	$3X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-9}$	$9X10^{-5}$
	Co-60	S	$1X10^{-8}$	$5X10^{-5}$
		I	$3X10^{-10}$	$3X10^{-5}$
Copper (29)	Cu-64	S	$7X10^{-8}$	$3X10^{-4}$
		I	$4X10^{-8}$	$2X10^{-4}$
Curium (96)	Cm-242	S	$4X10^{-12}$	$2X10^{-5}$
		I	$6X10^{-12}$	$2X10^{-5}$
	Cm-243	S	$2X10^{-13}$	$5X10^{-6}$
		I	$3X10^{-12}$	$2X10^{-5}$
	Cm-244	S	$3X10^{-13}$	$7X10^{-6}$
		I	$3X10^{-12}$	$3X10^{-5}$
	Cm-245	S	$2X10^{-13}$	$4X10^{-6}$
		I	$4X10^{-12}$	$3X10^{-5}$
	Cm-246	S	$2X10^{-13}$	$4X10^{-6}$
		I	$4X10^{-12}$	$3X10^{-5}$
	Cm-247	S	$2X10^{-13}$	$4X10^{-6}$
		I	$4X10^{-12}$	$2X10^{-5}$
	Cm-248	S	$2X10^{-14}$	$4X10^{-7}$
		I	$4X10^{-13}$	$1X10^{-6}$
	Cm-249	S	$4X10^{-7}$	$2X10^{-3}$
		I	$4X10^{-7}$	$2X10^{-3}$
Dysprosium (66)	Dy-165	S	$9X10^{-8}$	$4X10^{-4}$
		I	$7X10^{-8}$	$4X10^{-4}$
	Dy-166	S	$8X10^{-9}$	$4X10^{-5}$
		I	$7X10^{-9}$	$4X10^{-5}$
Einsteinium (99)	Es-253	S	$3X10^{-11}$	$2X10^{-5}$
		I	$2X10^{-11}$	$2X10^{-5}$
	Es-254m	S	$2X10^{-10}$	$2X10^{-5}$
		I	$2X10^{-10}$	$2X10^{-5}$
	Es-254	S	$6X10^{-13}$	$1X10^{-5}$
		I	$4X10^{-12}$	$1X10^{-5}$
	Es-255	S	$2X10^{-11}$	$3X10^{-5}$
		I	$1X10^{-11}$	$3X10^{-5}$
Erbium (68)	Er-169	S	$2X10^{-8}$	$9X10^{-5}$
		I	$1X10^{-8}$	$9X10^{-5}$
	Er-171	S	$2X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-8}$	$1X10^{-4}$

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
Europium (63)	Eu-152 (T =9.2 hrs)	S	$1X10^{-8}$	$6X10^{-5}$
		I	$1X10^{-8}$	$6X10^{-5}$
	Eu-152 (T =13 yrs)	S	$4X10^{-10}$	$8X10^{-5}$
		I	$6X10^{-10}$	$8X10^{-5}$
	Eu-154	S	$1X10^{-10}$	$2X10^{-5}$
		I	$2X10^{-10}$	$2X10^{-5}$
	Eu-155	S	$3X10^{-9}$	$2X10^{-4}$
		I	$3X10^{-9}$	$2X10^{-4}$
Fermium (100)	Fm-254	S	$2X10^{-9}$	$1X10^{-4}$
		I	$2X10^{-9}$	$1X10^{-4}$
	Fm-255	S	$6X10^{-10}$	$3X10^{-5}$
		I	$4X10^{-10}$	$3X10^{-5}$
	Fm-256	S	$1X10^{-10}$	$9X10^{-7}$
		I	$6X10^{-11}$	$9X10^{-7}$
Fluorine (9)	F-18	S	$2X10^{-7}$	$8X10^{-4}$
		I	$9X10^{-8}$	$5X10^{-4}$
Gadolinium (64)	Gd-153	S	$8X10^{-9}$	$2X10^{-4}$
		I	$3X10^{-9}$	$2X10^{-4}$
	Gd-159	S	$2X10^{-8}$	$8X10^{-5}$
		I	$1X10^{-8}$	$8X10^{-5}$
Gallium (31)	Ga-72	S	$8X10^{-9}$	$4X10^{-5}$
		I	$6X10^{-9}$	$4X10^{-5}$
Germanium (32)	Ge-71	S	$4X10^{-7}$	$2X10^{-3}$
		I	$2X10^{-7}$	$2X10^{-3}$
Gold (79)	Au-196	S	$4X10^{-8}$	$2X10^{-4}$
		I	$2X10^{-8}$	$1X10^{-4}$
	Au-198	S	$1X10^{-8}$	$5X10^{-5}$
		I	$8X10^{-9}$	$5X10^{-5}$
	Au-199	S	$4X10^{-8}$	$2X10^{-4}$
		I	$3X10^{-8}$	$2X10^{-4}$
Hafnium (72)	Hf-181	S	$1X10^{-9}$	$7X10^{-5}$
		I	$3X10^{-9}$	$7X10^{-5}$
Holmium (67)	Ho-166	S	$7X10^{-9}$	$3X10^{-5}$
		I	$6X10^{-9}$	$3X10^{-5}$

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
Hydrogen (1)	H-3	S	$2X10^{-7}$	$3X10^{-3}$
		I	$2X10^{-7}$	$3X10^{-3}$
		Sub[2]	$4X10^{-5}$	------
Indium (49)	In-113m	S	$3X10^{-7}$	$1X10^{-3}$
		I	$2X10^{-7}$	$1X10^{-3}$
	In-114m	S	$4X10^{-9}$	$2X10^{-5}$
		I	$7X10^{-10}$	$2X10^{-5}$
	In-115m	S	$8X10^{-8}$	$4X10^{-4}$
		I	$6X10^{-8}$	$4X10^{-4}$
	In-115	S	$9X10^{-9}$	$9X10^{-5}$
		I	$1X10^{-9}$	$9X10^{-5}$
Iodine (53)	I-125	S	$8X10^{-11}$	$2X10^{-7}$
		I	$6X10^{-9}$	$2X10^{-4}$
	I-126	S	$9X10^{-11}$	$3X10^{-7}$
		I	$1X10^{-8}$	$9X10^{-5}$
	I-129	S	$2X10^{-11}$	$6X10^{-8}$
		I	$2X10^{-9}$	$2X10^{-4}$
	I-131	S	$1X10^{-10}$	$3X10^{-7}$
		I	$1X10^{-8}$	$6X10^{-5}$
	I-132	S	$3X10^{-9}$	$8X10^{-6}$
		I	$3X10^{-8}$	$2X10^{-4}$
	I-133	S	$4X10^{-10}$	$1X10^{-6}$
		I	$7X10^{-9}$	$4X10^{-5}$
	I-134	S	$6X10^{-9}$	$2X10^{-5}$
		I	$1X10^{-7}$	$6X10^{-4}$
	I-135	S	$1X10^{-9}$	$4X10^{-6}$
		I	$1X10^{-8}$	$7X10^{-5}$
Iridium (77)	Ir-190	S	$4X10^{-8}$	$2X10^{-4}$
		I	$1X10^{-8}$	$2X10^{-4}$
	Ir-192	S	$4X10^{-9}$	$4X10^{-5}$
		I	$9X10^{-10}$	$4X10^{-5}$
	Ir-194	S	$8X10^{-9}$	$3X10^{-5}$
		I	$5X10^{-9}$	$3X10^{-5}$
Iron (26)	Fe-55	S	$3X10^{-8}$	$8X10^{-4}$
		I	$3X10^{-8}$	$2X10^{-3}$
	Fe-59	S	$5X10^{-9}$	$6X10^{-5}$
		I	$2X10^{-9}$	$5X10^{-5}$
Krypton (36)	Kr-85m	Sub[2]	$1X10^{-7}$	------
	Kr-85	Sub	$3X10^{-7}$	------
	Kr-87	Sub	$2X10^{-8}$	------
	Kr-88	Sub	$2X10^{-8}$	------

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
Lanthanum (57)	La-140	S	$5X10^{-9}$	$2X10^{-5}$
		I	$4X10^{-9}$	$2X10^{-5}$
Lead (82)	Pb-203	S	$9X10^{-8}$	$4X10^{-4}$
		I	$6X10^{-8}$	$4X10^{-4}$
	Pb-210	S	$4X10^{-12}$	$1X10^{-7}$
		I	$8X10^{-12}$	$2X10^{-4}$
	Pb-212	S	$6X10^{-10}$	$2X10^{-5}$
		I	$7X10^{-10}$	$2X10^{-5}$
Lutetium (71)	Lu-177	S	$2X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-8}$	$1X10^{-4}$
Manganese (25)	Mn-52	S	$7X10^{-9}$	$3X10^{-5}$
		I	$5X10^{-9}$	$3X10^{-5}$
	Mn-54	S	$1X10^{-8}$	$1X10^{-4}$
		I	$1X10^{-9}$	$1X10^{-4}$
	Mn-56	S	$3X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-8}$	$1X10^{-4}$
Mercury (80)	Hg-197m	S	$3X10^{-8}$	$2X10^{-4}$
		I	$3X10^{-8}$	$2X10^{-4}$
	Hg-197	S	$4X10^{-8}$	$3X10^{-4}$
		I	$9X10^{-8}$	$5X10^{-4}$
	Hg-203	S	$2X10^{-9}$	$2X10^{-5}$
		I	$4X10^{-9}$	$1X10^{-4}$
Molybdenum (42)	Mo-99	S	$3X10^{-8}$	$2X10^{-4}$
		I	$7X10^{-9}$	$4X10^{-5}$
Neodymium (60)	Nd-144	S	$3X10^{-12}$	$7X10^{-5}$
		I	$1X10^{-11}$	$8X10^{-5}$
	Nd-147	S	$1X10^{-8}$	$6X10^{-5}$
		I	$8X10^{-9}$	$6X10^{-5}$
	Nd-149	S	$6X10^{-8}$	$3X10^{-4}$
		I	$5X10^{-8}$	$3X10^{-4}$
Neptunium (93)	Np-237	S	$1X10^{-13}$	$3X10^{-6}$
		I	$4X10^{-12}$	$3X10^{-5}$
	Np-239	S	$3X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-8}$	$1X10^{-4}$
Nickel (28)	Ni-59	S	$2X10^{-8}$	$2X10^{-4}$
		I	$3X10^{-8}$	$2X10^{-3}$
	Ni-63	S	$2X10^{-9}$	$3X10^{-5}$
		I	$1X10^{-8}$	$7X10^{-4}$

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
	Ni-65	S	$3X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-8}$	$1X10^{-4}$
Niobium (41)	Nb-93m	S	$4X10^{-9}$	$4X10^{-4}$
		I	$5X10^{-9}$	$4X10^{-4}$
	Nb-95	S	$2X10^{-8}$	$1X10^{-4}$
		I	$3X10^{-9}$	$1X10^{-4}$
	Nb-97	S	$2X10^{-7}$	$9X10^{-4}$
		I	$2X10^{-7}$	$9X10^{-4}$
Osmium (76)	Os-185	S	$2X10^{-8}$	$7X10^{-5}$
		I	$2X10^{-9}$	$7X10^{-5}$
	Os-191m	S	$6X10^{-7}$	$3X10^{-3}$
		I	$3X10^{-7}$	$2X10^{-3}$
	Os-191	S	$4X10^{-8}$	$2X10^{-4}$
		I	$1X10^{-8}$	$2X10^{-4}$
	Os-193	S	$1X10^{-8}$	$6X10^{-5}$
		I	$9X10^{-9}$	$5X10^{-5}$
Palladium (46)	Pd-103	S	$5X10^{-8}$	$3X10^{-4}$
		I	$3X10^{-8}$	$3X10^{-4}$
	Pd-109	S	$2X10^{-8}$	$9X10^{-5}$
		I	$1X10^{-8}$	$7X10^{-5}$
Phosphorus (15)	P-32	S	$2X10^{-9}$	$2X10^{-5}$
		I	$3X10^{-9}$	$2X10^{-5}$
Platinum (78)	Pt-191	S	$3X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-8}$	$1X10^{-4}$
	Pt-193m	S	$2X10^{-7}$	$1X10^{-3}$
		I	$2X10^{-7}$	$1X10^{-3}$
	Pt-193	S	$4X10^{-8}$	$9X10^{-4}$
		I	$1X10^{-8}$	$2X10^{-3}$
	Pt-197m	S	$2X10^{-7}$	$1X10^{-3}$
		I	$2X10^{-7}$	$9X10^{-4}$
	Pt-197	S	$3X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-8}$	$1X10^{-4}$
Plutonium (94)	Pu-238	S	$7X10^{-14}$	$5X10^{-6}$
		I	$1X10^{-12}$	$3X10^{-5}$
	Pu-239	S	$6X10^{-14}$	$5X10^{-6}$
		I	$1X10^{-12}$	$3X10^{-5}$
	Pu-240	S	$6X10^{-14}$	$5X10^{-6}$
		I	$1X10^{-12}$	$3X10^{-5}$
	Pu-241	S	$3X10^{-12}$	$2X10^{-4}$
		I	$1X10^{-9}$	$1X10^{-3}$
	Pu-242	S	$6X10^{-14}$	$5X10^{-6}$
		I	$1X10^{-12}$	$3X10^{-5}$

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
	Pu-243	S	$6X10^{-8}$	$3X10^{-4}$
		I	$8X10^{-8}$	$3X10^{-4}$
	Pu-244	S	$6X10^{-14}$	$4X10^{-6}$
		I	$1X10^{-12}$	$1X10^{-5}$
Polonium (84)	Po-210	S	$2X10^{-11}$	$7X10^{-7}$
		I	$7X10^{-12}$	$3X10^{-5}$
Potassium (19)	K-42	S	$7X10^{-8}$	$3X10^{-4}$
		I	$4X10^{-9}$	$2X10^{-5}$
Praseodymium (59)	Pr-142	S	$7X10^{-9}$	$3X10^{-5}$
		I	$5X10^{-9}$	$3X10^{-5}$
	Pr-143	S	$1X10^{-8}$	$5X10^{-5}$
		I	$6X10^{-9}$	$5X10^{-5}$
Promethium (61)	Pm-147	S	$2X10^{-9}$	$2X10^{-4}$
		I	$3X10^{-9}$	$2X10^{-4}$
	Pm-149	S	$1X10^{-8}$	$4X10^{-5}$
		I	$8X10^{-9}$	$4X10^{-5}$
Protactinium (91)	Pa-230	S	$6X10^{-11}$	$2X10^{-4}$
		I	$3X10^{-11}$	$2X10^{-4}$
	Pa-231	S	$4X10^{-14}$	$9X10^{-7}$
		I	$4X10^{-12}$	$2X10^{-5}$
	Pa-233	S	$2X10^{-8}$	$1X10^{-4}$
		I	$6X10^{-9}$	$1X10^{-4}$
Radium (88)	Ra-223	S	$6X10^{-11}$	$7X10^{-7}$
		I	$8X10^{-12}$	$4X10^{-6}$
	Ra-224	S	$2X10^{-10}$	$2X10^{-6}$
		I	$2X10^{-11}$	$5X10^{-6}$
	Ra-226	S	$3X10^{-12}$	$3X10^{-8}$
		I	$2X10^{-12}$	$3X10^{-5}$
	Ra-228	S	$2X10^{-12}$	$3X10^{-8}$
		I	$1X10^{-12}$	$3X10^{-5}$
Radon (86)	Rn-220	S	$1X10^{-8}$	------
		I	------	------
	Rn-222[3]	S	$3X10^{-9}$	------
Rhenium (75)	Re-183	S	$9X10^{-8}$	$6X10^{-4}$
		I	$5X10^{-9}$	$3X10^{-4}$

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
	Re-186	S	$2X10^{-8}$	$9X10^{-5}$
		I	$8X10^{-9}$	$5X10^{-5}$
	Re-187	S	$3X10^{-7}$	$3X10^{-3}$
		I	$2X10^{-8}$	$2X10^{-3}$
	Re-188	S	$1X10^{-8}$	$6X10^{-5}$
		I	$6X10^{-9}$	$3X10^{-5}$
Rhodium (45)	Rh-103m	S	$3X10^{-6}$	$1X10^{-2}$
		I	$2X10^{-6}$	$1X10^{-2}$
	Rh-105	S	$3X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-8}$	$1X10^{-4}$
Rubidium (37)	Rb-86	S	$1X10^{-8}$	$7X10^{-5}$
		I	$2X10^{-9}$	$2X10^{-5}$
	Rb-87	S	$2X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-9}$	$2X10^{-4}$
Ruthenium (44)	Ru-97	S	$8X10^{-8}$	$4X10^{-4}$
		I	$6X10^{-8}$	$3X10^{-4}$
	Ru-103	S	$2X10^{-8}$	$8X10^{-5}$
		I	$3X10^{-9}$	$8X10^{-5}$
	Ru-105	S	$2X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-8}$	$1X10^{-4}$
	Ru-106	S	$3X10^{-9}$	$1X10^{-5}$
		I	$2X10^{-10}$	$1X10^{-5}$
Samarium (62)	Sm-147	S	$2X10^{-12}$	$6X10^{-5}$
		I	$9X10^{-12}$	$7X10^{-5}$
	Sm-151	S	$2X10^{-9}$	$4X10^{-4}$
		I	$5X10^{-9}$	$4X10^{-4}$
	Sm-153	S	$2X10^{-8}$	$8X10^{-5}$
		I	$1X10^{-8}$	$8X10^{-5}$
Scandium (21)	Sc-46	S	$8X10^{-9}$	$4X10^{-5}$
		I	$8X10^{-10}$	$4X10^{-5}$
	Sc-47	S	$2X10^{-8}$	$9X10^{-5}$
		I	$2X10^{-8}$	$9X10^{-5}$
	Sc-48	S	$6X10^{-9}$	$3X10^{-5}$
		I	$5X10^{-9}$	$3X10^{-5}$
Selenium (34)	Se-75	S	$4X10^{-8}$	$3X10^{-4}$
		I	$4X10^{-9}$	$3X10^{-4}$
Silicon (14)	Si-31	S	$2X10^{-7}$	$9X10^{-4}$
		I	$3X10^{-8}$	$2X10^{-4}$

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column II Water (μCi/ml)
Silver (47)	Ag-105	S	$2X10^{-8}$	$1X10^{-4}$
		I	$3X10^{-9}$	$1X10^{-4}$
	Ag-110m	S	$7X10^{-9}$	$3X10^{-5}$
		I	$3X10^{-10}$	$3X10^{-5}$
	Ag-111	S	$1X10^{-8}$	$4X10^{-5}$
		I	$8X10^{-9}$	$4X10^{-5}$
Sodium (11)	Na-22	S	$6X10^{-9}$	$4X10^{-5}$
		I	$3X10^{-10}$	$3X10^{-5}$
	Na-24	S	$4X10^{-8}$	$2X10^{-4}$
		I	$5X10^{-9}$	$3X10^{-5}$
Strontium (38)	Sr-85m	S	$1X10^{-6}$	$7X10^{-3}$
		I	$1X10^{-6}$	$7X10^{-3}$
	Sr-85	S	$8X10^{-9}$	$1X10^{-4}$
		I	$4X10^{-9}$	$2X10^{-4}$
	Sr-89	S	$3X10^{-10}$	$3X10^{-6}$
		I	$1X10^{-9}$	$3X10^{-5}$
	Sr-90	S	$3X10^{-11}$	$3X10^{-7}$
		I	$2X10^{-10}$	$4X10^{-5}$
	Sr-91	S	$2X10^{-8}$	$7X10^{-5}$
		I	$9X10^{-9}$	$5X10^{-5}$
	Sr-92	S	$2X10^{-8}$	$7X10^{-5}$
		I	$1X10^{-8}$	$6X10^{-5}$
Sulfur (16)	S-35	S	$9X10^{-9}$	$6X10^{-5}$
		I	$9X10^{-9}$	$3X10^{-4}$
Tantalum (73)	Ta-182	S	$1X10^{-9}$	$4X10^{-5}$
		I	$7X10^{-10}$	$4X10^{-5}$
Technetium (43)	Tc-96m	S	$3X10^{-6}$	$1X10^{-2}$
		I	$1X10^{-6}$	$1X10^{-2}$
	Tc-96	S	$2X10^{-8}$	$1X10^{-4}$
		I	$8X10^{-9}$	$5X10^{-5}$
	Tc-97m	S	$8X10^{-8}$	$4X10^{-4}$
		I	$5X10^{-9}$	$2X10^{-4}$
	Tc-97	S	$4X10^{-7}$	$2X10^{-3}$
		I	$1X10^{-8}$	$8X10^{-4}$
	Tc-99m	S	$1X10^{-6}$	$6X10^{-3}$
		I	$5X10^{-7}$	$3X10^{-3}$
	Tc-99	S	$7X10^{-8}$	$3X10^{-4}$
		I	$2X10^{-9}$	$2X10^{-4}$

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
Tellurium (52)	Te-125m	S	$1X10^{-8}$	$2X10^{-4}$
		I	$4X10^{-9}$	$1X10^{-4}$
	Te-127m	S	$5X10^{-9}$	$6X10^{-5}$
		I	$1X10^{-9}$	$5X10^{-5}$
	Te-127	S	$6X10^{-8}$	$3X10^{-4}$
		I	$3X10^{-8}$	$2X10^{-4}$
	Te-129m	S	$3X10^{-9}$	$3X10^{-5}$
		I	$1X10^{-9}$	$2X10^{-5}$
	Te-129	S	$2X10^{-7}$	$8X10^{-4}$
		I	$1X10^{-7}$	$8X10^{-4}$
	Te-131m	S	$1X10^{-8}$	$6X10^{-5}$
		I	$6X10^{-9}$	$4X10^{-5}$
	Te-132	S	$7X10^{-9}$	$3X10^{-5}$
		I	$4X10^{-9}$	$2X10^{-5}$
Terbium (65)	Tb-160	S	$3X10^{-9}$	$4X10^{-5}$
		I	$1X10^{-9}$	$4X10^{-5}$
Thallium (81)	Tl-200	S	$9X10^{-8}$	$4X10^{-4}$
		I	$4X10^{-8}$	$2X10^{-4}$
	Tl-201	S	$7X10^{-8}$	$3X10^{-4}$
		I	$3X10^{-8}$	$2X10^{-4}$
	Tl-202	S	$3X10^{-8}$	$1X10^{-4}$
		I	$8X10^{-9}$	$7X10^{-5}$
	Tl-204	S	$2X10^{-8}$	$1X10^{-4}$
		I	$9X10^{-10}$	$6X10^{-5}$
Thorium (90)	Th-227	S	$1X10^{-11}$	$2X10^{-5}$
		I	$6X10^{-12}$	$2X10^{-5}$
	Th-228	S	$3X10^{-13}$	$7X10^{-6}$
		I	$2X10^{-13}$	$1X10^{-5}$
	Th-230	S	$8X10^{-14}$	$2X10^{-6}$
		I	$3X10^{-13}$	$3X10^{-5}$
	Th-231	S	$5X10^{-8}$	$2X10^{-4}$
		I	$4X10^{-8}$	$2X10^{-4}$
	Th-232	S	$1X10^{-12}$	$2X10^{-6}$
		I	$1X10^{-12}$	$4X10^{-5}$
	Th-natural	S	$2X10^{-12}$	$2X10^{-6}$
		I	$2X10^{-12}$	$2X10^{-5}$
	Th-234	S	$2X10^{-9}$	$2X10^{-5}$
		I	$1X10^{-9}$	$2X10^{-5}$
Thulium (69)	Tm-170	S	$1X10^{-9}$	$5X10^{-5}$
		I	$1X10^{-9}$	$5X10^{-5}$

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
	Tm-171	S	$4X10^{-9}$	$5X10^{-4}$
		I	$8X10^{-9}$	$5X10^{-4}$
Tin (50)	Sn-113	S	$1X10^{-8}$	$9X10^{-5}$
		I	$2X10^{-9}$	$8X10^{-5}$
	Sn-125	S	$4X10^{-9}$	$2X10^{-5}$
		I	$3X10^{-9}$	$2X10^{-5}$
Tungsten (74)	W-181	S	$8X10^{-8}$	$4X10^{-4}$
		I	$4X10^{-9}$	$3X10^{-4}$
	W-185	S	$3X10^{-8}$	$1X10^{-4}$
		I	$4X10^{-9}$	$1X10^{-4}$
	W-187	S	$2X10^{-8}$	$7X10^{-5}$
		I	$1X10^{-8}$	$6X10^{-5}$
Uranium (92)	U-230	S	$1X10^{-11}$	$5X10^{-6}$
		I	$4X10^{-12}$	$5X10^{-6}$
	U-232	S	$3X10^{-12}$	$3X10^{-5}$
		I	$9X10^{-13}$	$3X10^{-5}$
	U-233	S	$2X10^{-11}$	$3X10^{-5}$
		I	$4X10^{-12}$	$3X10^{-5}$
	U-234	S[4]	$2X10^{-11}$	$3X10^{-5}$
		I	$4X10^{-12}$	$3X10^{-5}$
	U-235	S[4]	$2X10^{-11}$	$3X10^{-5}$
		I	$4X10^{-12}$	$3X10^{-5}$
	U-236	S	$2X10^{-11}$	$3X10^{-5}$
		I	$4X10^{-12}$	$3X10^{-5}$
	U-238	S	$3X10^{-12}$	$4X10^{-5}$
		I	$5X10^{-12}$	$4X10^{-5}$
	U-240	S	$8X10^{-9}$	$3X10^{-5}$
		I	$6X10^{-9}$	$3X10^{-5}$
	U-natural	S[4]	$5X10^{-12}$	$3X10^{-5}$
		I	$5X10^{-12}$	$3X10^{-5}$
Vanadium (23)	V-48	S	$6X10^{-9}$	$3X10^{-5}$
		I	$2X10^{-9}$	$3X10^{-5}$
Xenon (54)	Xe-131m	Sub[2]	$4X10^{-7}$	------
	Xe-133m	Sub	$3X10^{-7}$	------
	Xe-133	Sub	$3X10^{-7}$	------
	Xe-135	Sub	$1X10^{-7}$	------
Ytterbium (70)	Yb-175	S	$2X10^{-8}$	$1X10^{-4}$
		I	$2X10^{-8}$	$1X10^{-4}$

Element (atomic number)	Isotope[1]		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
Yttrium (39)	Y-90	S	$4X10^{-9}$	$2X10^{-5}$
		I	$3X10^{-9}$	$2X10^{-5}$
	Y-91m	S	$8X10^{-7}$	$3X10^{-3}$
		I	$6X10^{-7}$	$3X10^{-3}$
	Y-91	S	$1X10^{-9}$	$3X10^{-5}$
		I	$1X10^{-9}$	$3X10^{-5}$
	Y-92	S	$1X10^{-8}$	$6X10^{-5}$
		I	$1X10^{-8}$	$6X10^{-5}$
	Y-93	S	$6X10^{-9}$	$3X10^{-5}$
		I	$5X10^{-9}$	$3X10^{-5}$
Zinc (30)	Zn-65	S	$4X10^{-9}$	$1X10^{-4}$
		I	$2X10^{-9}$	$2X10^{-4}$
	Zn-69m	S	$1X10^{-8}$	$7X10^{-5}$
		I	$1X10^{-8}$	$6X10^{-5}$
	Zn-69	S	$2X10^{-7}$	$2X10^{-3}$
		I	$3X10^{-7}$	$2X10^{-3}$
Zirconium (40)	Zr-93	S	$4X10^{-9}$	$8X10^{-4}$
		I	$1X10^{-8}$	$8X10^{-4}$
	Zr-95	S	$4X10^{-9}$	$6X10^{-5}$
		I	$1X10^{-9}$	$6X10^{-5}$
	Zr-97	S	$4X10^{-9}$	$2X10^{-5}$
		I	$3X10^{-9}$	$2X10^{-5}$
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours.		Sub[2]	$3X10^{-8}$	------
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours.			$1X10^{-10}$	$3X10^{-6}$

Element (atomic number)	Isotope[1]	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.		$2X10^{-14}$	$3X10^{-8}$

[1]Soluble (S); Insoluble (I).

[2]"Sub" means that values given are for submersion in a semi-spherical infinite cloud of airborne material.

[3]These radon concentrations are appropriate for protection from radon-222 combined with its short-lived daughters. Alternatively, the value in Table I may be replaced by one-third (1/3) *working level*. (A *working level* is defined as any combination of short-lived radon-222 daughters, polonium-218, lead-214, bismuth-214 and polonium-214, in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of $1.3x10^5$ MeV of alpha particle energy.) The Table II value may be replaced by one-thirtieth (1/30) of a *working level*. The limit on radon-222 concentrations in restricted areas may be based on an annual average.

[4]For soluble mixtures of U-238, U-234 and U-235 in air chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour workweek, Table I, is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed $8x10^{-3}$ SA μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The concentration value for Table II is 0.007 milligrams uranium per cubic meter of air. The specific activity for natural uranium is 6.77×10^{-7} Curies per gram U. The specific activity for other mixtures of U-238, U-235 and U-234, if not known, shall be:

$SA = 3.6 \times 10^{-7}$ Curies/gram U — U-depleted

$SA = (0.4 + 0.38\ E + 0.0034\ E^2)(10^{-6})$ — $E \geq 0.72$

where E is the percentage by weight of U-235, expressed as percent.

APPENDIX A

NOTE: In any case where there is a mixture in air or water of more than one radionuclide, the limiting values for purposes of this Appendix should be determined as follows:

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix "A" for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").

   Example: If radionuclides a, b and c are present in concentrations C_a, C_b and C_c, and if the applicable MPC's are MPC_a, MPC_b and MPC_c respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_a}{MPC_a} + \frac{C_b}{MPC_b} + \frac{C_c}{MPC_c} \leq 1$$

2. If either the identity or the concentration of any radionuclide in the mixture is not known, the limiting values for purposes of Appendix "A" shall be:

   a. For purposes of Table I, Col. 1 . . . . . $6X10^{-13}$
   b. For purposes of Table I, Col. 2 . . . . . $4X10^{-7}$
   c. For purposes of Table II, Col. 1 . . . . . $2X10^{-14}$
   d. For purposes of Table II, Col. 2 . . . . . $3X10^{-8}$

3. If any of the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in paragraph 2 above.

   a. If the identity of each radionuclide in the mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the concentration limit for the mixture is the limit specified in Appendix "A" for the radionuclide in the mixture having the lowest concentration limit; or

   b. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Appendix "A" are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Appendix "A" for any radionuclide which is not known to be absent from the mixture; or

c. Radionuclide	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
If it is known that Sr-90, I-125, I-126, I-129, I-131, (I-133 Table II only), Pb-210, Po-210, At-211, Ra-223, Ra-224, Ra-226, Ac-227, Ra-228, Th-230, Pa-231, Th-232, Th-nat, Cm-248, Cf-254 and Fm-256 are not present -------	------	$3X10^{-6}$
If it is known that Sr-90, I-125, I-126, I-129, (I-131, I-133, Table II only), Pb-210, Po-210, Ra-223, Ra-226, Ra-228, Pa-231, Th-nat, Cm-248, Cf-254 and Fm-256 are not present ----------	------	$2X10^{-6}$
If it is known that Sr-90, I-129, (I-125, I-126, I-131, Table II only), Pb-210, Ra-226, Ra-228, Cm-248 and Cf-254 are not present ----------	------	$6X10^{-7}$
If it is known that (I-129, Table II only), Ra-226 and Ra-228 are not present ----------	------	$1X10^{-7}$
If it is known that alpha-emitters and Sr-90, I-129, Pb-210, Ac-227, Ra-228, Pa-230, Pu-241 and Bk-249 are not present ----------	$1X10^{-10}$	------
If it is known that alpha-emitters and Pb-210, Ac-227, Ra-228 and Pu-241 are not present ----------	$1X10^{-11}$	------
If it is known that alpha-emitters and Ac-227 are not present -----	$1X10^{-12}$	------
If it is known that Ac-227, Th-230, Pa-231, Pu-238, Pu-239, Pu-240, Pu-242, Pu-244, Cm-248, Cf-249 and Cf-251 are not present ------	$1X10^{-13}$	------

4. If the mixture of radionuclides consists of uranium and its daughter products in ore dust prior to chemical processing of the uranium ore, the values specified below may be used in lieu of those determined in accordance with paragraph 1 above or those specified in paragraphs 2 and 3 above.

   a. For purposes of Table I, Column 1, 1×10^{-10} µCi/ml gross alpha activity; or 5×10^{-11} µCi/ml natural uranium; or 75 micrograms per cubic meter of air natural uranium.

   b. For purposes of Table II, Column 1, 3×10^{-12} µCi/ml gross alpha activity; 2×10^{-12} µCi/ml natural uranium; or 3 micrograms per cubic meter of air natural uranium.

5. For purposes of this note, a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture (C_a) to the concentration limit for that radionuclide specified in Table II of Appendix "A" (MPC_a) does not exceed 1/10, (i.e., $C_a/MPC_a \leq 1/10$) and (b) the sum of such ratios for all radionuclides considered as not present in the mixture does not exceed 1/4, (i.e., $C_a/MPC_a + C_b/MPC_b + \ldots\ldots \leq 1/4$).

APPENDIX A

Technical Changes Recommended to Dr. Woods' Rule

a. "Rule 345-50-020 should be revised to recognize that Health Division distinguished between radioactive materials contained in one discrete quantity versus several individual quantities. The Council should not attempt to define exempt quantities for americium, plutonium, uranium, or thorium or other isotopes which do not currently have accepted exempt quantity limits.

The parallel section of Health Division regulations is B.4(f)(1) which reads:

> Except as provided in Sec. B.4(f)(2) and (3), any person is exempt from these regulations to the extent that such person receives, possesses, uses, transfers, owns or acquires radioactive material in individual quantities, none of which exceeds the applicable quantity set forth in Schedule C of this part and provided that the number of individual quantities does not exceed ten (10).

Any single source with an activity in excess of that listed in the table requires licensing by Health Division and disposal by transfer to an authorized recipient (Reference Oregon Regulations for the Control of Radiation, Section C.301(a)).

Health Division regulations do not recognize any exempt quantities for alpha emitters. Americium and plutonium require licensing regardless of amount and disposal should be treated similarly. Uranium and thorium are dealt with as source material under Health Division and are treated in other sections of these proposed rules.

b. "Rule 345-50-025 should reference Health Division's exempt concentrations in solid materials rather than values derived from tables for effluent concentrations in air or water."

Although Dr. Woods correctly notes that many of the values for concentrations in solids in OAR 333-22-150 Part B, Schedule A are exactly ten times the values for water soluble species in Part C, Appendix A, Table II, Column 2, there is one notable difference. This relates to the radioactive isotopes of iodine and results from the fact that soluble iodine in effluents has demonstrated potential for resulting in exposures to members of the public. Consequently, allowable effluent releases are lower than they would be if they were merely one tenth of the exempt quantity limits in Part B.

Extension of the table to other radioactive materials and to the naturally occurring materials in particular may be perfectly reasonable as long as exceptions for materials such as radium-226 which have demonstrable health impacts are considered. The staff has reviewed the potential impacts of the extension of the table and believes that the radium isotopes are the only significant isotopes which require such an adjustment. We are aware, however, that much of the information required to confirm that fact is not readily available. We have considered the research required to generate a complete table to be beyond the scope of this rulemaking.

c. "Rule 345-50-030(1) should be revised to exempt all consumer products that have been evaluated for potential hazards by the Health Division. It should not, however, exempt ores."

Sections B.3(a) and (b) of the Health Division regulations exempt certain materials containing "source material". Although it is somewhat unclear in this portion of the Health Division regulations, source material specifically does not include the daughters of uranium and thorium. Compliance with provisions of ORS 453.605 through 453.745 requires that the use of all materials, including ores which contain the daughters of uranium and thorium, must meet the standards of Part C. Although rules under consideration up to this point have included the exemption in B.3(b) of Health Division rules, there is potential confusion in the fact that these materials are really not exempt from Health Division licensing. Consistency with existing Health Division regulations requires that the disposal of ores be subjected to the Health Division standards for doses to individuals.

d. Alternate Rule 345-50-021(2) should be modified to ensure that premises used in the case by case evaluation are generally applicable to all potential sources of activity.

The staff agrees with Dr. Woods that potentially affected parties should be aware of the procedure which the staff would use to apply radiation dose limits to generators of waste. We also concede the argument of others that materials and circumstances vary with each proposed disposal and, therefore, many assumptions will have to be based on a case-by-case evaluation.

Consequently, we are recommending that two of these conditions be modified. Condition 3 specifies a projected length of waste generation which we now propose to be considered on a case by case basis. Condition E references gamma radiation dose levels from uranium mill tailings. While this is probably a reasonable approximation of other materials of uranium origin, we recommend deleting E and inserting into D the condition that external gamma radiation levels will be based on actual measurements and that consideration may be given both for the degree of equilibrium and for self-shielding within the material.

One additional change is recommended. At the time of the November 3 hearing, the staff had not located any published models for radon levels in homes which considered a crawl space under the home. Since that time, we have received a report by J. W. Healy and J. C. Rodgers ("A Preliminary Study of Radium Contaminated Soils", LA-7391-MS, October 1978) which contains a model for such a home. Since this model has now been published and is available for professional scrutiny and experimental verification, we feel comfortable recommending a modification to Condition F which would allow consideration of a house built so as to meet the Uniform Building Codes. Such a condition was suggested by PGE in their criticism of our calculational procedure. However, no consideration should be allowed to any specific construction techniques or treatments designed to reduce radon diffusion into the structure.

JMP:sj
12/6/78
1322A

APPENDIX B
Non-Technical Exceptions to Dr. Woods' Rule

a. "The rule should become effective upon adoption rather than delaying until August 1979; this would be more responsive to the Legislature."

The statute prohibiting radioactive waste disposal was adopted by the state Legislature in 1977 and became effective along with other statutes adopted during that session. We are advised by Mr. Ostrander that a delayed effective date is probably not legal. The argument presented at the hearing for a delayed effective date is to allow the Legislature a chance to consider the effect of the statute and to clarify its position. At the request of Associated Oregon Industries, the Department of Energy has contacted the Attorney General requesting an opinion on the applicability of ORS 469.525 to pre-existing disposal sites. If this opinion concludes that existing sites are prohibited under the statute, the staff would require a period of time to generate a sufficient evidence to support an order for removal of material from any site. The effect of this is that, even acting in good faith towards enforcement of the statute, it is unlikely that any action could be taken prior to the end of the legislative session.

b. "The rule adopted by the Council should incorporate Health Division rules rather than simply referencing them; this is at the request of the EFSC committee."

Dr. Wang requested that the staff draft Option 2 incorporating the appropriate Health Division statutes rather than referencing them. This was done, distributed to the committee, and reviewed by the Health Division. While the reorganization of the rule in these exceptions to Dr. Woods report has not been reviewed by Health Division, the staff believes that it is faithfully rendered and incorporates all concerns expressed by the Health Division.

JMP:sj
1331A
12/7/78

APPENDIX C
Justification for Specific Levels of Activity

During the course of hearings on this subject, Dr. Woods proposed the use of specific concentration and quantity limits for materials containing radium 226 and radium 228 (thorium 232). While the staff does not recommend the adoption of these levels as the sole criteria for exemption of NORM, we do feel that the exemption of materials which do not exceed these levels is reasonable. Under the staff proposal, materials exceeding these levels would be subjected to an evaluation of potential health effects.

A. Radium 226 -- exempt below 5 pCi/gm.

The original source of the proposed level was a draft regulation by EPA designed for use in enforcement of the Resource Conservation and Recovery Act (RCRA) provisions for the disposal of hazardous wastes. At the November 3 hearing, the staff noted that this value is based on potential radon buildup in a house constructed on the disposal site. It was also demonstrated that, using a specific model and by the fact that very few references are available relating soil concentration to indoor radon concentrations. The following information is presented by the staff in support of retaining 5 pCi/gm as the level:

1. The reference used by PGE to support the claim that ~~random~~ Radon levels average considerably less than 3 pCi/l contains the statement, "Assuming that a representative value of the average ^{222}Rn concentration indoors is 1 pCi/l ..." (UNSCEAR, 1978 p. 78). In a table values for U-238 in soil (and hence Radium-226) an average value is listed of 0.7 pCi/gm (UNSCEAR, 1978 p. 44). The staff is well aware of the fact that these are not true averages and that an unknown portion of the indoor radon results from the use of building materials containing radium-226 rather than from the soil. This data does not appear to support the contention that the staff assumptions are overly conservative.

2. The "background" value used by EPA and the Colorado Department of Health for radon in houses in Grand Junctin is 0.007 WL (1 pCi/l of Radon-222 equals 0.01 WL if all of the alpha emitting daughters are in equilibrium) at an assumed 50% equilibrium. This approximates 1.4 pCi/l of Radon-222. Soil concentrations in Grand Junction range

from less than 1 pCi/gm to 3 pCi/gm (private communication with Bud Franz, supervisor of Grand Junction Project, Colorado Department of Health.)

3. Data generated by the University of Florida for the Florida Phosphate Council and used by EPA in their draft RCRA standard is the only data the staff has been able to locate which directly relates soil concentration to radon levels. Although this data has apparently not been officially published it strongly suggests that, for phosphate wastes, 5 pCi/gm is a good and perhaps not even very conservative value.

4. A report by J. W. Healy and J. C. Rodgers (Los Alamaos Scientific Laboratory) entitled "A Preliminary Study of Radium Contaminated Soils" (LA-7391-MS, October 1978) has been received by the staff since the November 3 hearing. The purpose of this document is to "provide guidance on limits to be applied in decontaminating land." In that document, Dr. Healy calculates radon levels in homes using two models; one assuming concrete slab construction, the other a crawl space. These values are then related to maximum soil concentrations allowable without exceeding a radon level of 0.01 WL. This value is one-third the limit permitted under the staff proposal. The result of that calculation is the following table:

PERMISSIBLE RADIUM LEVELS IN SOILS TO LIMIT Rn DAUGHTERS IN HOME

Depth of Contaminated Soils (cm)	Soil Type	
	Sand (pCi/g)	Loam (pCi/g)
1	250	150
10	15	15
100	2	3
1000	1	2.7

Dr. Healy notes that "...it is of interest that the EPA in spot sampling of homes in Florida not on reclaimed land have found radon daughter concentrations 2-2½ times the 0.01-WL limit which may indicate that for tightly built homes through the country, the limit of 0.01 WL may be exceeded by the natural radium content of the soils."

This document also evaluates all other pathways of potential human exposure and confirms the fact that radon exposure is the limiting pathway. The summary table from that document is attached to this appendix.

In conclusion, the staff believes that 5 pCi/gm is not overly conservative and that the assumptions used in our calculation of November 3 for radon are reasonable. We feel that potential cases of significant radiation exposure below 5 pCi/gm are rare. We do recognize that some materials exceeding 5 pCi/gm may not present a significant potential for exceeding the referenced health limits, however, we feel that this must be judged on a case-by-case basis.

B. Radium 226 -- exempt below 10 pCi total activity.

This value was also derived from EPA draft rules. It came in turn from 10 CFR 20, "Standards for the Protections Against Radiation". In that context it is the maximum quantity of material which may be disposed of on a licensee's property under certin specified conditions.

C. Thorium 232 (Radium 228) -- exempt below 10 pCi/gm.

This value was proposed by Dr. Woods as part of his extension of the Health Division exempt contentions table. The identical value appears in the "Suggested State Regulations for the Control of Radiation" from which the Oregon Health Division regulations derive. Health Division has chosen not to adopt this table as it relates to naturally-occurring materials. The staff does feel, however, that this value is significantly above "normal" concentrations, that no few normal wastes will exceed it and those situations requiring a case-by-case evaluation will be minimal.

It is also adequate to protect public health in that the primary pathway of exposure to thorium and its daughters is due to gamma exposures. NCRP Report No. 45, Natural Background Radiation in the United States, reports that soil containing Thorium-232 and its daughters (including Radium-228) will yield an absorbed dose rate in air of 21.6 mrad/y per pCi/gm. Assuming that this value holds for most materials, this will result in a dose of 432 mR/yr. If the Council adopts the staff proposal, materials exceeding this level would be treated on a case-by-case basis.

D. Thorium 232 (radium 228) -- exempt if total quantity is below 100 microcuries.

This value was proposed by Dr. Woods and does not appear to have been based on any other documents. The staff does believe, however, that it is necessary to have a quantity below which a case-by-case evaluation of health impacts could be avoided. Provided the Council adopts the staff recommendation to evaluate such wastes on a case-by-case basis, the staff believes the 100 microcuries (about 1 kg of pure thorium or some larger quantity if it is contained in a mixture) is not unreasonable.

JMP:sj
12/7/78
1333A

ROBERT W. STRAUB
GOVERNOR

Department of Energy

LABOR & INDUSTRIES BUILDING, ROOM 111, SALEM, OREGON 97310 PHONE 378-

TO: Members of the Energy Facility Siting Council

DATE: December 11, 1978

FROM: W. Kelly Woods

SUBJECT: Rules Defining Radioactive Material Under ORS 469.525

The following pages present a summary of options open to the Council on specific rules, for use during your meeting on December 12.

Other industry comments unrelated to specific rules are as follows:

1. PGE considers it unwise for the Council to respond by rule to a poorly defined statute.
2. Some industries urge the Council to defer any rulemaking for about six months, pending further study. additional hearings, and hoped-for legislative guidance.
3. Some industries ask that the Council declare that ORS 469.525 does not apply to existing accumulations of radioactive material, only to future accumulations. This appears to be a legal determination outside of the scope of the Council's authority.
4. It is generally recognized that any reasonable interpretation of ORS 469.525 will result in severe economic penalties to several Oregon industries.

Existing Rule

"Rule 345-50-005 Disposal Sites For Radioactive Waste Materials: All radioactive wastes produced from the operation of thermal power plants or nuclear installations, and for which the U.S. Atomic Energy Commission has discontinued its regulatory authority pursuant to Section 274 of the Atomic Energy Act of 1954, as amended, may be stored or disposed of only at a disposal site which is licensed by the Department of Environmental Quality and which remains in full compliance with Department of Environmental Quality regulations. The Oregon State Health Division assumes the responsibility for environmental radiation surveillance related to the site. Radioactive wastes which remain under the regulatory authority of the U.S. Atomic Energy Commission may be stored or disposed of in Oregon only at a site approved by the Energy Facility Siting Council." (Filed 5-19-72)

Proposed Change

"Rule 345-50-005 Disposal Sites for Radioactive Materials is repealed."

- -

There has been no objection to the proposed repeal of this obsolete rule.

Proposed Rule

"Rule 345-50-006 Disposal Prohibited: Effective ~~August~~ March 1, 1979, except as provided herein, no discarded or unwanted radioactive material may be held or placed for more than seven days at any geographical site in Oregon except the site at which the radioactive material was used or generated pursuant to a license under ORS 453.635 or a site of a thermal power plant used for the temporary storage of radioactive material from that plant for which a site certificate has been issued by the Energy Facility Siting Council."

- - - - - - - - - - - - - - - - - - - -

There are two considerations regarding this proposed rule. First is the appropriateness of adopting a rule which merely restates the law. In the proposed rule ORS 469.525 has been reworded to incorporate definitions found elsewhere in the law, thereby saving the reader the trouble of looking up the statutes. The Department of Energy (DOE) considers this unnecessary and recommends against the proposed rule.

30 pCi/g human ash

Second is the appropriateness of delaying implementation of the rule. This feature is strongly supported by the industry. DOE proposes that the rule become effective upon filing, and notes that it will take several months to accumulate enough information to permit enforcement. Either procedure should give the legislature opportunity to provide further guidance. Also, either procedure could conceivably be subject to challenge in the courts.

Woods advocates adoption of the proposed rule.

Proposed Rule

"Rule 345-50-010 Purpose and Applicability: Since virtually all materials contain some measure of radioactivity, it is the purpose of these rules to identify those materials which present such small health hazards that they are exempt from the provisions of ORS 469.525 (1977 Replacement Part) as incorporated in Rule 345-50-006 and may be disposed of within the state."

- -

There has been no objection to this proposed rule. If Rule 345-50-006 has not been adopted reference to that rule would be deleted.

Proposed Rule

"Rule 345-50-015 Referenced Regulations: Reference to OAR 333-22-150 means State of Oregon Regulations for the Control of Radiation issued by the Radiation Control Section of the State Health Division."

- - - - - - - - - - - - - - - - - - - -

Dr. Wang's committee has recommended that tabular material from Health Division regulations be incorporated into EFSC rules by table rather than by reference. This would make the above Rule 345-50-015 unnecessary.

Woods is agreeable to deletion of this proposed rule if tables in EFSC rules acknowledge the source of information.

Proposed by Woods

"Rule 345-50-020 Exempt Quantities: Materials are exempt from the provisions of Rule 345-50-006 (or ORS 469.525) if the total curies of contained radioactivity are less than ten times the quantities listed in Table II."

Alternate by Woods

"Rule 345-50-020 Exempt Quantities: Materials are exempt from the provisions of Rule 345-50-006 (or ORS 469.525) if the total curies of radioactivity contained in individual quantities are less than the quantities listed in Table II, provided that the number of individual quantities does not exceed 10."

→ Alternate by DOE

"Rule 345-50-020 Exempt Quantities: ~~The disposal of products or~~ materials are exempt from provisions of ORS 469.525 provided that such ~~products or~~ materials contain radioactive material in individual quantities none of which exceeds the applicable quantity set forth in Table II and provided that the number of individual quantities does not exceed 10."

- - - - - - - - - - - - - - - - - - - -

(continued)

Rule 345-50-020--continued

This rule is intended to authorize the occasional disposition of very small quantities of radioactive material regardless of concentration. It offers no significant relief to industry and is generally non-controversial. Hence, neither this rule nor the subsequent discussion of Table II warrants any extensive debate.

Since the subject of this set of rules is "Definition of Radioactive Materials", Woods prefers his format which exempts materials rather than the DOE format which exempts disposal.

Health Division regulations regarding disposal of multiple packages are incorporated into Woods alternate and DOE recommendations. Woods primary recommendation is simpler, but there is merit to retaining the Health Division format to minimize proliferation of standards.

TABLE II--EXEMPT QUANTITIES

Health Division regulations contain two tables relating to quantities of radioactivity. For convenience I will refer to these tables as Table W and Table X. (Table W is Schedule C, Part B; Table X is Appendix B, Part C.)

Table W lists quantities (microcuries) of individual radioisotopes which a person can have without needing to be licensed, except that one can have ten times this quantity in ten separate packages.

Table X lists quantities (microcuries) of individual isotopes. If a room contains less than ten times the quantity listed in Table B the room does not have to be posted with radiation warning signs. Also, subject to certain limitations, up to ten times the quantity listed in Table X can be discharged daily into a sanitary sewerage system.

Tables W and X are almost identical except that Table X lists numbers for americium, plutonium, radium, thorium and uranium while Table W makes no mention of these elements.

The DOE version of Table II is an exact copy of Table W. This table should be amended by including a footnote saying: "Unless otherwise noted, this table is copied from Schedule C, Part B of the State of Oregon Regulations for the Control of Radiation."

(continued)

TABLE II--Continued

The Woods version of Table II is the same as the DOE version with the addition of the following items:

Materials	Microcuries
Americium-241	0.01
Plutonium-239	0.01
Thorium (natural)	100
Uranium (natural)	100
Uranium-233	0.01
Uranium -234 plus Uranium-235	0.01

with a footnote that these values came from Appendix B, Part C of the State of Oregon Regulations for the Control of Radiation.

Woods recommends that the Council adopt the Woods version of Table II. If a certain quantity of americium, etc. can be discharged daily to a sewer, at least this amount should be exempt from ORS 469.525. DOE is concerned that the Woods version uses Table X for a purpose for which it was not intended.

Proposed by Woods

"Rule 345-50-025 Exempt Concentrations: Materials are exempt from the provisions of Rule 345-50-006 (or ORS 469.525) if the concentration of radioactivity is less than the concentration shown in Table I."

Proposed by DOE

"Rule 345-50-025 Exempt Concentrations: ~~The disposal of products or materials~~ are ~~is~~ exempt from the provisions of ORS 469.525 provided that such ~~products or~~ materials contain radioactive materials in concentrations not in excess of those of Table I." DOE table I

- - - - - - - - - - - - - - - - - - - -

Controversy over exempt concentrations centers over the content of Table I, which is discussed later. The choice between the two versions of the above rule regarding exempt concentrations is a matter of format. The Council should follow whichever philosophy they elected in considering Rule 345-50-020 Exempt Quantities. (See page 6.)

TABLE I--EXEMPT CONCENTRATIONS

Health Division regulations contain three tables relating to concentration of radioactive materials, only two of which are involved in this discussion. For convenience I will refer to these two tables as Table Y and Table Z. (Table Y is Schedule A, Part C; Table Z is Table II, Appendix A, Part C.)

Table Y lists concentrations of radioactivity (microcuries per gram for solids or microcuries per milliliter for gases) in materials below which a person can have the material without needing to be licensed.

Table Z lists concentrations of radioactivity (microcuries per milliliter) below which air or water may be released to unrestricted areas. For example, if the radioactive content of water is this low it is all right to fill a swimming pool with it.

Table Y lists 153 radioisotopes (none of which are alpha emitters). Table Z lists 247 isotopes (55 of which are alpha emitters). Theoretically a license is needed to possess any radioactive material not exempted by Table Y. In any event the user must comply with rules limiting the concentration of radioactivity in discharges and limiting personal doses to the general public to less than 500 mrem per year.

(continued)

TABLE I--Continued

For most of those isotopes listed in both Table Y and Table Z, the values shown in Table Y for solids are exactly ten times the values shown in Table Z for soluble species in water.

The DOE version of Table I is an exact copy of the concentrations shown for solids in Table Y. This table should be amended by including a footnote saying: "This table is copied from Schedule C, Part B of the State of Oregon Regulations for the Control of Radiation."

The Woods version of Table I is a copy of all values in Table Z for soluble species in water, multiplied by ten and shown as microcuries per gram of solid. The table has a footnote stating this basis for the table. Surely if there is a permissible concentration of radioactivity in swimming pools, concentrations at least ten times this high could be discarded at a disposal site without undue hazard to public health.

In the Woods version of Table I an exception is made for radioiodines and for strontium-89 where less restrictive values from Table Y are used. Also, no exempt concentrations for radium-226 and radium-228 are shown since these are treated elsewhere.

Woods recommends that the Council adopt the Woods version of Table I. DOE is concerned that the Woods version uses Table Z for a purpose for which it was not intended.

Proposed Rules

"Rule 345-50-030 Specific Exemptions: In addition to the exemptions under Rules 345-50-020 and 345-50-025, the following materials are exempt from the provisions of Rule 345-50-006 (or ORS 469.525):

"(1) Radioactive material which has been incorporated into a customer product ~~approved by the Oregon Health Division.~~ manufactured under agreement license by NRC . . . .

"(4) Thorium-bearing materials containing less than 20 picocuries of radium-228 per gram of solids, ~~providing~~ regardless of quantity that the radium-228 is present with the parent thorium-232, regardless of quantity of soli

"(5) Thorium-bearing materials containing a total radium-228 activity of less than 100 microcuries, providing that the radium-228 is present with the parent thorium-232." regardless of concentration in the solid,

- - - - - - - - - - - - - - - - - - - -

None of these rules has encountered objection. Part (1) has been proposed by DOE and Woods joins in recommending it since it is a simpler statement than had previously been proposed.

Parts (4) and (5) say that radium-228 in equilibrium with exempt concentrations or amounts of parent thorium-232 is itself exempt, even though more stringent regulations apply to separated radium-228. The exempt concentration and quantity for radium-228 are the values in equilibrium with thorium-232 as shown in the Woods version of Tables I and II.

Proposed Rule

"Rule 345-50-030 Specific Exemptions: In addition to the exemptions under Rules 345-50-020 and 345-50-025, the following materials are exempt from the provisions of Rule 345-50-006 (or ORS 469.525):

"(2) Radium-bearing materials containing less than 5 picocuries of radium-226 per gram of solid, regardless of quantity

"(3) Radium-bearing material containing a total radium-226 activity of less than 10 microcuries." regardless of concentration

- -

If these rules are considered by themselves without further exemption under proposed Rule 345-50-035 Pathway Exemption, industry considers the rules far too stringent since phosphate fertilizers and some building materials have a radium-226 content greater than 5 picocuries per gram. However, fertilizer is not "discarded or unwanted" material under Rule 345-50-006 (or ORS 469.300(3)), and the Legislature has given no guidance whether or not they object to the disposal of radioactive building materials within the state of Oregon.

If the rules are supplemented by Rule 345-50-035, they become less controversial. The numbers quoted are threshold numbers for automatic exemption. Higher concentrations or larger quantities of radium-226 would be subject to the more rigorous case-by-case analysis of Rule 345-50-035.

(continued)

345-50-030--Continued

The basis for the numbers used in proposed Rules 345-50-030(2) and (3) should be noted. The concentration of 5 picocuries of radium-226 per gram is a reasonable concentration below which radon concentrations greater than 3 picocuries per liter of air (as specified in Table III) should not be encountered, and gamma radiation exposures will be very small.

If a quantity of unencapsulated radium-226 were located directly under a small mobile home, and the assumptions used in proposed Rule 345-50-035 Pathway Exemption were adopted, it would require at least 20 microcuries of radium-226 to create a concentration of 3 picocuries per liter of air within the house. However, a limiting quantity of only 10 microcuries is used in the proposed rule because this is the maximum quantity permitted to be buried in soil by a licensee under 10CFR20.

Proposed Rule (DOE Version)

"Rule 345-50-035 Pathway Exemption: ~~Materials containing~~ Naturally occurring radioactive materials shall be exempt from the provisions of Rule 345-50-006 (or ORS 469.525) if it can be demonstrated that accumulation of material will not result in exposures exceeding 500 millirem of external gamma radiation per year, nor in the release of effluents to air and water in annual average concentrations exceeding the values in Table III. An evaluation of potential radiation exposures and effluent releases shall be performed using the following premises: .

(1) The material shall be considered in the form it exists when it is removed from the users' equipment, systems, or settling ponds prior to disposal unless there is ~~to any~~ dilution or remedial action designed to reduce radiation levels.

(2) No consideration shall be given to the ameliorating effects of land use restrictions, maintenance operations, or overburden at the disposal site.

(3) Accumulations of material over the reasonably projected period of waste generation shall be evaluated.

(4) External gamma radiation exposures shall be based on actual measurements and allowance may be made for the degree of equilibrium and for self-shielding.

(5) In computing radon concentrations in the air above a disposal site containing radium-226, the following additional premises shall be used:

(continued)

345-50-035--Continued

(a) Any house built on ground contaminated with radium-226 is assumed to have an 8-foot high ceiling on the first floor, to have one complete air change per hour, and to have a foundation constructed so as to meet the Uniform Building Codes effective at the time of adoption of these rules. No consideration will be allowed for any special construction or treatments designed to reduce radon diffusion into the structure.

(b) The relation between radon-emanation rate and radium concentration will be based upon experimental measurements on material intended for disposal."

- - - - - - - - - - - - - - - - - - - -

Woods recommends deletion of the words "~~containing~~ naturally occurring ~~radioactive materials~~" in the first sentence of this rule, but DOE objects to such a deletion. Woods sees no reason why different standards should be used for man-made radioisotopes than for radioisotopes which occur in nature, or why we should prohibit disposal of low level wastes from the Trojan plant but permit disposal of more hazardous radium contaminated wastes. In the absence of Legislative guidance I cannot in good conscience recommend that the Council voluntarily make this distinction.

Aside from the above matter, Woods supports adoption of Rule 345-50-035.

Industry objections to this rule are concerned primarily with assumptions (2) and (5)(a).

TABLE III--CONCENTRATIONS IN AIR AND WATER

Table III is an exact copy of the table referred to above as Table Z. It should include a footnote stating "This table is copied from Table II, Appendix A, Part C of the State of Oregon Regulations for the Control of Radiation."

WKS:sh

1359A

• glossary

Exhibit B
Senate Committee on
Environment and Energy
20 February 1979
Tape 10 Side 1
SB 394
2 page exhibit

GOVERNOR

Department of Energy

ENERGY FACILITY SITING COUNCIL

528 COTTAGE STREET N.E., SALEM, OREGON 97310 PHONE 378-
Room 111, Labor & Industries Building

MEMORANDUM of CONCERN

1. Introduction: The 1975 Legislature banned the disposal of all radioactive wastes in Oregon. The 1977 Legislature explicitly defined radioactive wastes as both man-made and naturally occurring radioactivity and directed the Energy Facility Siting Council (EFSC) to enforce the ban. Continued use and transportation of all radioactive materials would be permitted; the law is aimed at waste disposal.

   Man-made radioactivity includes wastes from the Trojan Nuclear Plant. Trojan wastes containing low levels of radioactivity are currently shipped to Hanford, Washington for disposal. Temporary storage of spent fuel is currently allowed at Trojan pursuant to ORS 469.300(20). Nothing in this memorandum proposes that this situation be changed.

   Waste from use of naturally occurring radioactive materials generally includes natural ores or soils which have been used in a manner that concentrates their radioactivity. In the past, these wastes have been disposed of in Oregon. It is these wastes that are affected the most by the Legislature's ban on waste disposal.

   An exemption to the disposal ban is allowed if the wastes are collected at an industrial site under a Health Division license. The costs of transporting some wastes to out-of-state disposal sites may be prohibitive for the affected industry because of the volume of material involved.

   The Attorney General has advised that the legislature left it to the EFSC to define those levels of radioactive waste that constitute a potential hazard. The EFSC has adopted a rule exempting from the disposal ban those radioactive wastes which do not create a hazard to the public health and safety.

   However, the EFSC believes that this rule is likely to cause unnecessary economic hardships for several Oregon firms by requiring them to dispose of radioactive wastes out of the state. Further, it may not be possible to ship wastes out of Oregon. For example, Washington has refused to accept some wastes at its Hanford site.

2. EFSC Action: The EFSC held public hearings to define which radioactive wastes were of sufficiently low level that they should be exempt from the ban on disposal. Some participants urged the EFSC to

delay adoption of any rule because they believed the Legislature did not intend to ban the disposal of naturally occurring radioactive waste.

The EFSC was concerned that immediate enforcement of a rule could have adverse impacts on Oregon industries. These concerns were resolved on December 12, 1978 by deferring the effective date of the rule until March 1, 1979. This action provides the Legislature with an opportunity to review the statute and decide whether it wishes the ban to be implemented.

3. Industries Affected by the Rule: The EFSC rule, in conjunction with the existing disposal ban, may require removal of existing waste from an abandoned uranium mill near Lakeview, from a landfill owned by ESCO in Portland, and from a field owned by Teledyne Wah Chang, Albany. Future wastes generated at these industries, the Boardman Coal Plant and a proposed uranium mill in southern Oregon may also require shipment out of state. Other sources may exist but have not been identified.

4. Basis for EFSC Rule: The rule adopted by the EFSC is based on criteria for permissible radiation exposures used by the federal government. The current trend is to reduce allowable radiation exposures. Consequently, the EFSC's rule should not be considered to be unnecessarily restrictive. Once the wastes are disposed of by burial, radiation levels will be much lower than the permissible federal radiation exposure levels.

5. Proposal to Resolve the Problem: The EFSC believes that disposal of radioactive wastes should be regulated because disposal may involve a long term (thousands of years) commitment of land. Once used, a waste disposal site may not be available for other purposes.

   The EFSC believes that the existing statute could be improved. First, the statute allows the Oregon Health Division to permit radioactive waste disposal at industrial sites. While these sites may be adequate, they may not be the best choice for disposal of radioactive waste. Consequently, even with the existing "ban", land in Oregon may be committed to radioactive waste disposal.

   Further, the EFSC believes that the potentially adverse impacts to Oregon industries caused by the existing ban could be obviated if the EFSC were permitted to consider disposal of naturally-occurring radioactive waste (i.e., waste not related to the nuclear fuel cycle except uranium mill waste) in Oregon. ORS 469.375 establish the standards by which disposal decision must be made. The EFSC sees no advantage to permitting disposal of man-made radioactivity (e.g., nuclear wastes) in Oregon.

DWG:sj
1509A
1/18/79