CLEANUP LEVELS FOR
AM-241, PU-239, U-234, U-235 & U-238
IN SOILS AT THE
ROCKY FLATS ENVIRONMENTAL
TECHNOLOGY SITE

Rick Roberts - Safe Sites of Colorado
Brian Colby - SEG
Laura Brooks - Kaiser-H
Steve Slaten - DOE

July 3, 1997
DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.
DISCLAIMER

Portions of this document may be illegible electronic image products. Images are produced from the best available original document.
CLEANUP LEVEL DEVELOPMENT

- Rocky Flats Vision/Cleanup Agreement
- Regulatory Analysis
- Site Conceptual Model
- Soil Cleanup Levels

July 3, 1997
ROCKY FLATS VISION/CLEANUP AGREEMENT

- Radionuclide Cleanup Levels For Soils Were Derived to Support the Rocky Flats Vision and the Rocky Flats Cleanup Agreement (RFCA)
REGULATORY ANALYSIS

- DOE, EPA and NRC Regulations Reviewed
- The Radiation Dose Limit Methodology
  From EPA’s Draft 40CFR196 Chosen
REGULATORY ANALYSIS (cont)

- Radiation Dose Limit Methodology
  - 15 mrem Annual Radiation Dose Applied to the Most Appropriate Exposure Scenario
  - 85 mrem Annual Radiation Dose Applied to a Hypothetical Residential Exposure Scenario
LAND USE

- Most Appropriate Land Uses
  - Open Space Exposure Scenario
  - Office Worker Exposure Scenario
- Hypothetical Residential Exposure Scenario
SOIL TYPES

■ Surface Soils
  ◦ Top 6 Inches of Soil

■ Subsurface Soils
  ◦ Soils From 6 Inch Depth to the Top of Ground Water
RADIONUCLIDE TYPES

- Am-241
- Pu-238, Pu-239, Pu-240, Pu-241, Pu-242
- U-234, U-235, U-238
EXPOSURE PATHWAY ANALYSIS - SURFACE SOILS

- Open Space & Office Worker Exposure Scenarios
  - Soil Ingestion
  - Soil Inhalation
  - External Exposure

- Hypothetical Future Resident Exposure Scenario
  - All of the Above
  - Homegrown Produce Ingestion

July 3, 1997
EXPOSURE PATHWAY ANALYSIS - SUBSURFACE SOILS

- Concerned With Protection of Surface Water
- Assess Leaching of Radionuclides to Ground Water With Subsequent Transport to Surface Water
COMPUTER MODEL

- RESRAD Computer Model Used
- Each Input Parameter Examined
- Parameter Values Technically Justified
- 162 Parameters Assessed
SURFACE SOIL CLEANUP LEVELS

- Open Space Exposure Area at RFETS
  - Am-241: 215 pCi/gram
  - Pu-239: 1429 pCi/gram
  - U-234: 1738 pCi/gram
  - U-235: 135 pCi/gram
  - U-238: 586 pCi/gram
SURFACE SOIL CLEANUP LEVELS (cont)

Office Worker Exposure Area at RFETS

- Am-241: 209 pCi/gram
- Pu-239: 1088 pCi/gram
- U-234: 1627 pCi/gram
- U-235: 113 pCi/gram
- U-238: 506 pCi/gram

July 3, 1997
SUBSURFACE SOIL CLEANUP LEVELS

- Due to Heterogeneity of Subsurface Soils, Leaching of Contaminants Could Not be Accurately Modeled
- Surface Soil Cleanup Levels are Currently Applied to Subsurface Soils

July 3, 1997
ACTION LEVELS FOR RADIONUCLIDES IN SOILS
FOR THE ROCKY FLATS CLEANUP AGREEMENT

FINAL

US DEPARTMENT OF ENERGY
US ENVIRONMENTAL PROTECTION AGENCY
COLORADO DEPARTMENT OF PUBLIC HEALTH AND THE ENVIRONMENT

OCTOBER 31, 1996

REVIEWED FOR CLASSIFICATION
BY S. L. CUNNINGHAM
Date 10/31/96 UNCLASSIFIED
EXECUTIVE SUMMARY

INTRODUCTION

During the Rocky Flats Cleanup Agreement (RFCA) negotiations, the Action Levels and Standards Framework for Surface Water, Ground Water and Soils (ALF) Working Group realized that setting soil action levels and cleanup standards for radionuclides was a complex process and could not be completed before public notice of the draft RFCA. The RFCA Attachment 5 states that "The parties commit to expeditiously convene a working group to determine the derivation and application of the 15 mrem per year level as well as the derivation and potential application of the 75 mrem per year level." This summary explains the consensus recommendation of that Working Group.

The Working Group convened in early March 1996 and was composed of personnel from the Department of Energy (DOE), the Environmental Protection Agency (EPA), the Colorado Department of Public Health and Environment (CDPHE) and Kaiser-Hill, L.L.C. The Working Group agreed that its charter was to develop technically defensible standards which will not exceed the 15/75 mrem per year dose limits in ALF. The Working Group recognized that the 15/75 requirement was based on EPA's draft 40CFR196, Radiation Site Cleanup Regulations, which were intended for the release of government property. Because the RFCA preamble and the Rocky Flats Vision identify future land uses for the RFETS, which exclude release of government property and permit no residential land use, pertinent sections of the draft regulation were used as guidance for the Working Group.

Radiation dose was chosen as the primary criterion for assessing radionuclide action levels. The ALF called for the consideration of both radiation dose assessment and radiation risk assessment by the working group in making its recommendations. The use of radiation dose to develop action levels is consistent with EPA's draft 40CFR196, Nuclear Regulatory Commission decommissioning requirement, DOE Order 5400.5, "Radiation Protection of the Public and the Environment", and
DOE's proposed 10CFR834. Since these regulations are all radiation dose based, this is compelling evidence that the radiation protection community is recommending the use of radiation dose to limit environmental levels of radionuclides. In addition, the preamble to draft 40CFR196 compares the risks associated with remediation, transportation and disposal of contaminated soils against the risks of leaving contaminated soils in place at the 15/75 mrem per year dose limit. EPA concluded that the use of a 15/75 mrem dose limit to establish action levels is protective of the public. Furthermore, the dose assessment process incorporates all pertinent facets of EPA's CERCLA risk assessment process. The radionuclide working group agrees with the EPA draft regulation and is recommending the use of a radiation dose basis.

To translate the radiation dose requirements into soil action levels, it is necessary to first model radionuclide transport within the environment to a human receptor and then assess the receptor's radiation dose. The "RESRAD" computer code was chosen to model this complex process. RESRAD was specifically developed to calculate the radiation dose to an individual and also to derive action levels for radionuclides in soil. RESRAD has been verified and validated for use in assessing radioactive material in soils. An asset of the RESRAD code is its capability to assess contaminant transport to a human receptor in air, surface water, ground water and unsaturated zone soils over the 1,000 year modeling period as specified in the draft EPA regulation. This makes it possible to calculate radiation dose and action levels over any applicable exposure routes (e.g., ingestion, inhalation and external irradiation pathways) for a given receptor. RESRAD also has the capability to model multiple exposure scenarios (e.g., residential, open space and office worker) and to assess radioactive daughter products over the 1,000 year modeling period. The radionuclide working group recommends the use of RESRAD in calculating action levels for the RFETS.

SITE CONCEPTUAL MODEL

There are two separate soil types that need to be assessed at the RFETS: surface soils and subsurface soils. Surface soils are defined in the ALF from the surface to a depth of 15 cm. Consistent with the
RFCA preamble and the Rocky Flats Vision, ALF specifies that surface soil action levels would be derived using an open space exposure scenario in the buffer zone and an office worker exposure scenario in the industrial area. Subsurface soils are defined in the ALF from a depth of 15 cm to the top of the ground water table. Per the ALF, subsurface soil action levels are protective of surface water standards through ground water transport of contaminants to surface water. Ground water is not considered a potential drinking water source at RFETS as prescribed in the RFCA preamble and the Rocky Flats Vision.

Per the RFCA preamble and the Rocky Flats Vision, institutional controls may be applied at RFETS. Use of institutional controls may be considered under EPA's draft 40CFR196 when releasing a site. EPA's draft regulation states that any radioactive material in surface soils shall not impart an annual radiation dose to the appropriate human receptor (e.g. an open space receptor in the buffer zone or an office worker receptor in the industrial area) in excess of 15 millirem. Since radiation dose is being examined for a 1,000 year time period, the draft EPA regulation conservatively assumes that institutional controls fail in the future and that a hypothetical resident moves onto the site. Due to the long lived nature of radionuclides at Rocky Flats, the working group is recommending the assessment of a hypothetical future resident. This recommendation was a conscious decision by the working group despite the guidance in the vision which provides for no future residential uses. The annual radiation dose received by this hypothetical future resident will not exceed 85 millirem (Note: The annual radiation dose for this hypothetical individual in EPA's draft 40CFR196 recently changed from 75 mrem to 85 mrem).

There are two action levels that need to be calculated for surface soils. Tier I action levels are numeric levels that, when exceeded, trigger an evaluation, remedial action and/or management action, given the presence of institutional controls. Tier II action levels are numeric levels that, when met, do not require remedial action and/or institutional controls. The final action levels were derived by examining both the hypothetical future resident action levels and the action levels based on the most appropriate land use and then choosing the most conservative action level. The radionuclide working
group recommends adopting the Tier I and Tier II methodology outlined in the "Action Levels and Standards Framework for Radionuclides in Surface Water, Groundwater and Soils (ALF)." Proposed modifications to ALF and a discussion of put-back levels can be found in the document entitled, "Modifications to the Action Levels and Standards Framework." Table ES-1, "Tier I & II Soil Action Levels," outlines the Tier I and Tier II action levels being recommended by the radionuclide working group. The working group is recommending that the hypothetical future resident exposure scenario at the 85 mrem level be the Tier I action level for surficial soils in the buffer zone. The working group is also recommending that the office worker exposure scenario at the 15 mrem level be the Tier I action level for surficial soils in the industrial area. Further, the working group is recommending that the Tier II action level be the hypothetical future resident exposure scenario at the 15 millirem level.

Per the ALF, subsurface soil action levels must be protective of surface water standards through the transport of contaminants in ground water. The ALF requires that subsurface soil action levels be based on the leaching of contaminants to ground water, such that the ground water levels are protective of surface water standards. This concept was discussed by the radionuclide working group and not recommended for use at RFETS. Since the subsurface soils at RFETS are highly heterogeneous, it is not currently possible to accurately model radionuclide transport in these subsurface soils. Therefore, the radionuclide working group currently recommends a conservative approach by applying the Tier I and Tier II surface soil action levels to the subsurface soils. In addition, subsurface soil leaching of radionuclides to ground water is currently being investigated at the RFETS. If an accurate subsurface soil leaching model can be developed for RFETS in the future, and is agreed upon by the RFCA parties, the current working group recommendations may need to be updated.

**RESRAD INPUT PARAMETERS**

In the RESRAD computer code, there are approximately seventy different inputs that were discussed and agreed upon by the radionuclide working group for each exposure scenario. Site-specific values
were chosen for these inputs whenever possible so that the action levels could be tailored to RFETS. If a site-specific value was not available, the RESRAD default input was used. The RESRAD code was used to evaluate the office worker exposure scenario, the open space exposure scenario and the hypothetical future resident exposure scenario over the 1,000 year modeling period.

RECOMMENDATIONS

The working group recommends that the hypothetical future resident exposure scenario at the 85 mrem level be the Tier I action level for surficial soils in the buffer zone. The working group also recommends that the office worker exposure scenario at the 15 mrem level be the Tier I action level for surficial soils in the industrial area. Further, the working group is recommending that the Tier II action level for the entire site be the hypothetical future resident exposure scenario at the 15 millirem level. Soils with levels of radionuclides at or below the Tier II action level do not require remedial action and/or institutional controls. Although direct exposure to subsurface soils is not anticipated for the hypothetical future resident, open space or office worker exposure scenarios, the radionuclide working group currently recommends conservatively applying the Tier I and Tier II surface soil action levels to the subsurface soils. This subsurface soil recommendation may be updated in the future. Table ES-1 outlines these Tier I and Tier II action levels.

This working group acknowledges that in the future, new regulations, different guidance, improved calculation methods and models and better input parameters will likely become available. As this new information becomes available it will be considered in accordance with paragraph 5 of RFCA.

APPLICATION

Action levels as calculated above are only applicable when a single radionuclide is found in the environment. This is not the case at RFETS. In the environment at RFETS, the uranium (U) isotopes of U-234, U-235 and U-238 are found together, and the americium (Am) and plutonium (Pu)
isotopes of Am-241 and Pu-239/240 are found together. When multiple radionuclides are found in the environment, it must be ensured that the sum of the radiation doses from all radionuclides present does not exceed the action level basis (e.g., a hypothetical future resident assessed at the 15 mrem level).

The action levels for americium and plutonium together can also be calculated since the activity of Am-241 is about 18% of the Pu-239+Pu-240 (Pu-239/240) activity in the environment (Ibrahim, 1996). Given this activity ratio, the action level for Am-241 and Pu-239/240 can be computed so that the sum of their radiation doses equals either 15 or 85 millirem to the appropriate exposure scenario. Table ES-1 includes an example of these adjusted action levels for Am-241 and Pu-239/240 if they are the only radionuclides present in soil. Since the 18% ratio actually varies in the environment, site specific data will be used to make action level comparisons. If uranium is also present in the soil, then the contribution to the radiation dose from the uranium also needs to be assessed so that the Tier I and/or Tier II action level basis is not exceeded.
**TABLE ES-1**  
**TIER I & II SOIL ACTION LEVELS**

### Tier I Action Level For The Buffer Zone (Hypothetical Resident)

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Hypothetical Resident - 85 mrem Annual Radiation Dose (a) (pCi/gram)</th>
<th>Hypothetical Resident - Ratio Sum to 85 mrem Annual Radiation Dose (b) (pCi/gram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Americium-241</td>
<td>215</td>
<td>117</td>
</tr>
<tr>
<td>Plutonium-239/240</td>
<td>1429</td>
<td>651</td>
</tr>
<tr>
<td>Uranium-234</td>
<td>1738</td>
<td></td>
</tr>
<tr>
<td>Uranium-235</td>
<td>135</td>
<td></td>
</tr>
<tr>
<td>Uranium-238</td>
<td>586</td>
<td></td>
</tr>
</tbody>
</table>

### Tier I Action Level for The Industrial Area (Office Worker)

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Office Worker - 15 mrem Annual Radiation Dose (a) (pCi/gram)</th>
<th>Office Worker - Ratio Sum to 15 mrem Annual Radiation Dose (b) (pCi/gram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Americium-241</td>
<td>209</td>
<td>101</td>
</tr>
<tr>
<td>Plutonium-239/240</td>
<td>1088</td>
<td>562</td>
</tr>
<tr>
<td>Uranium-234</td>
<td>1627</td>
<td></td>
</tr>
<tr>
<td>Uranium-235</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>Uranium-238</td>
<td>506</td>
<td></td>
</tr>
</tbody>
</table>

### Tier II Action Level For RFETS (Hypothetical Resident)

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Hypothetical Resident - 15 mrem Annual Radiation Dose (a) (pCi/gram)</th>
<th>Hypothetical Resident - Ratio Sum to 15 mrem Annual Radiation Dose (b) (pCi/gram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Americium-241</td>
<td>38</td>
<td>21</td>
</tr>
<tr>
<td>Plutonium-239/240</td>
<td>252</td>
<td>115</td>
</tr>
<tr>
<td>Uranium-234</td>
<td>307</td>
<td></td>
</tr>
<tr>
<td>Uranium-235</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Uranium-238</td>
<td>103</td>
<td></td>
</tr>
</tbody>
</table>

(a) - These values apply to single radionuclides only which does not occur in the environment at RFETS. The "Sum of Ratios" method will be applied at RFETS so that the total dose from multiple radionuclides are correctly assessed.

(b) - This example assumes that the Am-241/Pu-239 activity ratio equals 0.18 and that only Pu-239 and Am-241 are present.