

APPENDIX C
ANALYSIS OF EXPOSURE PATHWAYS
FOR USE IN DERIVING ACTION LEVELS

Introduction

Per the Rocky Flats Cleanup Agreement (RFCA, 1996), the Rocky Flats Environmental Technology Site (RFETS) will have designated land uses in the future. These uses will include an open space land use in the buffer zone and an office complex within the industrial area of the RFETS. The radiation dose to both of these potential future receptors needs to be assessed. Also, the radiation dose that may be received by a hypothetical future residential receptor needs to be assessed to comply with draft regulations from the Environmental Protection Agency (EPA). Since radiation dose is assessed by examining specific exposure pathways to a human receptor, the exposure pathways to these exposure scenarios need to be defined.

The RESRAD computer code can assess one or more of the following exposure pathways to a potential human receptor:

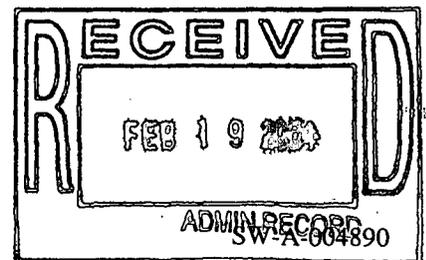
- * External Gamma Exposure,
- * Soil Inhalation,
- * Plant Ingestion,
- * Meat Ingestion,
- * Milk Ingestion,
- * Aquatic Food Ingestion,
- * Ground/Surface Water Ingestion,
- * Soil Ingestion, and
- * Radon Exposure

Exposure pathways were selected for the hypothetical future residential receptor, the open space user

Public Review Draft
Radionuclide Action Levels
August 30, 1996

C - 1

DOCUMENT CLASSIFICATION
REVIEW WAIVER PER
CLASSIFICATION OFFICE



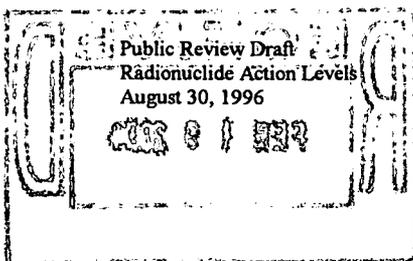
receptor and the office worker receptor taking into account the specifications of the site conceptual model and the significance of the pathway with respect to radiation dose.

Hypothetical Future Residential Receptor

The exposure pathways of external gamma exposure, soil inhalation, plant ingestion and soil ingestion are being assessed for the hypothetical future residential receptor. The RESRAD exposure pathways of meat ingestion, milk ingestion, aquatic food ingestion, ground/surface water ingestion and radon exposure were deleted from further consideration. The Department of Energy (DOE), the EPA and the Colorado Department of Public Health and the Environment (CDPHE) have agreed that only the pathways of soil ingestion, soil inhalation, external gamma exposure, plant ingestion, dermal exposure, ground water/subsoil VOC inhalation and ground/surface water ingestion may be applicable to the hypothetical future residential exposure scenario (DOE, 1995b). Eventhough the aquatic food ingestion, meat ingestion and milk ingestion exposure pathways are not discussed in this jointly approved exposure pathway document, they will be discussed below.

The aquatic food ingestion exposure pathway, ground/surface water ingestion exposure pathway and the radon exposure pathway are not consistent with the site conceptual model for the hypothetical future resident and were deleted from further consideration. The meat ingestion exposure pathway, milk ingestion exposure pathway and dermal exposure pathway were deleted from consideration since they contribute insignificantly to the total radiation dose.

The aquatic food ingestion pathway was deleted from further consideration since there are no surface water sources that can sustain a fish population. The surface water available on the RFETS is either at a seep on a hillside or at the bottom of the hillside at a surface water stream. Since these surface water sources are dry during much of the year, there is no possibility of a sustained fish population within them.



2

The ground/surface water ingestion pathway was also dropped from further consideration because the ground water found on the RFETS is not capable of providing enough water to support domestic use (RFCA, 1996). The surface water present on the RFETS is also not appropriate for ingestion since it is dry much of the year.

The ground water/VOC inhalation pathway is considered to be equivalent to the radon exposure pathway within the RESRAD code. Both of the exposure pathways assessed within the radon exposure pathway were dropped from consideration. These two pathways are the migration of radon into a basement vertically from subsurface soils and the emanation of radon from contaminated ground water being used domestically. First, residential dwellings are built into the ground and not built on the top of the ground surface (Even the default value within the RESRAD code for "Foundation Depth Below Ground Surface" is 1 meter (Argonne, 1993). Therefore, it is not possible for radon in surface soils to migrate into a basement. Lastly, since domestic use of ground water is not considered applicable at RFETS (RFCA, 1996), ground water will not be used domestically at the RFETS. Therefore, radon cannot emanate into a dwelling from domestic use of ground water. In addition, the uranium used at RFETS is primarily enriched U-235 and depleted U-238. Neither of these radionuclides will decay to radon or radon daughter products during the 1,000 year period of interest.

The meat ingestion exposure pathway and the milk ingestion exposure pathway were eliminated from consideration since their contribution to radiation dose is insignificant. This is shown by examining the draft Operable Unit (OU) 3 RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report (DOE, 1995c). The exposure pathways of soil ingestion, soil inhalation, external gamma exposure, vegetable consumption, beef consumption and milk consumption were assessed for a residential receptor in this RI Report. This assessment showed that the beef consumption pathway and the milk consumption pathway combined contributed between 0 and 3.1 percent of the total radiation dose to a residential receptor. Due to this small contribution to radiation dose, it is not necessary to assess the beef consumption and milk consumption exposure pathways.

The dermal exposure pathway is also not considered a significant contributor to radiation dose. This is first seen in the RESRAD code where the dermal pathway is not assessed (Argonne, 1993). The RESRAD code only assesses exposure pathways that are significant contributors to radiation dose. Also, dermal uptake of radionuclides is considered a negligible pathway and was not assessed in the OU 2 RI Report human health risk assessment (DOE, 1995a). Dermal exposure has been dropped from consideration for the hypothetical future residential exposure scenario.

Open Space Exposure Scenario

There are three exposure pathways assessed for the open space exposure scenario. These exposure pathways are soil ingestion, soil inhalation and external gamma exposure. The RESRAD exposure pathways of plant ingestion, meat ingestion, milk ingestion, aquatic food ingestion, ground/surface water ingestion and radon exposure were deleted from further consideration. The DOE, the EPA and the CDPHE have agreed that only the pathways of soil ingestion, soil inhalation, external gamma exposure, dermal exposure and incidental ingestion of surface water may be applicable to the open space exposure scenario (DOE, 1995b). Therefore, it has been jointly agreed by DOE, EPA and CDPHE that the exposure pathways of plant ingestion, meat ingestion, milk ingestion, aquatic food ingestion, ground water ingestion and radon exposure are not applicable to the open space exposure scenario. The incidental ingestion of surface water and dermal exposure pathways have been eliminated due to their relatively small contribution to radiation dose.

The incidental ingestion of surface water pathway was not assessed since it is not a significant contributor to radiation dose. This is seen in the OU 2 RFI/RI Report, human health risk assessment where the radiation dose from the surface water ingestion pathway was 0.004% of the total radiation dose received for the open space exposure scenario (DOE, 1995a). Plus, the RESRAD code does not assess insignificant exposure pathways, and surface soil transport to surface water is not assessed within the code (Argonne, 1993). These factors plus the low contribution to radiation dose from this pathway does not warrant its assessment.

The dermal exposure pathway is also not considered a significant contributor to radiation dose. This is first seen in the RESRAD code where the dermal pathway is not assessed (Argonne, 1993). The RESRAD code only assesses exposure pathways that are significant contributors to radiation dose. Also, dermal uptake of radionuclides is considered a negligible pathway and was not assessed in the OU 2 RI Report, human health risk assessment (DOE, 1995a). Therefore, dermal exposure has been dropped from consideration for the open space exposure scenario.

Office Worker Exposure Scenario

There are three exposure pathways assessed for the office worker exposure scenario. These exposure pathways are soil ingestion, soil inhalation and external gamma exposure. The RESRAD exposure pathways of plant ingestion, meat ingestion, milk ingestion, aquatic food ingestion, ground/surface water ingestion and radon exposure were deleted from further consideration. The DOE, the EPA and the CDPHE have agreed that only the pathways of soil ingestion, soil inhalation, external gamma exposure, dermal exposure to soil, ground water/subsoil VOC inhalation and ground water ingestion may be applicable to the office worker exposure scenario (DOE, 1995b). Therefore, it has been jointly agreed by DOE, EPA and CDPHE that the exposure pathways of surface water ingestion, plant ingestion, meat ingestion, milk ingestion and aquatic food ingestion are not applicable to the office worker exposure scenario. The ground water ingestion and ground water/VOC inhalation pathways were eliminated from consideration since they are not compatible with the site conceptual model. The dermal exposure pathway was eliminated from consideration due to its relatively small contribution to radiation dose.

The ground water ingestion pathway was dropped from consideration since it is not compatible with the site conceptual model. Since the ground water found on the RFETS is not capable of providing enough water to support domestic use (RFCA, 1996), it would not be able to support an office complex. This conclusion is supported by the fact that all water currently used at the RFETS is

brought to the plant.

The ground water/VOC inhalation pathway is considered to be equivalent to the radon exposure pathway within the RESRAD code. Both of the exposure pathways assessed within the radon exposure pathway were dropped from consideration since they are not compatible with the site conceptual model. These two pathways are the migration of radon into a basement vertically from subsurface soils and the emanation of radon from contaminated ground water being used within the office complex. First, office buildings are built into the ground and not built on the top of the ground surface (Even the default value within the RESRAD code for "Foundation Depth Below Ground Surface" is 1 meter (Argonne, 1993)). Therefore, it is not possible for radon in surface soils to migrate into a basement. Lastly, since industrial use of ground water is not considered applicable at RFETS, ground water will not be used industrially at the RFETS. Therefore, radon cannot emanate into a building from industrial use of ground water. In addition, the uranium used at RFETS is primarily enriched U-235 and depleted U-238. Neither of these radionuclides will decay to radon or radon daughter products during the 1,000 year period of interest.

The dermal exposure pathway is not considered a significant contributor to radiation dose. This is first seen in the RESRAD code where the dermal pathway is not assessed (Argonne, 1993). The RESRAD code only assesses exposure pathways that are significant contributors to radiation dose. Also, dermal uptake of radionuclides is considered a negligible pathway and was not assessed in the OU 2 RFI/RI Report, human health risk assessment (DOE, 1995a). Therefore, dermal exposure has been dropped from consideration for the office worker exposure scenario.

References

Argonne, 1993 - Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0, Environmental Assessment and Information Sciences Division, Argonne National Laboratory, ANL/EAD/LD-2, September 1993

DOE, 1995a - Phase II RFI/RI Report, 903 Pad, Mound and East Trenches Area, Operable Unit Number 2, Draft Final, US Department of Energy, May 1995

DOE, 1995b - Site Specific Exposure Factors, DOE Letter 95-DOE-08453, From S. Slaten (DOE) to M. Hestmark (EPA) and J. Schieffelin (CDPHE), June 15, 1995

DOE, 1995c - Draft Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report, Operable Unit 3 (Offsite Areas), US Department of Energy, October 1995

RFCA, 1996 - Rocky Flats Cleanup Agreement, Joint Agreement between the US Department of Energy, the US Environmental Protection Agency, the Colorado Department of Public Health and Environment and the State of Colorado, dated July 19, 1996