RFCA Stakeholder Focus Group
Meeting Agenda

When: **January 31, 2001 3:30 - 6:30 p.m.**

Where: **Broomfield Municipal Hall, Bal Swan and Zang's Spur Rooms**

3:30 – 3:40	Introductions, Agenda Review, 1/17/01 Meeting Minutes Review
3:40 – 4:10	RSAL Workshop design team report back and discussion
4:10 – 4:30	Regulatory Analysis questions for peer reviewers
4:30 – 5:00	Land Use Scenarios discussion
5:00 – 5:15	Break
5:00 – 5:40	Land Use Scenarios discussion (Continued)
5:40 – 6:15	Definition of Resident Rancher Land Use scenario
6:15 – 6:30	Set Future Agendas and Review Meeting
6:30	Adjourn

Reviewed for Classification/UCNI/OUO
By: Janet Nesheim, Derivative Classifier
DOE, EMCBC Classif Offcr
Date: 08-12-09
Confirmed Unclassified, Not UCNI/Not OUO

1/340
1/190

RFCA Stakeholder Focus Group
January 31, 2001
Meeting Minutes

INTRODUCTION AND ADMINISTRATIVE

A participants list for the January 31, 2001 Rocky Flats Cleanup Agreement (RFCA) Stakeholder Focus Group meeting is included in this report as Appendix A.

Reed Hodgin of AlphaTRAC, Inc., meeting facilitator, reviewed the purpose of the RFCA Stakeholder Focus Group and the meeting rules for this group. Introductions were made.

Reed reviewed the meeting agenda, which included:

- Radioactive Soil Action Levels (RSALs) Workshop design team report back and discussion
- Regulatory Analysis questions for peer reviewers
- Land Use Scenarios discussion
- Definition of Resident Rancher Land Use scenario

Reed asked the Focus Group if there were any changes or additions / corrections to the January 17, 2001 meeting minutes.

A member of the Focus Group remarked on the reference to "dose and other physical forces" on page 9 of the minutes and asked if "other physical forces" had been defined. The Colorado Department of Public Health and Environment (CDPHE) responded that the reference was from the Risk Assessment Corporation (RAC) report.

A member of the Focus Group asked that the minutes be modified to clarify that the RFCA Agencies do not believe that the Resident Rancher Land Use scenario as presented in the RAC analysis is not realistic and that this is not an opinion attributed to the Focus Group as a whole. Reed Hodgin and Christine Bennett of AlphaTRAC, Inc. agreed to modify the minutes for this clarification.

A member of the Focus Group noted that the discussion on comparison of versions of the RESRAD model on page 4 should reference the following model versions: 5.61, 5.8, and the RAC or 6.0.

ADMIN RECORD

RFCA Stakeholder Focus Group
Attachment A

Title:	Agenda for January 31, 2001 Focus Group Meeting
Date:	January 25, 2001
Author:	C. Reed Hodgin AlphaTRAC, Inc.
Phone Number:	(303) 428-5670
Email Address:	cbennett@alphatrac.com

ADMIN RECORD

RSAL WORKSHOP DESIGN TEAM REPORT BACK AND DISCUSSION

Reed introduced the topic by summarizing that a working group had been formed at the January 17, 2001 RFCA Focus Group meeting to draft a detailed design for workshops for consideration by the group as a whole. He turned the discussion over to Gerald DePoorter for presentation of the Working Group's results.

Gerald introduced the members of the working group:

- Gerald DePoorter
- Ken Brakken
- Victor Holm
- John Marler

He credited Ken Brakken for helping to lead the group to results.

He then presented a summary of the working group's recommendations (Appendix B). The presentation addressed four topics:

- Assumptions
- Workshop 1: RSAL Modeling Workshop
- Workshop 2: RESRAD 6.0 Input Parameters Scenarios and Numbers
- Workshop formats.

The members of the focus group then discussed the purpose and content of the workshops at length. Key issues identified during the discussion included:

- What experts would be appropriate to teach the first workshop (on the RESRAD model)?
  - The authors of Version 6.0 (and possibly other versions)
  - Independent third party experts (possibly completely independent of DOE, possibly just independent of the Rocky Flats application)
  - Three specific experts were suggested –

1. John Till,
2. Version 6.0 authors from Argonne National Laboratory, and
3. Kathleen Higley

- What should the focus of Workshop 1 be (strong proponents for each approach)?
  1. Assume that RESRAD 6.0 will be used in the RSAL analysis and focus on learning about this version – do not address other versions or historical applications (such as the RAC study),
  2. Learn about RESRAD 6.0 but also have a strong focus on a comparison among the versions of RESRAD with the intent to determine if the planned application (RESRAD 6.0) incorporates the most appropriate features and approaches for the Rocky Flats RSAL review. One member of the Focus Group suggested that the comparison include side-by-side model runs for a benchmark scenario.

- What level of information (prior audience knowledge) should be assumed?
  - The portion of the community already knowledgeable about the RSAL Review and the RESRAD versions (essentially the RFCA Stakeholder Focus Group),
  - The interested community, many of whom may have little knowledge of the process or the RESRAD model.

With insufficient time to resolve these issues and still address the rest of its agenda, the Focus Group decided to expand the working group to include all strongly held perspectives and create a revised proposal for the next Focus Group meeting. The following Focus Group members agreed to work on the next draft:

- Shirley Garcia
- Ken Korkia
- Joe Goldfield
- Tom Marshall
- Mary Harlow
- Victor Holm
- Kent Brakken

Reed asked the members of the working group to bring back a workshop design that they really felt would meet the interests of all members of the Focus Group. He suggested that thoughts and draft designs be shared with all members via email between meetings so that broad input could be obtained during the drafting process.

Reed closed the discussion by thanking Gerald and the other members of the working group for their time and effort in drafting the current version of the workshop design.

REGULATORY ANALYSIS QUESTIONS FOR PEER REVIEWERS

Reed summarized the review process for the Regulatory Analysis Report (Task 1) of the RSAL Review project. He noted that Draft 2 of the report had been circulated to the Focus Group and the Peer Reviewers. The next step is for the members of the Focus Group to compile a list of questions to serve as guidance for the Peer Reviewers in their evaluation of the report.

Individual members of the Focus Group proposed questions which were then discussed among the group. Reed committed to submit all of the questions, along with overall guidance to the Peer Reviewers, by February 1, 2001. He captured the guidance and questions as follows:

1. The Peer Reviewers should conduct an overall evaluation of the draft report. This overall evaluation should address the questions:

   - Is the regulatory approach described in the report appropriate for developing RSALs for the Rocky Flats Environmental Technology Site (RFETS)?
   - If the approach is inadequate in any way, why is it inadequate and what approaches would be appropriate?

2. Given that the primary focus is the overall evaluation described above, the Peer Reviewers should answer any of the following questions that they feel qualified to address and for which they have sufficient effort available within the scope of the peer review commitment.

   - Is the regulatory approach used for setting RSALs at RFETS (as described in the draft document) consistent with that used elsewhere (best industry practice)?

- What is the relevance of the U. S. Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance to the specific cleanup at RFETS?
- Is the Nuclear Regulatory Commission (NRC) rule actually an Applicable or Relevant and Appropriate Requirement (ARAR) for this application - does the 25 mrem dose level under NRC rule meet the CERCLA risk requirement?
- Is the NRC rule appropriate for the specific conditions at RFETS (a cleanup action rather than a nuclear reactor or active production facility)?
- Which method of health impact evaluation– dose assessment or risk assessment – will be most protective of human health?
- Is the dose level chosen for the analysis appropriate and adequately protective?
- Is the risk range chosen for the analysis appropriate and adequately protective – is a specific value in the risk range considered most appropriate?
- Is there a regulatory requirement to maintain institutional controls in the future if such controls are used to meet CERCLA requirements?
- Is the As Low As Reasonably Achievable (ALARA) principle being applied properly in this cleanup approach?
- Does the document adequately address the role of community acceptance in setting RSALs?
- Does the wildlife worker scenario described in the document meet the CERCLA criterion for protection of the reasonably maximally exposed individual, especially with regard to the long-term stewardship period?

LAND USE SCENARIOS DISCUSSION

Steve Gunderson, CDPHE, introduced presenters for the five land use scenarios being considered in the RSAL review:

- Office Worker, Mark Aguilar
- Open Space User, Rick Roberts,
- Wildlife Refuge Worker, Diane Niedzwiecki,
- Rural Resident (replacing Suburban Residential), Jim Benetti
- Resident Rancher, Jim Benetti

Wildlife Refuge Worker Scenario

Diane Niedzwiecki, CDPHE, briefed the Focus Group on the Wildlife Refuge Worker Land Use scenario (see Appendix C for briefing slides). This scenario is based primarily on information from two sources:

- Interviews over the phone with Carl Mackey, Shell at the Rocky Mountain Arsenal (RMA) and Mark Sattelberg, U.S. Fish and Wildlife Service, and
- Document prepared by Shell for the RMA risk assessment, which was based on a survey that they did: *Wildlife Refuge Worker* in three different wildlife refuges around the country.

In summarizing this scenario, Diane indicated that the Wildlife Refuge Worker scenario may be the most likely land use when institutional controls are in place.

A member of the Focus Group noted that the inclusion of direct radiation as a pathway was important and often not considered in previous studies. In response, it was noted that direct radiation would be considered in evaluating each of the land use scenarios.

Office Worker Scenario

Mark Aguilar, EPA, briefed the Focus Group on the Office Worker Land Use scenario (see Appendix D for briefing slides). He indicated that this scenario was being considered as a requirement under the terms of the RFCA, and that it was not considered a likely scenario. He stated that the scenario would be defined in a very similar manner to that developed for the 1996 RSAL study.

This scenario will feature a typical office worker, working 8 hours a day, 5 days a week. These individuals will be indoors all the time, knowing that on occasion they're going to go out for lunch. They drive in and out of the site every morning and every evening. These individuals will not be in direct contact with soil.

A member of the Focus Group asked if radioactive gases would be considered in the modeling analysis. The response was that none of the radioactive parent or daughter products involved with the Rocky Flats cleanup are gases.

Open Space User Scenario

Rick Roberts, Kaiser-Hill, briefed the Focus Group on the Open Space User Land Use scenario (see Appendix E for briefing slides). He indicated that this scenario was being considered as a requirement under the terms of the RFCA, and that it had been examined over the past five to six years. The anticipated use is the type of open space activity typically conducted in the area around Rocky Flats. Information about open space use in Jefferson County will be a focus, but information from Boulder County will be used as well. Parks, access roads, and trails will be addressed.

Both adult and child open space users will be considered in the analysis.

Rural Resident Scenario

Jim Benetti of EPA briefed the Focus Group on the Rural Resident Land Use scenario (see Appendix F for briefing slides). He indicated that this scenario was being developed for two reasons:

1. To pick the scenario that is most likely to drive the setting of the RSAL in the event that there are no institutional controls on the site, and
2. To make sure that our scenario is the most conservative of the realistic future resident scenarios.

Because this Scenario is new and of particular interest to the Focus Group, Mr. Benetti's briefing is reproduced verbatim in Appendix F.

Resident Rancher Scenario

Jim Benetti of EPA briefed the Focus Group on the Resident Rancher Land Use scenario (see Appendix F for briefing slides).

He indicated that this scenario would be based on the Resident Rancher scenario described in Task 5 of the RAC report, modified as necessary for input to RESRAD 6.0. This scenario describes what could be considered to be the hypothetical extreme exposure. The resident rancher is living on the Rocky Flats mesa 100% of the time, 365 days a year. They spend a much higher fraction of time outdoors and have a higher breathing rate because they're working on the site, growing their own meat, drinking their own milk, and drinking shallow groundwater.

Because this scenario is of particular interest to the Focus Group, Mr. Benetti's briefing is reproduced verbatim in Appendix F.

A group question-and-answer session followed the briefings. When it became apparent that the group's focus was on the Resident Rancher Scenario, a further briefing was provided by Mr. Benetti (see Appendix F) after which the discussion continued. Key discussion points are summarized below.

- A member of the Focus Group noted that the amount of vegetables produced and eaten on the Rocky Flats mesa should account for the poor growing qualities at the site. Mr. Benetti noted that contaminated dust on the leaves of the plants should be considered as well as direct root uptake.

- A member of the Focus Group asked if horses or other dust-raising activities would be considered in the scenario. Mr. Benetti responded that raising horses and the associated dust had not been considered, but that it was a reasonable expectation and would be examined. He indicated that other dust-raising activities should be postulated and examined.

- CDPHE asked about a statement in the background paper that stated "Although this approach is not comparable with the RAC approach, it is likely to be more conservative." Mr. Benetti responded:

"What RAC did, when they were calibrating their mass loading to the air sampling data, they used meteorological data and the entire wind rose. That has not just wind frequency of velocity, but different directions. And then they calibrated in all the different compass points, or at least a significant number of them. What we'd be doing is almost like a linear version of this. We're going to be taking the velocity distribution of the winds, but not considering the direction, because the algorithm in RESRAD assumes that theyre always downwind. If the wind is blowing 100% in your direction, that's the same case. You can only go downhill if the wind varies in direction."

- A member of the Focus Group asked about the effect of Rocky Flats' elevation on the air sampling results that were used in the wind tunnel analysis of wind erosion. A discussion developed with the end result that the lower atmospheric pressure and air density at Rocky Flats are accounted for in the way that air volume is calculated.

- A member of the Focus Group asked if the effects of swirling winds, including dust devils, would be included in the estimation of wind erosion. The possibility that the wind tunnel results, which focused on straight-line winds, could have underestimated this effect was raised. Mr. Benetti responded that the results from the wind tunnel tests which examined changing mass loading with wind speed could help with this issue.

- A member of the Focus Group asked how the probability of a fire occurring would be addressed in the RESRAD analysis. Mr. Benetti responded:

"Preliminarily, you could construct in the way I've just described, if you have a frequency versus velocity diagram taken from wind rose data, and then you had next to it a mass loading versus velocity curve for both the vegetated and the fire case. You could construct through mapping two different distributions; one is vegetated and the other is unvegatated, and presumably the probability and the values of mass loading would be higher in the unvegetated case. If you then knew with a reasonable amount of certainty what the probability of a fire was, you can do a weighted sum of those two curves. The one curve you multiply by the probability of a fire, which is maybe one in five, like every five years you had a fire. The vegetated curve would be multiplied by one minus that probability, which is the

remainder. Then you'd add the two together, and what you'd have is a single curve that maybe would have a shoulder on the high up. If that was reasonable and thought to be a conservative approach, it would be a much-simplified way of getting at this, and yet, at the same time, bounding both the vegetated and unvegetated case complete with probability altogether. "

- A member of the Focus Group noted that there was a child exposure value considered for the Open Space scenario and asked if a child should be considered for the Office Worker or Wildlife Refuge Worker scenarios (possibly through an onsite daycare center). A discussion determined that such a possibility should be considered. It was noted that, for the Wildlife Refuge Worker scenario, the child would be outdoors less than the worker.

- A member of the audience asked if pregnant women would be included as exposure receptors in all scenarios. The agencies agreed to examine this question and return with an answer at the next meeting.

RSAL REVIEW SCHEDULE

DOE provided an updated RSAL review schedule to the Focus Group (Appendix G). It was noted that the schedule needs to be updated further and brought back again.

A member of the Focus Group noted that there was no opportunity in the schedule for the Focus Group to discuss the comments from the Peer Reviewers on the Task 1 report. The agencies asked that the Focus Group discuss this need and resolve it with the Agencies.

AGENDA FOR NEXT MEETING

The Focus Group agreed on the following topics for the February 14, 2001 meeting:

- Review of RESRAD 6.0 approach to air pathway
- Regulatory Analysis Report, Revision 2 - Discussion
- Report-back from Workshop Design Group

ADJOURNMENT

The RFCA Stakeholder Focus Group meeting was adjourned at 6:30 p.m.

Summary of Actions and Commitments

- If and how pregnant females are considered in RSAL risk / dose calculations - all land use scenarios (CDPHE – Gunderson)
- **Consider child exposure values for Office Worker or Wildlife Refuge Worker scenarios**
- Revised / detailed design for RSAL Workshops (Workshop Design Group)
- Revised RSAL schedule (DOE)
- Schedule an agenda item in 4-6 weeks: discussion on ALARA (AlphaTRAC)

RFCA Stakeholder Focus Group
January 31, 2001
Meeting Minutes

Appendix A
Participants List

Appendix B
Gerald DePoorter: RESRAD 6.0 Working Group Report

Appendix C
Diane Niedzwiecki: Wildlife Refuge Worker Scenario

Appendix D
Mark Aguilar: Office Worker Scenario

Appendix E
Rick Roberts: Open Space User Scenario

Appendix F
Jim Benetti: Rural Resident and Resident Rancher Scenarios

Appendix G
Joe Legare: RSALs Schedule

RFCA Stakeholder Focus Group
January 31, 2001
Participants List

NAME		ORGANIZATION / COMPANY
David	Abelson	RFCLOG
Mark	Aguilar	EPA
Christine	Bennett	AlphaTRAC, Inc.
Kent	Brakken	DOE, RFFO
Laura	Brooks	Kaiser-Hill Company, LLC
John	Ciolek	
John	Corsi	Kaiser-Hill Company, LLC
Carol	Deck	Kaiser-Hill Co, LLC
Gerald	DePoorter	RFCAB
Rick	DiSalvo	US DOE - RFFO
Shirley	Garcia	City of Broomfield
Joe	Goldfield	RFSALOP
Aaron	Grider	Jefferson County
Steve	Gunderson	CDPHE
Mary	Harlow	City of Westminster
Jerry	Henderson	RFCAB
Reed	Hodgin	AlphaTRAC, Inc.
Victor	Holm	RFCAB
Jeremy	Karpatkin	US DOE - RFFO
Paul	Kilburn	JCNA
Ken	Korkia	RFCAB
Joe	Legare	DOE
Sandi	MacLeod	U.S. DOE
John	Marler	RFCLOG
Tom	Marshall	Rocky Mountain Peace and Justice Center
Anna	Martinez	US DOE
Dan	Miller	Natural Resources and Environment Section Colorado Department of Law
LeRoy	Moore	RMPJC
Diane	Niedzwiecki	CDPHE

ADMIN RECORD

RFCA Stakeholder Focus Group
Participants List

Broomfield City Hall
January 31, 3:30-6:30 p.m.

Sheila	Plunkett	Rocky Mtn Peace and Justice Center
Karen	Reed	EPA
Rick	Roberts	RMRS
Mark	Sattelberg	US Fish and Wildlife Service

NAME		ORGANIZATION / COMPANY
Kathy	Schnoor	City of Broomfield
Joan	Seeman	CCANWI
Joel	Selbin	
Dave	Shelton	Kaiser-Hill Company, LLC
Carl	Spreng	CDPHE
Honorable Hank	Stovall	City of Broomfield
George	Vancil	City of Arvada
Doug	Young	Rep. Mark Udall

RESRAD 6. WORKING GROUP
Summary Report

Ken Brakken, Gerald DePoorter,
Victor Holm, John Marler

ADMIN REC

ASSUMPTIONS

- RESRAD 6.0 will be used by CDPHE, EPA, and DOE to calculate RSALs for the RFETS. This was decided in October, 2000, and is not an issue.
- Once input parameters are agreed upon, the RESRAD 6.0 RSAL is the number.

ASSUMPTIONS

- Time is of the essence. A set of RSAL's is needed by December, 2001.
- The code pedigree is not being questioned based on the fact that the NRC has accepted and is using RESRAD 6.0.

Titles and Objectives of RESRAD Workshops

Workshop 1

RSAL Modeling Workshop

To facilitate community understanding of the calculation of RFETS RSALs using dose and environmental transport models.

Workshop 2

RESRAD 6.0 Input Parameters

Scenarios and Numbers

To understand and defend (not debate or agree with) why the values for the input parameters were chosen. There are 100 or more parameters. This workshop will address the 10 most "sensitive" parameters.

WORKSHOP VENDORS

Workshop 1

RSAL Modeling Workshop

An independent third party vendor is suggested for this Workshop. Some suggestions are:

1. Kathy Higley, Oregon State University
2. An Argonne National Laboratory technical specialist.
3. ?

Workshop 2

RESRAD 6.0 Input Parameters

Scenarios and Numbers

A diverse, expert, third party panel. Regulators and D.O.E. will also have representatives on the panel to explain their choices.

WORKSHOP FORMAT

Workshop 1

RSAL Modeling Workshop

RESRAD 6.0 Workshop

- Discuss the dose response models. Describe what a RSAL is.
- Discuss what criteria are used to select a dose response model. Review the three models used at the RFETS. (RESRAD 5.82, RAC modified RESRAD 5.82, RESRAD 6.0)

WORKSHOP FORMAT

Workshop 1

RSAL Modeling Workshop

RESRAD 6.0 Workshop

- Look at the environmental transport models within the code. Use narrative descriptions, not formulas
- Review the models behind Dose Conversion Factors and the Slope Factor Method

WORKSHOP FORMAT

Workshop 1

RSAL Modeling Workshop

RESRAD 6.0 Workshop

- Discuss the sensitivity of the parameters.
- Use a computer wired to a projector to go through a complete RESRAD 6.0 run. Show the effects of varying the values

WORKSHOP FORMAT

Workshop 2
RESRAD 6.0 Input Parameters
Scenarios and Numbers

The panel of third party experts will discuss the choice of the RESRAD 6.0 input parameters for the RFETS RSAL calculations with the regulator and DOE representatives. There will also be extensive audience participation. The workshop is intended to be very interactive. The panel will not "re-hash" the input parameters, but rather discuss how and why they were selected.

For this workshop also there should be a computer wired to a projector so that RESRAD 6.0 can be run to demonstrate the effect of changing parameters.

Wildlife Refuge Worker Scenario Description

Diane Niedzwiecki, Ph.D.

CDPHE, Disease Control and Environmental Epidemiology

ADMIN RECORD

Wildlife Refuge Worker Scenario Description

- If Rocky Flats becomes a National Wildlife Refuge, this receptor likely will be significantly exposed to any contamination remaining on site.
- This scenario may become the driver for Soil Action Levels for this site.

Types of job categories included

- Secretaries, who may spend 100% of their time at work inside.
- Scientifically trained personnel such as biologists, foresters, habitat management specialists, and various interns or trainees.
- Maintenance workers, equipment operators and mechanics.

Amount of time spent outside

- Weather dependent.
- For scientifically trained personnel:
  - at least 50% of their time during spring, summer and fall.
  - Less time during the winter.

- Maintenance personnel or equipment operators:
  - often spend greater periods of time outdoors or in shops open to the outside air.

Size of exposure unit depends upon type of work

- Examples:
  - When doing road surveys of various types of wildlife, the worker may be exposed to the entire site over a several day period.
  - When trapping small mammals, the entire study may be spent on a 100 m^2 area.

Examples of specific tasks

- Planning and interpreting studies, planning prescribed burns, writing management plans.
- Performing wildlife or vegetation surveys.
- Performing prescribed burns.
- Applying pesticides or herbicides.
- Plowing, harrowing, and planting during revegetation programs.
- Fence building and maintenance.
- Building sheds.
- Guiding tours for the public.

Anticipated Sensitive Pathways for Radionuclide Exposure

- Incidental ingestion of surface soil, subsurface soil, and sediment.
- Inhalation of surface soil particulates.
- External exposure to gamma radiation.

Anticipated Sensitive Pathways for non-radionuclide exposure

- Incidental ingestion of surface soil, subsurface soil, and sediment.
- Dermal exposure, especially to some semivolatile contaminants in surface soil, subsurface soil, or sediment.
- Inhalation of indoor air contaminated by volatile organic compounds over groundwater plumes.
- Inhalation of surface soil particulates.

Wildlife refuge worker summary

- Because of the type of potential exposures to different media that this receptor could potentially have, this receptor may drive the Soil Action Levels at Rocky Flats.

Task 3 Update

Scenarios

ADMIN RECORD

Site Scenario List

- Office Worker Scenario
- Open Space User Scenario
- Wildlife Refuge Worker Scenario*
- Rural Residential
- Residential Rancher

Scenario #1: Office Worker (OW) Scenario Description

- The OW scenario is designated in RFCA
- OW(s) will be indoors most of the time
  - outside occasionally at lunch time
  - drive on and office site daily (M-F)
- OW(s) will not be in direct contact with soil

Anticipated Sensitive Pathways:

- Incidental ingestion of surface soil
- Inhalation of surface soil particulate
- External exposure to gamma radiation

Office Worker Summary

- The office worker Scenario is described by RFCA.
  - there are currently no plans for such use.
- Distributions will be used for the most sensitive parameters within a given sensitive pathway.
- It is not expected that this scenario will drive the Soil Action Levels at the site.

Rural Resident Scenario

In the rural resident scenario, we're trying to pick the scenario that's most likely to drive the setting of the RSAL in the event that there are no institutional controls on the site. Secondly, we want to make sure that our scenario is the most conservative of the realistic future resident scenario. That's the main reason we departed from the suburban resident - because the rural resident is actually more conservative and you'll set a lower number using this scenario. The basis for this rural resident scenario is taken from the Technical Basis Document for the proposed Radionuclide Cleanup Levels that EPA had at 40 CFR 196. That standard has been remanded; nonetheless, the technical basis is there and it's useful to start. But it's a very generic scenario. We propose to adapt it to site-specific conditions (for instance, mass loading).

The key component is that we are going to have a scenario that involves a resident that lives on a larger parcel of land which is essentially undeveloped. We've selected a 2- to 10-acre farmette / ranchette as something that might be typical for that area (if someone can acquire that much land).

The size of the person's land would have no general effect on their exposure, except that it would limit to where they would not be growing their own meat or their own milk. We would propose that they would not be drinking the shallow groundwater, which is not potable right now. They might grow fewer fruits and vegetables, but they will grow and eat their own fruit and vegetables.

The key thing about this scenario is that the surface soil would not be developed. This is why we rejected the suburban resident. If you went out to Rock Creek or any of the typical subdivisions in that area, you'll see that the majority of the land is covered. It's paved. People put sod on their lawns. This is all protective of the contamination in the surface. So the RSAL that you would derive from that would be much higher, because you would be attempting to take credit for all that covering over the contamination. We wanted to go with something that was much more exposed. The key feature is the surface soil would not be developed. It would be contaminated on the surface as it is now. The other key thing is, even though the rural resident would have a job and would work offsite, we're going to model this on the person that stays at home; who would spend the majority of time onsite (24 hours a day, probably up to 350 days a year); and they eat homegrown fruit and vegetables. We would also model the adult and child cases and try to predict which would be the most exposed. For example, a child eats more soil, but an adult breathes more dust and eats more vegetables. We want to compare the two and see which is the most protective.

ADMIN RECORD

Resident Rancher Scenario

We were asked to do this and model it using the RESRAD 6.0. The actually scenario is described in the RAC task 5 report. It describes what could be considered to be the hypothetical extreme exposure. The person there is living there 100% of the time, 365 days a year - a much higher fraction of time spent outdoors. This creates a higher breathing rate because they're working on the site, growing their own meat, drinking their own milk, and drinking shallow groundwater.

The model that we're going to use includes all the inputs that we can which are identical to the ones that RAC used. Most of those are listed in Table 4 of the RAC Task 3. There are some exceptions. There are three critical parameters, which RAC did their whole computer calculations for which we are not able to duplicate using an off-the-shelf model. In fact, they had to defeat parts of the RESRAD code that they modified and turn off those calculations to plug there own in. We are going to propose alternative approaches to this. It leaves us with the fact that we will not be strictly comparable with RAC, but we intend to be conservative in the approaches that we take. The three critical parameters are:

1. The area of the contaminated zone
2. The mass loading factor, and
3. The average wind speed.

We'll use the shallow groundwater pathway turned on. That means that if the person will be using shallow groundwater, as improbable as that may be, to water their stock and also to drink, it's an extreme situation. We model the adult and child case to see which is the most restrictive.

It occurred to me in working on the working group, what we're trying to do with RESRAD 6.0 is to use the additional feature of doing probabilistic or Monte Carlo calculations to improve our past calculations. It's along the lines of what RAC did in their Task 5 calculations. The RESRAD 6.0 might provide for a more comparable calculation. What we have found as we got more familiar with the Task 5 report, how they did this, and what we know of RESRAD 6.0, is that it's obvious that we're not going to be able to do that with these three parameters that I've mentioned. RAC decided that from limitations in the computer algorithms, or the subprograms for calculating these particular parameters in the RESRAD model that they used, they turned those off and wrote their own software, which is very complex. They modeled the variability of contamination on the site using curve fittings, they did boot strap

calculations of resuspension, they used alternative air transport modeling, and they calibrated this to actual air sampler results. It's way outside the scope of what our working group is capable of doing to duplicate that. In doing this, they incorporated a different approach for the area of the contaminated zone, which is one of the sensitive parameters for RESRAD or other computer models. They developed their own way of dealing with the variability of mass loading and they integrated five years worth of meteorological data, which I think was taken from the airport nearby. Those are the things that are outside the capabilities of RESRAD.

Since these were among the most sensitive parameters that they used, we would have a hard time being able to take an alternative approach and say we can compare one by one our results with theirs. But with that caveat, what we're proposing to do is to take everything that we can of what they did and then come up with alternative approximation methods which are quite a bit simpler than what they did. We believe that they could be conservative and complete. What we're proposing here for your consideration is something that our technical subgroup talked about in our last meeting. We have kind of a consensus that these appear to be a feasible approach, but we need to dig into them more deeply. The limitation that RAC attempted to address in RESRAD is that it models based on an input defined area, which is presumed to be uniformly or at least homogeneously contaminated. The reality of the situation is, at Rocky Flats, you have an area that would be cleaned and then a larger area that would be below the RSAL that would not be cleaned, but would nevertheless have a contribution to the cleanup area which you have to take into account.

What we're proposing to do, at least in concept, is to have at least two zones that we model. They would be modeled as concentric circles, with the larger zone being the area that's not cleaned up and the smaller area would be the area that is cleaned up. The approach we would take would be to compute the dose per year to a maximally exposed resident. That's what RESRAD does, that's its algorithm. Due to the large zone which is not cleaned up, we would come up with a dose based on the average value of contamination or something larger than the average value of contamination in that area now. We have a lot of soil data so we can do that. Then we would subtract that dose from the bounding dose that we're using to derive the RSAL, which is proposed to be 25 mrem. The smaller circle, the circle that gets cleaned up, would be modeled based on 25 mrem, minus that residual dose. So it may be 23 mrem, or 20 mrem, or something like that. That would set the RSAL value down lower in order to take into account that larger area that doesn't get cleaned up. We feel that that is a conservative approach. We may not be able to do it with just two zones, we may have to use three or so zones in order to make sure that we're bounding things, because contamination varies quite a bit in the area that won't be cleaned up. We feel that

would be a sound approach, and would be much simpler than what RAC did. They did a considerable amount of mathematical work in trying to capture that whole variability of soil contamination.

The second parameter is mass loading; again, RAC carried on with their approach and did some very impressive calculations using bootstrap and calibrating to all the air sampling data on the site. They also were able to come up with a distribution of mass loading based on that, because they did Monte Carlo analysis. Given the version of RESRAD that was available at that time, they probably did a lot more than RESRAD would have permitted them. We believe that RESRAD 6.0, since they can't accept a distribution of a parameter and do Monte Carlo modeling, that we can actually create a distribution for the mass loading based on something other than the approach that RAC took. We believe that we can use the wind tunnel studies and past studies that have actually shown the relationship between mass loading and wind velocity. We then would incorporate the meteorological data from the site to come up with the distribution, which reflects, in other words, the probability of a certain mass loading is related to the frequency of winds at that particular velocity. Since the more recent wind tunnel study has studied both the burned area and unburned areas, we believe that we can do distributions for each of those and possibly combine them into a single distribution with appropriate weighting factors that reflect the probability of a fire. That would be the appropriate way to address site specific conditions.

One of the things that RAC was faced with was trying to figure out what the change of resuspension rate would be when you had limited data. A lot of it was taken from the Nevada Test Site, which is quite a bit different in geologic content from Rocky Flats. If you actually have site specific data, which we do now, we believe that it would be better to treat it that way.

RAC approached the average wind speed by using the meteorological array. We believe that we can actually just use the average value for the meteorological rate that is taken from site specific map data and that the algorithm, if it's given as mass loading distribution, will handle that in a conservative way. One of the main reasons we believe that it will be conservative is that the RESRAD always models the dose to the receptors as if the receptor is always downwind, so that when you take the wind distribution frequency versus velocity, and then you neglect the fact that it's not blowing in different directions, but always in the same direction towards the receptor, you're likely to come up on the conservative side.

We feel that those are appropriate adjustments and approximations to use. We may run into obstacles becuase these are still conceptual. They seem to be feasible. We've got

kind of a consensus to plow ahead and look into that. They also promise to be expedient if they will work, because the wind tunnel data is coming out in the final version in the not too distant future. The approximation on the area of the contaminated zone is really within our grasp right now if it works.

RFCA Stakeholder Focus Group
Attachment B

Title:	Meeting Minutes for January 31, 2001 Focus Group Meeting
Date:	February 8, 2001
Author:	C. Reed Hodgin AlphaTRAC, Inc.
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ADMIN RECORD

Scenario #4: Rural Resident

- Adapt to site specific conditions
- 2 - 10 acre farmette / ranchette
- Surface soil undeveloped
- Majority of time onsite
- Homegrown fruit/vegetables
- adult and child cases

48

[redacted]

Anticipated Sensitive Pathways

- Ingestion of surface soil
- Inhalation of surface soil particulate
- Ingestion of homegrown plant material
- Incidental external exposure to gamma radiation

Rural Resident Summary

- Absence of institutional controls
- Most conservative of the realistic parameters
- Distributions for most sensitive parameters
- Deterministic values for slightly sensitive parameters

Scenario #5: Resident Rancher

- Described in RAC Task 5 report
- Will use all possible inputs identical to RAC's
- Muse use alternate approximations for:
  - area of contaminated zone
  - mass loading
  - average wind speed

Resident Rancher cont.

- Shallow groundwater pathway turned on
- adult and child cases
- results will not be directly comparable to RAC's

Anticipated Sensitive Pathways

- Ingestion of surface soil
- Inhalation of surface soil particulate
- Ingestion of homegrown plant material
- Ingestion of homegrown meat

Anticipated Pathways cont.

- Shallow groundwater pathway turned on
- Incidental external exposure to gamma radiation

Resident Rancher Summary

- Several aspects not deemed credible
- represents a more hypothetical extreme
- will be modeled as closely to RAC approach as possible
- For comparative purposes only

8/8

RESRAD 6. WORKING GROUP
Summary Report

Ken Brakken, Gerald DePoorter, Victor Holm, John Marler
Report compiled by Gerald DePoorter

The RESRAD Workshop working group met Friday, January 19, to discuss the proposed RESRAD workshops. We began by listing the assumptions that we would use to further discuss the workshops. Both workshops are based on the following Assumptions:

1. RESRAD 6.0 will be used by CDPHE, EPA, and DOE to calculate RSALs for the RFETS. This was decided in October, 2000, and is not an issue.
2. Once input parameters are agreed upon, the RESRAD 6.0 RSAL is the number.
3. Time is of the essence. A set of RSAL's is needed by December, 2001.
4. The code pedigree is not being questioned based on the fact that the NRC has accepted and is using RESRAD 6.0.

We continued by defining the titles and objectives of the proposed workshops. These are listed in Table I below.

TABLE I. Titles and Objectives of RESRAD Workshops

Workshop 1 RSAL Modeling Workshop	Workshop 2 RESRAD 6.0 Input Parameters Scenarios and Numbers
To facilitate community understanding of the calculation of RFETS RSALs using dose and environmental transport models.	To understand and defend (not debate or agree with) why the values for the input parameters were chosen. There are 100 or more parameters. This workshop will address the 10 most "sensitive" parameters.

We next discussed the intended audience of the workshops. We concluded that the audience for the workshops should be the RFCA Focus Group participants. When we realized that the audience should be the entire RFCA Focus Group, we abandoned the idea of a specific workshop dedicated to running RESRAD 6.0. Those RFCA Focus Group members who desire more detailed technical information on the basis for and running RESRAD 6.0 will pursue different avenues to achieve that purpose.

We then discussed the "vendor" or who would be conducting the workshop. These outcomes are summarized in Table II below.

The Format of the workshops, and what would be discussed at the workshops was discussed and are summarized in Table III below.

We did not discuss Workshop scheduling or timing.

When the RFCA focus group agrees on vendors and formats for the RESRAD workshops, the working group will then fill in details and work on implementing the workshops with DOE and the regulators.

ADMIN RECORD

TABLE II. Workshop Objectives, Audience, and Vendor

Workshop 1 RSAL Modeling Workshop		Workshop 2 RESRAD 6.0 Input Parameters Scenarios and Numbers	
OBJECTIVE	To facilitate community understanding of the calculation of RFETS RSALs using using dose and environmental transport models.	OBJECTIVE	To understand and defend (not debate or agree with) why the values for the input parameters were chosen. There are 100 or more parameters. This workshop will address the 10 most "sensitive" parameters.
AUDIENCE	RFCA Focus Group participants	AUDIENCE	RFCA Focus Group participants
VENDOR	An independent third party vendor is suggested for this Workshop. Some suggestions are: 1. Kathy Higley, Oregon State University 2. An Argonne National Laboratory technical specialist. 3. ?	VENDOR	A diverse, expert, third party panel. Regulators and D.O.E. will also have representatives on the panel to explain their choices.

TABLE III. Workshop Formats

Workshop 1 RSAL Modeling Workshop (RESRAD 6.0 Workshop)		Workshop 2 RESRAD 6.0 Input Parameters Scenarios and Numbers	
FORMAT	1. Discuss the dose response models. Describe what a RSAL is. 2. Discuss what criteria are used to select a dose response model. Review the three models used at the RFETS. (RESRAD 5.82, RAC modified RESRAD 5.82, RESRAD 6.0) 3. Look at the environmental transport models within the code. Use narrative descriptions, not formulas 4. Review the models behind Dose Conversion Factors and the Slope Factor Method 5. Discuss the sensitivity of the parameters. 6. Use a computer wired to a projector to go through a complete RESRAD 6.0 run. Show the effects of varying the values for the parameters.	FORMAT	The panel of third party experts will discuss the choice of the RESRAD 6.0 input parameters for the RFETS RSAL calculations with the regulator and DOE representatives. There will also be extensive audience participation. The workshop is intended to be very interactive. The panel will not "re-hash" the input parameters, but rather discuss how and why they were selected. For this workshop also there should be a computer wired to a projector so that RESRAD 6.0 can be run to demonstrate the effect of changing parameters.

RFCA Stakeholder Focus Group
Attachment C

Title:	RESRAD 6 Working Group Summary Report
Date:	January 25, 2001
Author:	Gerald DePoorter Rocky Flats Citizens Advisory Board
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ADMIN RECORD

RFCA Stakeholder Focus Group
Attachment D

Title:	Determining Cleanup Goals at Radiologically-contaminated Sites
Date:	January 17, 2001
Author:	Carl Spreng Colorado Department of Public Health and Environment
Phone Number:	(303) 692-3358
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ADMIN RECORD

DETERMINING CLEANUP GOALS AT RADIOLOGICALLY-CONTAMINATED SITES

RSAL Annual Review Task 5

January 17, 2001

ADMIN RECORD

Determining Cleanup Goals at Radiologically-Contaminated Sites

INTRODUCTION

The purpose of this report is to explain the context in which cleanup levels have been developed at radiologically-contaminated sites. This report documents cleanup levels and presents case studies from selected sites to demonstrate variations in the decision-making framework and basis.

The cleanup level development process begins with determining which regulatory authority applies, which determines the applicable radiological standard. Table 1 lists major radiological standards in effect in the United States. The Conference of Radiation Control Program Directors (CRCPD, 1998) has complained that radioactively-contaminated sites "are not being cleaned up in a timely manner because there is no uniform cleanup standard applicable to the radioactive materials. ... [T]he U.S. has a mixed bag of inconstant annual dose limit fractions (4 mrem/year for water, 10 mrem/year for air, 15 mrem/year for high level waste, 25 mrem/year for fuel cycle). Uniformity is not apparent in this melange."

Many sites involving the research, development, processing, assembly, waste disposal, or even deployment of nuclear weapons are CERCLA sites. According to the CERCLA and the NCP, selected remedies, and therefore cleanup guidelines, must be protective of human health and the environment and must comply with applicable or relevant and appropriate requirements (ARARs). Cleanup guidelines and remedies based on ARARs must ultimately be found to fall within the CERCLA risk range.

Various terms are used, sometimes interchangeably, to describe numbers that guide remedial actions at radiologically-contaminated sites. Cleanup levels from site to site, or even at a single site, cannot be compared without knowing their purpose, how they were derived, and how they will be applied. Soil screening levels, Preliminary Remediation Goals (PRGs), action levels, and Remedial Action Objectives (RAOs) are usually used to describe relatively conservative numerical values developed early in the remediation process. Final cleanup levels, Final Remediation Levels, or Remediation Goals (RGs), are established by Records of Decision (RODs) and guide final remedial or management actions at a site or portion of a site.

An <u>Action Level</u> in the Superfund program refers to the existence of a contaminant concentration in the environment high enough to warrant action or trigger a response under the Superfund Amendments and Reauthorization Act (SARA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The term can be used similarly in other regulatory programs (EPA OSWER Glossary). Responses triggered may include actions such as removal, treatment, containment, stabilization, or institutionally controlling exposure. The action level is sometimes referred to as the <u>investigation level</u> (EPA, et al, 2000).

Preliminary Remediation Goals (PRGs) are the initial or proposed cleanup goals usually developed early in the Remedial Investigation phase to provide risk reduction targets. PRGs based on ARARs are generally considered protective for single pathways or contaminants. Depending on which requirements are determined to be ARARs, PRGs are usually established by assessing radiological health effects using a risk-based or dose-based approach. Either approach requires selecting appropriate scenarios, models / equations, and site-specific input parameters. Risk-based PRGs are developed when multiple pathways or contaminants are present. Numerical PRGs for radionuclides are typically based on the upper bound carcinogenic risk of one in a million (10^{-6}). Only cancer risks are considered for most radionuclides; non-cancer hazards are sometimes also included for uranium. Until the final remedy is selected and documented in the Record of Decision (ROD), PRGs constitute initial guidelines, not final cleanup goals [40 CFR 300.430 (e)(2)(i)].

Remedial Action Objectives (RAOs) or final Remediation Goals (RGs) are media-specific cleanup goals for a selected remedial action. CERCLA requires the development of "...methods and criteria for determining the appropriate extent of removal, remedy, and other measures..." for responding to releases of hazardous pollutants and contaminants [CERCLA Section 105(a)(3)]. In order to meet this requirement, a process defined in the revised NCP evaluates potential remedial alternatives, once it has been determined that remediation is warranted. The development of remedial action objectives is directly tied to this alternatives evaluation. These numerical remediation goals can be based on existing standards that are ARARs or on risk calculations [40 CFR 300.430(e)]. These two requirements are the "threshold criteria" for evaluating both remedial alternatives and remedial action objectives. Because risk-based PRGs do not necessarily represent realistic exposure and risk, those numbers may not be appropriate cleanup levels and they may be adjusted before being applied as RGs. Factors related to technical limitations (e.g., detection or quantification limits) can be applied. In addition, the "balancing criteria" and the "modifying criteria" for analyzing remedial alternatives, such as cost, state and community acceptance, should also be considered [40 CFR 300.430(e)(2)(i)(A)]. In some cases, RGs may be adjusted downward to account for multiple radionuclides or co-occurring non-radionuclide chemicals. Final RGs are documented in the Decision Summary section of the ROD as radionuclide-specific "remediation levels" [40 CFR 300.430(f)(5)] or as a qualitative definition of the risk-reduction cleanup objective to be achieved for the non-numerical RGs.

ORGANIZATION OF THE REPORT

Case studies from 12 radiologically-contaminated sites present a background of each site including the site history and nature of contamination. These case studies then discuss the unique manner in which each site developed cleanup levels – the regulatory basis, models and inputs used, and what factors may have been applied to derive a final cleanup number. If actual cleanup has taken place at the site, the status of those activities is reported. Contact information is listed for most sites, including persons who are knowledgeable about the site and websites, if available. The sites reported are:

1. Brookhaven National Laboratory, NY
2. Enewetak Atoll, Marshall Islands
3. Fernald Environmental Management Project, OH
4. Ft. Dix, NJ
5. Hanford Site, WA
6. Johnston Atoll
7. Linde Site, NY
8. Maralinga, Australia
9. Nevada Operations, NV
10. Oak Ridge Reservation, TN
11. Savannah River Site, SC
12. Weldon Spring Site, MO

Cleanup levels have been identified for several other sites besides those included in this report. Without the background and context for these values, however, they will not be reported here. Most cleanups of nuclear weapons accident sites will also not be discussed in this report. At least 11 nuclear bombs from the Cold War era, including five in the United States, have still not been recovered. Accident sites where contamination was spread and cleanup occurred include Palomares, Spain (1966) and Thule, Greenland (1968). For the most part, activity levels reported at these sites are post-remediation measurements rather than cleanup levels determined prior to remediation. As such, these levels are not appropriate for comparison in this report.

Cleanup levels for plutonium at various sites are listed in Table 2; Table 3 contains cleanup levels for uranium. Comparison of values in these tables can be meaningfully done only in context of the explanation of the site-specific cleanup level development process in the case studies. Table 4 presents key RESRAD input parameters used by several sites, which used that computer model to determine cleanup levels.

CONCLUSIONS

Differences in cleanup levels from site to site are due to variations in one or more of the elements in the cleanup level development process. Variations in the elements of this process have led each site to establish different cleanup levels. The differences in cleanup levels can only be understood by understanding the context in which the decisions in each cleanup level development process were made.

- *Soil cleanup levels can vary due to variations in regulatory standards and authorities.*

- *Final clean-up numbers used may differ from the values derived from a site risk assessment because of modifying factors such as ALARA.*

- *Soil cleanup levels examined at several sites for plutonium and uranium demonstrate that levels can vary due to the land use assumptions and exposure scenarios.*

- *Variation in the basis of risk assessment approaches (slope-factor and dose) leads to variation in assessed risk. Neither approach can be attributed as leading to more conservative cleanup numbers than the other.*

- *Differences in computer codes (especially different versions of RESRAD) can be significant. For example, newer versions of the RESRAD computer code have improved the air model, which has led to a greater percentage of risk attributed to soil ingestion.*

- *The input parameters used in computer codes such as RESRAD have significant influence on the result. The outcome is typically very sensitive to a very few of the parameters such as the form of plutonium, inhalation rate, dose conversion factors, soil ingestion rate, mass loading for inhalation, etc.*

A document explaining the context for cleanup level decisions at radiologically-contaminated sites is also being produced by the Radionuclides Work Team of the Interstate Technology & Regulatory Cooperation (ITRC), a cooperative effort among state regulators, federal agencies, industry, and academia. This document is currently being compiled by regulators from various states and is scheduled to be published early in 2001. The case studies presented in this report will become part of that document.

CASE STUDY: BROOKHAVEN NATIONAL LABORATORY

Background

Brookhaven National Laboratory (BNL), formerly Camp Upton, was administered by the U.S. Army during World Wars I and II and has been operated by DOE and its predecessors since 1947. This facility processed, treated, and stored radioactive and hazardous waste. The BNL site was placed on New York State's Department of Environmental Conservation (NYDEC) list of Inactive Hazardous Waste Sites in 1980 and on the NPL in 1989. Remediation at this site is being done under CERCLA, 40 CFR Part 300. Soils in several areas were contaminated with radionuclides from past waste handling operations, spills, or inadvertent use of contaminated soils for landscaping. Most of the radioactively contaminated soils are at the former Hazardous Waste Management Facility.

Cleanup Level Development

The radionuclide soil cleanup level is based on a total dose limit of 15 mrem/year above background assuminging 50 years of institutional controls for the selected land use. The basis for this limit is EPA's proposed rule in draft 40 CFR 196 and subsequent EPA guidance. Residual radiological contamination following remediation will also be within the CERCLA risk range. Specific cleanup levels for individual radionuclides were determined using the RESRAD computer code. Cesium cleanup levels within the Former Hazardous Waste Management Facility assumes industrial land use with 50 years of institutional controls and residential land use with 100 years of institutional controls. Outside the Facility, cleanup levels for cesium are based on residential land use with 50 years of institutional controls. The cleanup level for strontium-90 is based on impacts to groundwater and is protective of residential and industrial use as well. DOE Order 5400.5 is the basis for the cleanup level chosen for radium-226. The New York Department of Environmental Conservation's guidance of 10 mrem/year above background will be an ALARA goal to be considered during remedial design.

Soil Cleanup Levels for Radiological Contaminants at Brookhaven (pCi/g)

Radionuclide	Residential Land Use	Industrial Land Use
Cesium-137	23	67
Strontium-90	15	15
Radium-226	5	5

Remedial Actions

Operable Unit I includes soils at the site contaminated with radionuclides. Over 2,500 cubic yards of landscaping soils with low levels of radionuclides have been excavated and shipped to a disposal facility in Utah. Other areas of radiologically contaminated soils include the Hazardous Waste Management Facility, the Waste Concentration Facility, the Reclamation Facility sump, and tanks at Building 811. All soil cleanups at Operable Unit I are expected to be completed by 2005. Post-remedial sampling will ensure that the dose from all residual radionuclides will not exceed 15 mrem/year (considering 50 years of institutional control for the specified land use).

Contacts

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CASE STUDY: ENEWETAK ATOLL

Background

Enewetak Atoll is a ring of 40 named islands, surrounding a lagoon about 20 miles in diameter, in the Marshall Islands. The total area of the islands is about 1800 acres. Before World War II, Enewetak was used as a military base by the Japanese. It was attacked and taken by the U.S. in February 1944. After the war, the AEC required a site for nuclear weapons tests. Enewetak Atoll was selected and in December 1947 its 136 inhabitants were transported to Ujelang, a nearby atoll. Between 1948 and 1957 forty-three different nuclear devices were detonated on Enewetak including the largest device tested by the U.S. These tests left much of the atoll contaminated with short-lived fission products as well longer lasting isotopes of plutonium. In 1971 the U.S. government made the decision to return the atoll to the Trust Territory of the Pacific Islands and planning for the cleanup began.

Cleanup Level Development

Enewetak represents the first time the U.S. attempted to set cleanup standards for plutonium. Many different agencies were involved. From the published sources it is not clear how the first standards were derived. It appears that 400 pCi/g was chosen by the Atomic Energy Commission (AEC) in 1974 as the maximum exposure and one-tenth of that, 40 pCi/g, was considered safe. It was then decided to remove all soil over 400 pCi/g and leave soil below 40 pCi/g. Soil between 40 and 400 would be considered on a case-by-case basis. In September of 1974, a draft Environmental Impact Statement (EIS) was published that recommended the 40-400 standards and rejected cleanup of fission products due their short half-life and the extreme disruption of islands that removing them would cause. One interesting concept discussed in the EIS was that once a cleanup action was initiated, the plutonium concentrations should be reduced to lowest possible levels. This concept is similar to ALARA. During the comment period on the draft EIS, numerous objections were brought up both about the standards and the placement of the waste; nevertheless, the final EIS was nearly identical to the draft.

Although demolition of the buildings and cleanup of the debris was started there continued to be controversy over the soil cleanup. In Aug of 1977 an independent committee chaired by Dr. W. Blair (the Blair Committee) was formed to recommend a course of action. The EPA had recently released its draft guidance on plutonium cleanup, which contained a 15 pCi/g cleanup recommendation. This value was rejected as being not applicable to Enewetak. Also, planning and budgeting were already too advanced to allow the project to be delayed by more studies. The Blair Committee generally endorsed the standards in the EIS. Meanwhile, the short-lived Energy Research and Development Administration (ERDA), the successor to the AEC, proposed applying the new EPA plutonium in soil cleanup guidance. The project was again put on hold until a decision could be made. In the meantime the DOE replaced ERDA. In January 1978, the Blair committee was again asked to recommend cleanup levels. The Committee made the following recommendations:

1. Residential islands should be cleaned up if the average concentration in soil exceeded 40 pCi/g.
2. Agriculture islands should be given second priority and should be cleaned up if the average was greater than 80 pCi/g.
3. Third priority should be given to the other islands and they should be cleaned up if the average was greater than 160 pCi/g.

They reaffirmed that once cleanup was begun it should continue until a level of at least 40 pCi/g is achieved. The committee recognized that because of the fixed cleanup budget this standard could result in some islands not being cleaned up and that they may have to be quarantined. This recommendation essentially formed the basis for the soil cleanup.

Remedial Actions

During 1977 and 1978 a total of 253 thousand cubic yards of debris were removed including nearly 6000 cubic yards of contaminated debris. The soil cleanup went much better than planned and in the end only one island, Runit, was quarantined due the disposal cell being on the island even though the surface soil was cleaned up. All the other islands were cleaned to at least the 160 pCi/g standard and most did not exceed 40 pCi/g.

CASE STUDY: FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Background

The Fernald Environmental Management Project (Fernald) is a 1500-acre DOE facility about 17 miles northwest of Cincinnati near the village of Fernald, Ohio. Fernald operated from 1952 to 1989 as the Feed Materials Production Center, a large-scale production facility extracting uranium from ores and ore concentrates to yield high-purity metal products in support of U.S. defense programs. During this period, over 500 million pounds of slightly enriched and depleted uranium metal products were shipped to other DOE sites across the country. Smaller amounts of thorium were also produced. Production stopped in 1989 and the site was added to the EPA's National Priorities List. In 1991 the site was officially closed and renamed to reflect its new cleanup mission.

Topography in the area consists of gently rolling uplands with steep hillsides along major stream. Surface drainage at Fernald is from east to west and south into Paddy's Run, with the exception of the northeast corner, which drains east toward the Great Miami River. Groundwater is contained in two geologic units: glacial overburden ranging in thickness between 0 and 50 feet, and sand and gravel of the Great Miami Aquifer. Groundwater in the glacial overburden is considered perched since it is contained within silty sand lenses within a low-permeability, clay-rich soil. The underlying Great Miami Aquifer is the principal drinking water supply for the region and is regulated as a sole-source aquifer under the Safe Drinking Water Act.

Six waste pits used during past operations contain approximately 475,000 tons of waste, including uranium, thorium and other radioactive and chemical contaminants. The pits range in size from a football field to a baseball diamond, and vary in depth from 13 to 30 feet. Two of the pits have a water cover, one has a synthetic cap and the others have a soil cover. The waste pits are either in close proximity to, or in contact with, the Great Miami Aquifer and are contributing to contamination of the ground water.

There are four concrete silos at the FEMP that were constructed to store radioactive materials. Two of them, referred to as the K-65 silos, contain high radium-bearing residues, one contains lower-level dried uranium residues, and one has never been used. To reinforce the K-65 silos, a soil berm was added in the 1960s and enlarged in the early 1980s. In 1991, bentonite clay was injected into the tops of the two K-65 silos to cap the high radium residues and reduce radon emissions from the silos.

Large volumes of contaminated soil exist on site as a result of dumping, spilling and fugitive emissions during site operations. Disposal areas include the Southern Waste Units, Solid Waste Landfill, and Lime Sludge Ponds. Soil underlying the current production area is contaminated as a result of leaks and spills.

A Federal Facility Agreement covering CERCLA remediation and NESHAP activities exists between EPA and DOE. The State of Ohio and DOE have a Consent Order covering hazardous waste, surface water, and natural resource restoration.

Cleanup Level Development

Cleanup levels for the entire site have been established through CERCLA Records of Decision (RODs) for the five operable units that encompass the site. Soil cleanup levels are risk based using EPA risk assessment guidance and land uses consisting of an on-site undeveloped park and an off-site resident farmer. Groundwater cleanup levels are based upon EPA drinking water MCLs, proposed MCLs, or risk-based numbers. The following tables list cleanup values presented in the Operable Unit 5 ROD, which addresses the large majority of the site. Cleanup values differ in other portions of the site based upon proximity to groundwater and contaminant type, but are generally similar.

FINAL REMEDIATION LEVELS (FRLs) FOR SOIL AT FEMP

Contaminant	On-Property FRL(pCi/g)	Off-Property FRL (pCi/g)
Cesium-137 + 1D	1.4×10^{0}	8.2×10^{-1}
Neptunium + 1D	3.2×10^{0}	4.9×10^{-1}
Lead-210	3.8×10^{1}	2.2×10^{0}
Plutonium-238	7.8×10^{1}	9.3×10^{0}
Plutonium-239/240	7.7×10^{1}	9.0×10^{0}
Radium-226 + 8D	1.7×10^{0}	1.5×10^{0}
Radium-228 + 1D	1.8×10^{0}	1.4×10^{0}
Strontium-90	1.4×10^{1}	6.1×10^{-1}
Technetium-99	3.0×10^{1}	1.0×10^{0}
Thorium-228 + 7D	1.7×10^{0}	1.5×10^{0}
Thorium-230	2.8×10^{2}	8.0×10^{1}
Thorium-232 + 10D	1.5×10^{0}	1.4×10^{0}
Uranium, total (K_d=325 L/kg) (ppm)	8.2×10^{1}	5.0×10^{1}
Uranium, total (K_d=15 L/kg) (ppm)	2.0×10^{1}	NA

FRLs FOR SEDIMENT AT FEMP

Contaminant	FRL (pCi/g)	Contaminant	FRL (pCi/g)
Cesium-137 (+1D)	7.0×10^{0}	Radium-226 (+8D)	2.9×10^{0}
Neptunium-237 (+1D)	3.2×10^{1}	Radium-228 (+1D)	4.8×10^{0}
Lead-210 (+2D)	3.9×10^{2}	Strontium-90 (+1D)	7.1×10^{3}
Plutonium-238	1.2×10^{3}	Technetium-99	2.0×10^{5}
Plutonium-239/240	1.1×10^{3}	Thorium-228 (+7D)	3.2×10^{0}

FRLs FOR GMA GROUNDWATER AT FEMP

Contaminant	FRL (pCi/L)	Contaminant	FRL (pCi/L)
Neptunium-237 (+1D)	1.0×10^{0}	Thorium-228 (+7D)	4.0×10^{0}
Radium-226 (+8D)	2.0×10^{1}	Thorium-230	1.5×10^{1}
Radium-228 (+1D)	2.0×10^{1}	Thorium-232 (+10D)	1.2×10^{0}
Strontium-90 (+1D)	8.0×10^{0}	Uranium, total (mg/L)	2.0×10^{-2}
Technetium-99	9.4×10^{1}		

Remediation

Waste Pits Remedial Action Project (Waste storage area, including six waste pits, clear well and bum pit) - The waste pit contents will be excavated, thermally dried and shipped by rail to a permitted commercial disposal facility. Significant effort has been put into upgrading on- and off-site rail systems.

On-Site Disposal Facility - Contaminated soil and debris is being excavated and disposed in the on-site engineered disposal cell. Any waste that exceeds the waste acceptance criteria will be disposed off-site. No off-site waste will be allowed in the disposal cell. The first waste
placement occurred in December, 1997. The OSDF is designed to hold 2.5 million yards of waste.

Facilities Closure and Demolition Project (Former production area, including all buildings, equipment, inventoried hazardous material and scrap metal piles) – All on-site buildings will be decontaminated and dismantled. Debris within the waste acceptance criteria will go in the on-site disposal facility, with higher level materials going off-site. Significant progress has been made in the safe shutdown of nuclear materials and the decontamination and dismantlement of production facilities. A number of innovative technologies have been deployed during the D&D activities including gas-oxy torch, insulation removal, decon equipment, scanning equipment, etc.

Silos Project (Silos 1-4, including the K-65 silos, their contents and associated piping and soils) Due to the 1996 failure in the Vitrification Pilot Plant, an Explanation of Significant Difference was completed for Silo 3 and a Record of Decision Amendment will be completed for Silos 1 and 2.

Soils Characterization and Excavation Project (formerly OU2 and OU5) Contaminated soils will be excavated and those meeting the waste acceptance criteria will be disposed in the on-site disposal facility. Excavation of the first contaminated soils area was completed in 1997. Technologies being used include a number of field deployed analytical devices for quick assessment of radionuclide concentrations.

Aquifer Restoration and Waste Water Project (formerly OU5) The Great Miami Aquifer will be remediated by a combination of treatment, extraction and injection of the ground

water. The Advanced Waste Water Treatment Facility was completed in 1994 with additional capacity added in 1998. The South Plume extraction system removal action began pumping in August 1993. The South Field extraction and injection system became operational in the summer of 1998.

The future land use will include natural resource restoration on the majority of the site. Natural resource restoration is part of on-going negotiations to settle the State of Ohio's Natural Resource Damages claim against DOE. Restoration will include development of wetlands, forests and prairie areas. Low impact public access will be allowed. The On-Site Disposal Facility will remain and be managed/monitored.

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CASE STUDY: FORT DIX

Background

In June 1960, a large fire in an antiaircraft bunker melted the warhead of a Boeing Michigan Aeronautical Research Center (BOMARC) missile releasing plutonium to the environment. This antiaircraft bunker, associated with McGuire Air Force Base, was located on the Ft. Dix Military Reservation. Water used to fight the fire spread the plutonium over the land surface and into the subsurface. Some equipment was eventually removed and the area of contamination covered with layers of concrete. Many of the details regarding this accident and subsequent response remain classified.

Cleanup Level Development

On August 7, 2000, the New Jersey Commission on Radiation Standards promulgated Soil Remediation Standards for Radioactive Materials (N.J.A.C. 7:28-12). These standards are intended to apply as an ARAR at radiologically-contaminated CERCLA sites. Minimum remediation standards are based on a 15 mrem total annual effective dose equivalent (TEDE) limit. This annual dose limit includes the groundwater pathway and equates to 1 standard deviation of the background levels in the state. This dose limit was translated to soil concentration limits using an all pathways approach. These soil remediation standards are increments above background. Average background concentrations of the radionuclides at a site are determined using MARSSIM methodologies or other approved methods. The sum of fractions rule applies to sites with multiple radionuclides.

Derived Concentration Guideline Levels (DCGLs) have been calculated using a spreadsheet for several individual radionuclides (U-234, U-235, U-238, Ra-226, Ac-227, and Th-232). These dose-based DCGLs have been derived for unrestricted use (residential), limited restricted use (institutional controls required), and restricted use (institutional controls and engineering controls required) using parameters from EPA's Exposure Factors Handbook and NRC's NUREG 5512. The tables further provide different values for varying contaminant thicknesses and for varying amounts of clean cover.

Table Values for DCGLs for One Foot of Contaminated Soil (pCi/g)

Radionuclide	Unrestricted Use	Limited Restricted Use	Restricted Use* (1-foot cover)
Ac-227	3	5	17
Ra-226	3	5	7
Th-232	2	3	15
U-234	62	69	81
U-235	29	37	62
U-238	54	64	82

*for commercial use; cover must be maintained

Sites may petition for alternative remediation standards in lieu of the DCGL tables using RESRAD or the spreadsheet RaSoRS. These alternate soil cleanup standards must:

1. Not exceed 15 mrem/year TEDE;
2. Not exceed 3 pCi/L of radon in indoor air;
3. Not exceed New Jersey Groundwater Quality Standards;
4. Be derived using standard input values for certain parameters:

Parameter	Unrestricted Use	Limited or Restricted Use
Indoor onsite breathing rate (m3/hr)	0.63	1.4
Outdoor onsite breathing rate (m3/hr)	1.40	1.4
Soil ingestion rate (g/yr)	70	12.5
Homegrown crop ingestion rate (g/yr)	17,136	0
Drinking water consumption rate (l/yr)	700	700
Shielding factor through building or slab	0.20	0.20
Shielding factor through wall	0.80	0.80
Shielding factor outside	1	1
Fraction of time spent indoors onsite	0.70	0.18
Fraction of time spent outdoors onsite	0.05	0.05
Soil to Vegetation Transfer Factors (pC/g wet plant to pCi/g dry soil):		
Th	1E-3	1E-3
Ra	4E-2	4E-2
Pb	1E-2	1E-2
Po	1E-3	1E-3
U	2.5E-3	2.5E-3
Ac	2.5E-3	2.5E-3
Pa	1E-2	1E-2
Bi	1E-1	1E-1

The U.S. Air Force, which is responsible for the cleanup, derived a cleanup level of 8 pCi/g of plutonium for a ROD which was signed in 1992. This activity level was originally designed to represent a 4 mrem annual dose. Even though this value has not been reduced to account for other radionculides such as americium ingrowth, it is acceptable to the New Jersey Department of Environmental Protection since it is considerably lower than an unrestricted cleanup level based on the State's current dose criterion of 15 mrem/year (approximately 25 pCi/g of Pu). The ROD requires the removal and offsite disposition of concrete and soils that exceed the 8 pCi/g cleanup level.

The New Jersey Soil Remediation Standards include a section pertaining to changes in land use. These requirements state that a "subsequent proposed use of a property that is different from the intended use (other than unrestricted use remedial actions) described in the original remediation proposal shall require a prior review and prior approval by the Department [of Environmental Protection]." The Department and affected cities must be informed of the following:

- the new land use compared to the original use;
- additional remedial actions, or engineering or institutional controls to be implemented;
- a dose assessment analysis;
- new characterization data, such as soil concentrations.

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CASE STUDY: HANFORD SITE

Background

The DOE Hanford Site is occupies 586 square miles in the southeastern portion of Washington State. The site adjacent to the Columbia River in a semi-arid region, and constitutes one of the prime remaining examples of shrub-steppe habitat. The Site is divided into 4 different sites listed on the National Priority List, the 100 Area (9 former production reactors), 200 Area (fuel reprocessing and waste management), 300 Area (fuel fabrication), and 1100 Area (support and outlying areas).

Hanford is a government-owned, contractor-operated facility, which is part of the nationwide nuclear weapons complex. Previous operations at the site consisted of fabrication of uranium fuel for irradiation in production reactors (300 Area), irradiation of fuel in 8 single-pass and 1 closed-loop nuclear reactors (100 Area), and recovery of plutonium and uranium from irradiated fuel (200 Area). Each of the primary environmental issues has an estimated cost of $500 - $5,000 million:

- interim stabilization of the production reactors (100 Area),
- cleanup of burial grounds and liquid waste disposal sites adjacent to the reactors (100 Area),
- retrieval and repackaging of spent nuclear fuel (100 Area),
- disposition of the "canyon"-type reprocessing buildings (200 Area),
- closure of 177 waste tanks, including vitrification of the tank wastes (200 Area),
- environmental restoration of waste treatment, storage and disposal areas in the former fuel reprocessing (200) area,
- environmental restoration of the former fuel fabrication area, including retrieval and treatment of remotely-handled TRU waste from 2 burial grounds (300 Area).

Cleanup Level Development

The DOE , the U. S. Environmental Protection Agency, and the State of Washington Department of Ecology signed a comprehensive cleanup and compliance agreement: the Tri-Party Agreement (TPA): on May 15, 1989. The TPA prescribes numerous milestones for interim remedial actions (IRAs), including IRA Records of Decision (RODs). The RODs typically present chemical specific remediation levels based on the most restrictive number from different pathways, e.g., (1) protection from direct exposure, (2) contaminant-specific concentration in soil protective of groundwater, and (3) contaminant-specific concentration in soil protective of the Columbia River.

The State of Washington Department of Health administers radiation protection standards as an Agreement State with the Nuclear Regulatory Commission, but current usage of those regulations is limited to radionuclides in air. The IRA RODs at Hanford have generally defaulted to a remediation level of 15 mrem for soil, and 4 mrem for groundwater. The RESRAD model has been used to back-calculate soil concentrations corresponding to these doses.

The Hanford Site Risk Assessment Methodology (HSRAM) was published in May 1995. It ensures the use of consistent exposure scenarios, exposure parameters, and computer

models for IRA risk assessments. However, it is only guidance, and it needs to be updated because it was based on then-current (1995) EPA Risk Assessment Guidance for Superfund. The HSRAM has typically been applied on an action-specific (IRA-specific) basis, and is used to compute remediation levels for particular contaminants of concern. The Native American is an important risk scenario for Hanford, because of the expectation that after remediation the Native Americans will resume hunting, fishing, and cultural practices at usual and accustomed places. The HSRAM is weak in its treatment of ecological risk assessment. Typically, ecological risk assessment has been addressed on either a qualitative basis for particular actions, or has been focused on a specific contaminant of concern and specific receptor.

The State of Washington Model Toxics Control Act (MTCA), Washington Administrative Code 173-340, is an Applicable or Relevant and Appropriate Requirement (ARAR) under CERCLA. Typically, the critical pathway is contaminant-specific concentration in soil protective of the Columbia River, based on

- a provision in MTCA establishing the relationship that concentrations in soil shall be "equal to less than one hundred times the groundwater cleanup level," and
- an assumed dilution factor from groundwater into the Columbia River.

MTCA tabulates soil cleanup standards and ground water cleanup levels under method A (tabulated/routine), and cleanup levels can be calculated using the Cleanup Levels and Risk Calculation (CLARC) risk assessment model for method B (standard/industrial) and method C (conditional application). MTCA requires cleanup to 10^{-5} excess risk for carcinogens (10^{-6} per contaminant).

The MTCA risk assessment model is not appropriate for calculating risk due to direct exposure to radionuclides, and the State of Washington has not issued a policy statement regarding the use of MTCA for regulating radionuclides. Development of site-wide radiological cleanup levels is currently in flux. Proposed revisions to MCTA address this by including a consideration of radionuclides. These revisions to MTCA also include additional tools for ecological risk assessment.

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CASE STUDY: JOHNSTON ATOLL

Background

Johnston Atoll is located between Hawaii and the Marshall Islands. Oahu, 720 nm northwest of the atoll is the closest inhabited island. The atoll originated as a volcanic island, but is now composed exclusively of coral. There were no indigenous people and until World War II the island was only occasionally inhabited. Since 1941 the atoll has been used as a military reservation. The Atoll is composed of two islands, Johnston Island and Sand Island. Johnston Island was originally about 46 acres, but after several periods of dredging, the area at the time of the nuclear tests was 185 acres. Since the tests the island has been further enlarged to 625 acres. The atoll has been determined to have no further defense mission and remains an unincorporated territory of the U.S. Operational control is currently held by the Defense Threat Reduction Agency (DTRA) of the Department of Defense; after cleanup the island will be declared a wildlife refuge under the administration of the Fish and Wildlife Service.

The contamination on Johnston Atoll was caused by three separate accidents involving THOR rockets during high altitude tests of nuclear devices during the summer and fall of 1962. None of the accidents resulted in an accidental detonation of a nuclear device. One rocket exploded on the pad on Johnston Island distributing coarse plutonium particles over the immediate area around the launch pad. Two rockets were destroyed by the range safety officer at altitudes of 30,000 feet and 109,000 feet over Johnston Atoll. The explosion at 30,000 feet definitely contaminated large areas of the atoll. The higher altitude explosion may also have contaminated the atoll. The most serious contamination was in the immediate area of the launch pad. During cleanup, some of the material was placed in the lagoon, along with some debris from the high altitude rocket explosions, which rained down on the lagoon. Later dredging efforts to expand the island resulted in some of this contamination being spread over other areas on the island.

Cleanup Level Development

In the 1980s a cleanup level of 13.5 pCi/g was adopted. This level was derived for a 10-mrem dose based on EPA draft guidance for soil screening levels (EPA, 1977). That guidance has now been superceded by the current EPA guidance using lifetime cancer risk.

The DTRA issued the *Johnston Atoll Radiological Survey* (DTRA, 2000) in January 2000. Appendix C – An Assessment of the Risks on Johnston Island describes how cleanup levels were developed. RESRAD Version 5.82 program was used to determine cleanup levels that correspond to specific risk levels in the CERCLA risk range. Instead of entering a dose limit, the program was run in the cancer risk mode. This mode is not documented, but the program is fully capable of utilizing cancer slope factors to set a soil action level. Key model input parameters are listed in Table 4 where they are compared to parameters used by other sites.

Four separate scenarios were investigated. Two of these are similar in that they involve a cleanup worker and a Fish & Wildlife Service worker. The difference between the two is

that although both work outdoors in a dusty environment and ingest a large amount of soil, the cleanup worker also grows a modest amount of vegetables and because of the soil disturbance breaths twice the dust (.0002g/m^{-3}). The third scenario is an ecotourist who visits the island for two weeks a year to observe seabirds; therefore his exposure is less. The last scenario is a homesteader that surreptitiously lives on the island. The study used a soil ingestion rate of 73g/yr for the two worker scenarios and 36g/y for the homesteader. The EPA Exposure Factors Handbook recommends 18g/y for adults while the RESRAD default value is 36g/y. Based on this the values are conservative. Total excess cancer risk was calculated by the RESRAD code using cancer risk factors from the 1997 HEAST (EPA, 1997). The risk is greatest in the first year for all exposure scenarios. The estimated total excess lifetime risk per pCi/g of TRU alpha exposure results are given in the table below:

Allowable Residual Soil Concentration (pCi/g of TRU alpha)

Cancer Risk	Fish & Wildlife Service Worker	JA Resident	EcoTourist	Homesteader
1E-06	2.1	1.9	38	0.32
1E-05	21	19	380	3.2
1E-04	210	190	3800	32

If the pathways that produced the risks are examined, the ingestion pathway, especially soil ingestion, dominates.

Pathway	Fish & Wildlife Worker	JA Resident	EcoTourist	Homesteader
Inhalation	4.9%	9.3%	1.8%	3.7%
Soil Ingestion	86.9%	82.2%	16.1%	34.9%
Plant Ingestion	0%	0.7%	0%	56.6%
External Exposure	8.2%	7.7%	82.1%	4.6%

Following the release of its *Johnston Atoll Radiological Survey*, DTRA proposed a cleanup standard of 40 pCi/g, which is approximately 2.1 x 10^{-5} risk to a hypothetical resident.

In September 2000 EPA Region IX responded to the DTRA's proposed cleanup standard and risk assessment (EPA, 2000). EPA concluded that "the Johnston Atoll radiological risk assessment conforms with the standard and uniform methods for the evaluation of site-specific risk" and that the exposure parameters used are reasonable and appropriate. Any of the values calculated for the three risk levels are consistent with EPA's policies. In determining a reasonable maximum exposure (RME), EPA rejected the homesteader scenario as overly conservative because of the seventy-year exposure duration, the remote location, and the lack of potable water and productive soils. The eco-tourist was considered insufficiently conservative, since the U.S. Fish and Wildlife Service planned to remain on the atoll. The other two scenarios are nearly identical and EPA selected the resident to represent the RME for an individual.

EPA recommended a cleanup level of 13.5 pCi/g, the historically used value, which equates to a 7.1×10^{-6} risk to a resident. EPA considers this value ALARA, since DTRA had previously achieved this level, and believes this lower level will help to account for the presence of other contaminants, such as dioxins, PCBs, and lead.

Remedial Actions

The island has undergone several previous cleanup attempts. In 1962, the debris from the destroyed rockets and some surface coral was loaded into landing craft and disposed of at sea. The less contaminated soil was dumped into the lagoon. No formal cleanup standard was used to determine the extent of the cleanup. Two years later the lagoon was dredged and most of the contaminated soil was incorporated into the island. At the end of November 2000, the U.S. Army announced that all of the 400,000 chemical weapons that had been stockpiled on Johnston Atoll had been destroyed. The disposal facility used for the project will be shut down and the islands turned over to the U.S. Fish & Wildlife Agency.

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CASE STUDY: LINDE SITE

Background

The Linde Site is located in the Town of Tonawanda, New York near Buffalo. From 1942 to 1946 (or 1948 according to some records), this site was used for separation of uranium ores from Colorado and the Congo under the Manhattan Engineering District (MED). Ores were processed in three phases: 1) uranium separation from the ore; 2) conversion of U_3O_8 to uranium dioxide; 3) conversion of UO_2 to UF_4. The principal contaminants of concern resulted from the first processing phase; residues from the other phases were recycled. Disposal of processing wastes from the Linde property also contaminated three other sites in Tonawanda. Radioactive contamination occurs in processing buildings, surface and subsurface soils, and in sediments in sumps and storm and sanitary sewers. Also, approximately 55 million gallons of waste effluent containing dissolved uranium dioxide were injected into the subsurface through seven wells during a three-year period. The Remedial Investigation (BNI, 1993) concluded that subsurface radioactive contamination probably occurs as minor amounts of immobile uranyl sulfates and carbonates precipitated in the underlying shale.

Cleanup Level Development

The Army Corps of Engineers became the lead regulatory agency for the Linde site in 1998 when Congress handed the Formerly Utilized Sites Remedial Action Program (FUSRAP) to the Corps. DOE had previously handled the cleanup effort and had issued a Proposed Plan in 1993, which called for a cleanup level of 60 pCi/g for uranium. The EPA has an advisory role at the site since it is not an NPL site; the state exercises Safe Drinking Water Act authority.

In accordance with the NCP requirement that selected remedies must comply with ARARs, the Corps reviewed the Uranium Mill Tailings Radiation Control Act (UMTRCA) for applicability. Standards in UMTRCA (40 CFR Part 192) are not considered applicable since the regulation only applies to specific sites designated in the Act. The Corps, however, determined that UMTRCA is relevant and appropriate to the Linde Site cleanup since the processing activities and radionuclides in the resulting wastes are similar to those at uranium mill sites. In a new Proposed Plan issued in March 1999, the Corps calculated new cleanup levels based on UMTRCA. Subpart B of 40 CFR 192 addresses cleanup of soil and buildings and sets standards for residual concentrations of Ra-226 in soil. Radium concentrations cannot exceed background by more than 5 pCi/g in the upper 15 cm of soil or 15 pCi/g in any 15 cm layer below the upper layer, averaged over an area of 100 m^2.

In addition to UMTRCA requirements, the Corps also developed cleanup levels for various risks and doses (USACE, 1999). That assessment used the RESRAD computer code (version 5.782) and considered the most likely future land use to be the site's current industrial/commercial use.

RESRAD-Calculated Estimates for the Commercial/Industrial Exposure Scenario to Meet Acceptable Dose and Risk Limits

	Residual Concentration (pCi/g)					
	10 mrem/yr		25 mrem/yr		10^{-4} risk	
Radionuclide	6-in. cover	No cover	6-in. cover	No cover	6-in. cover	No cover
Ra-226	37	**5.7**	92	14	25	6.1
Th-230	107	**16**	267	41	71	11
Th-232	23	**3.9**	58	9.8	16	2.8
U-total [(1)]	1,888	**629**	4,720	1,572	7,400	6,200

[(1)] Total uranium includes U-238, U-235, and U-234 at natural concentration ratios (1.0/0.05/1.0 respectively)

Future Industrial/Commercial Worker

RESRAD Parameter	Value	Units
Area of impacted zone	2,000	m^2
Thickness of impacted zone	3	m
Cover depth	0, 0.15	m
Inhalation rate	8,400	m^3/yr
Mass loading for inhalation	0.0001	g/m^3
Exposure duration	25	yr
Shielding factor, inhalation	0.4	-
Shielding factor, External gamma	0.7	-
Fraction of time indoors	0.2	-
Fraction of time outdoors	0.03	-
Soil ingestion rate	18.25	g/yr
Drinking water intake	0	L/yr

In response to public comments, the Corps redefined how cleanup levels were derived. Subsequent to the cleanup levels calculated for the radiological assessment, a new amendment to 10 CFR 40, Appendix A, Criterion 6(6) was promulgated, which addressed areas contaminated with radionuclides in addition to radium. This criterion states that post-remedial radioactive contamination, considering all radionuclides including radium, cannot result in a total effective dose equivalent (TEDE) to the average member of the critical group exceeding the benchmark dose after cleanup to the 40 CFR Part 192 standards for soils contaminated with radium only. The benchmark dose for surface cleanup was derived by dividing the 10 mrem/year (with no cover) by the 5.7 pCi/g of Ra-226 associated with that dose, and then multiplying the result by 5 pCi/g of Ra-226. This results in a benchmark dose of 8.8 mrem/year for surface cleanups. The 10-mrem values for Th-230 and total uranium were used to calculate allowable concentrations for those radionuclides. The same methodology was used to derive a benchmark dose for subsurface cleanup levels as well.

Allowable Residual Concentration Limit for Indicated Benchmark Dose (pCi/g)

Radionuclide	Surface Soil 8.8 mrem/yr	Subsurface Soil 4.1 mrem/yr
Ra-226	5.0	15
Th-230	14	44
U-total	554	3,021

This new method of deriving cleanup levels resulted in a more stringent cleanup for total uranium than was required in the Proposed Plan. Radionuclide concentrations remaining in soils averaged over 100 square meters must be below these levels. If more than one residual radionuclide is present in a 100 m^2 area, the sum-of-the-ratios methodology will be applied. The ROD also commits that no concentration (hotspots) of total uranium greater than 600 pCi/g above background will remain in site soils.

The ROD for the Linde site was signed in March 2000 by the Corps' Deputy Commanding General for Civil Works. The EPA Region II and State of New York (Department of Environmental Conservation and Department of Health), however, have refused to support the cleanup levels designated in the ROD. The agencies disagree with these levels for several reasons:

- Since the site will not be government-owned, only a residential-based assessment will protect against future changes in ownership.
- The current industrial/commercial use is not sufficiently protective of future uses.
- The cleanup level calculations exclude a groundwater pathway.
- The ALARA concept was not incorporated.
- The calculations are not consistent with NRC guidance.
- The calculations do not consider state guidance in Technical & Administrative Guidance Memorandum (TAGM) #4003, which limits exposure of maximally-exposed individuals to 10 mrem/year.

The Corps expects that its remedial actions will lower the average activity levels due to residual contamination to about 60 pCi/g for uranium and 5 pCi/g for radium. The State would accept this level of cleanup, which is the level originally presented in the 1993 Proposed Plan. The State plans to require a Radioactive Materials License for any future landowner if the residual radiation is greater than .05% by weight. EPA's position is that the cleanup level should be below 100 pCi/g, a level "consistent with cleanup levels at other CERCLA radiation sites."

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CASE STUDY: MARALINGA, AUSTRALIA

Background

Between 1955 and 1963, the United Kingdom conducted a series of nuclear weapons tests at Maralinga, including seven nuclear explosions called "major trials". The sites of these major trials no longer present any significant health risk, because all the radioactivity released in these explosions was either dispersed throughout the world or has sufficiently decayed since (ARPNSA, 2000). Plutonium contamination was spread locally as a fine dust, as small submillimeter-size particles, and as surface contamination on larger fragments by several hundred "minor trials". These consisted of radioactive materials exploded with conventional explosives, similar to the "safety shots" conducted at the Tonapah Test Range in Nevada.

Cleanup Level Development

The selected remedy involves removing 10 millimeters of soil from the areas of worst contamination and restricting access to 120 km^2 of land. The contaminated soil and debris is buried in trenches on-site under at least 5 meters of fill. Unknown amounts of contaminated debris in 21 pits will be vitrified in-situ. Cleanup criteria were set by using "conservative principals" and by estimating doses for "realistic scenarios" (ARPNSA, 2000). These include Aborigines living just outside the controlled areas and hunting inside them. The highest activity allowed outside of controlled areas is 20 - 35 kBq/m^2 (about 540 – 950 pCi/m^2) of Pu-239 depending on the particular site, which is calculated to produce a 5 mSv (500 mrem) annual dose.

Because it is relatively easy to detect in the field, Am-241 is used to indicate concentrations of Pu-239. Ratios of Pu-239/Am-241 vary from site to site and even from test to test at a single site. Therefore, Pu-239/Am-241 ratios have been determined for every cleanup area. Actual soil removals are delineated by activity levels for Am-241 that are specific for that particular area based on these ratios.

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CASE STUDY: NEVADA OPERATIONS

Background

The Nevada Test Site (NTS) is a U.S. Department of Energy (DOE) installation occupying approximately 1,350 square miles (882,332 acres) in southeastern Nye County, Nevada. The site is situated about 65 miles (105 km) northwest of Las Vegas, Nevada. The NTS is larger than the State of Rhode Island and site features include deserts, playas, and mountainous terrain. NTS was established in 1951 as the nation's proving ground for testing and development of nuclear weapons. Between 1951 and 1992, the federal government conducted just over 900 nuclear tests at the site; 100 of these tests were conducted above ground. The NTS is surrounded by thousands of additional acres withdrawn from the public domain for use as a protected wildlife refuge and for military gunnery ranges, creating an unpopulated land area comprising some 5,470 square miles.

Contaminated soils and groundwater at NTS resulted from years of nuclear testing and from various research and development projects and radioactive waste disposal programs. Because NTS was used for both atmospheric and underground nuclear testing, it is not possible to fully define the level of residual contamination that remains from the atmospheric testing program. Nevertheless, the number of curies generated from above ground testing was estimated at about 6 billion. Obviously, most of the fission products and other short-lived nuclides released from above ground testing were dispersed into the atmosphere and have since decayed away. Longer-lived radionuclides remain in the soil and physical structures at the site. The primary radioactive isotopes that remain from above ground testing include americium, plutonium, cobalt, cesium, strontium, and europium. Underground testing left an estimated source term of 300 million curies in the environmental media (soil and groundwater). In terms of absolute volume, the NTS contains more contaminated media than any other site in the DOE weapons complex.

NTS currently functions as a major low-level waste disposal facility for both onsite and off-site generated defense low-level waste, as well as for storage of transuranic (TRU) waste. Two active waste management sites are located on NTS. The Area 5 disposal site, established in 1961, is a traditional engineered shallow landfill disposal facility. The Area 3 disposal is comprised of four subsidence craters with areas between the craters excavated to make two oval-shaped landfill units. On average, each year NTS receives about 750,000 ft^3 of low-level waste from 17 approved waste generators.

In addition to contamination caused by the detonation of nuclear devices and waste disposal operations, a significant amount of contamination in the form of muck piles, ponds, sumps, injection wells, inactive tanks, leach fields, waste site, etc. are present on the NTS. These sites remain as by-products of nuclear testing, various research and development programs, and related support activities. These chemical and radioactive contaminated areas, which number in excess of 2,000, are referred to as industrial sites.

DOE also conducted numerous "safety" experiments at five locations on the Nellis Air Force Range and at two locations on the NTS. While these experiments did not produce nuclear explosions, they did create significant surface contamination. These tests were conducted to determine the behavior of nuclear weapons in conventional explosive

accident scenarios during handling, storage, and transport operations. Safety tests were also conducted to determine the size and distribution of plutonium particles that might result from fires and conventional explosive accidents involving nuclear weapons. Some of the experiments determined the biological uptake of plutonium by various species of animals and plants. According to DOE, the depth of contamination at these soil sites may vary, but probably is one foot or less at any given site. DOE has estimated that these safety experiments contaminated about 2,885 acres with plutonium at levels in excess of 40 pCi/g.

Cleanup levels have been developed for the safety experiment locations known as Clean Slate Sites 1, 2, and 3. These sites are located on the Tonapah Test Range in the northwestern part of the Nellis Air Force Range, 240 miles northwest of Las Vegas. These sites became contaminated as a result of Project Roller Coaster experiments conducted in May and June of 1963. These experiments, known as "safety shots", detonated simulated nuclear weapons using conventional explosives, primarily to study the dispersion of plutonium. Residual radioactive contamination in the surface soil consists of weapons grade plutonium, depleted uranium, and their radioactive decay products. Concentrations of these radioactive materials at the Clean Slate Sites range from background to more than 12,800 pCi/g. Extensive radioactive monitoring has shown that:

- Approximately 40% of the original source term was vaporized, released to the atmosphere, and distributed onto the soils in the vicinity at very low levels, not distinguishable above background.
- Only about 60% of the initial source term remained on the Clean Slates Sites and only a fraction of that in the surface soil.
- Surficial distribution of the radionuclides is not uniform. Soil samples taken only a few meters apart can differ in plutonium concentration by up to four orders of magnitude.
- Most of the highly contaminated material was found close to ground zero.
- Uranium and plutonium particles became attached to soil particles by melting of the sols and formed a silicate glass.
- Soil measurements demonstrate a mean Pu-239:Am-241 activity ratio of 12.7:1, from which a source term ratio of 14:1 is assumed.
- There has been no significant migration of radioactive materials by wind or surface water.
- In areas outside ground zero, contamination is usually limited to the upper 1 cm and 2 to 3 cm around the base of plants.
- Groundwater is more than 55 meters (180 ft.) below the ground surface and has not been impacted by radionuclides from Clean Slates experiments.

Development of Cleanup Levels

The regulatory process established for DOE's Environmental Management (EM) program at the NTS is detailed in the Federal Facility Agreement and Consent Order (FFACO) signed May 10, 1996 between the State of Nevada, Division of Environmental Protection, the Department of Energy, and the Department of Defense. In that agreement, DOE asserts its authority for conducting EM program activities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),

the Atomic Energy Act, and Executive Order 12580, "Superfund Implementation." In addition, both DOE and the State acknowledge that the FFACO is subject to other authorities including the Solid Waste Disposal Act, which includes both the RCRA and the Hazardous and Solid Waste Act; the Nevada Revised Statutes, including the Nevada Water Pollution Control Law, the Nevada Hazardous Waste Law, the Nevada Administrative Code, the Nevada Administrative Procedure Act; and all other applicable provisions of state and federal law. Furthermore, as part of the FFACO, the State of Nevada has stipulated that it retains all of its hazardous waste and clean water authorities and legal rights delegated by the EPA and under its own laws and regulations as well. As for DOE, the FFACO stipulates that the agency does not waive any claim of jurisdiction over matters that may be reserved to it by law, including the Atomic Energy Act.

Achieving closure of contaminated sites on the NTS is accomplished through a regulatory scheme defined under the FFACO. This agreement contains a detailed process or Corrective Action Strategy for planning, implementing, and completing environmental corrective actions. The process is designed to produce decisions for closure of contaminated sites. In general, site closure activities at the NTS are being pursued to address the following sub-project areas:

1. Off-Site Corrective Action Units (Project Shoal and the Central Nevada Test Area underground nuclear test sites):
2. Soils Media Corrective Action Units (including sites on the Tonopah Test Range and Nellis Air Force Range Complex):
3. Underground Test Areas (UGTA) Corrective Action Units (nuclear shot cavities):
4. Industrial Sites Corrective Action Units (includes Defense Special Weapons Agency sites and decontamination and decommissioning projects):

This report will focus on the Soils Media Corrective Action Units, where surface soil cleanup levels have been developed for radionuclides. Cleanup levels are established as "guideline concentrations" in the *Radiological Dose Assessment for Residual Radioactive Material in Soil at the Clean Slate Sites 1, 2, and 3, Tonapah Test Range* (DOE, 1997). Guideline concentrations are concentrations of radionuclides in soil that are acceptable for specific future uses without restrictions due to residual radioactivity. Guidelines for the Clean Slate sites comply with the basic dose limits in DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE, 1993). This Order establishes a radiation dose criterion of 100 mrem/year, which is the DOE primary standard dose rate for members of the public and which conforms to the ICRP's recommended dose rate for the public. This radiation dose is defined as the effective dose equivalent from external radiation plus the committed effective dose equivalent from internal radiation. Order 5400.5 further defines residual radioactivity as concentrations in excess of background averaged over an area of 100 m^2.

The dose assessment for the Clean Slate sites (DOE, 1997) reviewed several dose analyses previously performed in the area of the Nevada Test Site and compared the calculated guideline concentrations and their associated doses. Each of these analyses used different exposure scenarios and parameter values. Although these analyses varied in their assumptions, the general conclusion reached by the dose assessment was that an average activity level of 200 pCi/g would assure that the public dose limit of 100 mrem/year would be met. Four human exposure scenarios were evaluated by means of

an environmental pathway analysis performed by a forward calculation of the RESRAD computer code:

- rancher,
- farmer,
- rural resident, and
- industrial worker.

The two agricultural scenarios were considered implausible, but were included for completeness. Even so, the maximum CEDE calculated in the dose assessment, 47 mrem/year to a rancher, is less than half the basic dose limit. The rural residential and industrial worker scenarios were included because they were established as part of EPA's proposed cleanup regulations (EPA, 1996). This proposed regulation was not considered to be applicable to DOE operations, but were included for comparison. Calculated CEDE values for both these scenarios were less than the 15 mrem/year dose limit in the proposed EPA regulations.

Dose to Hypothetical Individuals Exposed to 200 pCi/g at the Clean Slate Sites (mrem/yr)

Scenario	Clean Slate 1	Clean Slate 2	Clean Slate 3
Rancher	47	47	46
Rancher child	23	23	22
Farmer	12	12	12
Rural Resident	13	13	13
Industrial Worker	4.5	4.4	4.4

Key Parameter Values for Exposure Scenarios

Parameter (units)	Rural Resident	Rancher	Farmer	Industrial Worker	Child
Exposure frequency (day/yr)	341	341	341	250	330
Inhalation (m^3/day)	20	22	22	12.6	12.3
Soil ingestion (mg/day)	120	131	129	50	24
Exposure time indoors (h/day)	14.9	9	9	8	18.4
Exposure time outdoors (h/day)	0.4	15	15	2	5.6
Shielding factor – indoor inhalation	0.4	1	1	0.4	0.4
Drinking water ingestion (L/day)	1.4	1.86	1.86	0.875	0.32
Leafy vegetable ingestion (g/day)	29.5	29.5	29.5	0	18.5
Vegetable/fruit/grain ingestion (g/day)	354	354	353	0	397
Milk ingestion (L/day)	0.61	0.61	0.61	0	1.18
Meat/Egg ingestion (g/day)	274	274	274	0	153

For the purpose of calculating guideline concentrations, the Pu-239/240:Am-241 ratio is assumed be 14:1 and the depth of contamination is assumed to be 5 cm.

Remediation requirements for the Clean Slate sites are:

1. average soil concentrations over any 100 m^2 area must not exceed 200 pCi/g,
2. plutonium hotspot concentrations averaged over an area of 25 m^2 or less must not exceed the guideline concentration by a factor of $(100/\text{hotspot area in meters})^{0.5}$ (DOE Order 5400.5, Chapter IV, Section 4.a.(1)),
3. reasonable efforts must be made to remove any source of radionuclides that exceeds 30 times the guideline levels, regardless of the average concentrations.

These cleanup guideline levels were applied to cleanup activities at the Clean Slate 1, 2, and 3, Double Tracks, and Project 57 sites. Several unresolved issues remain concerning discrepancies among the verification data.

Current Issues

Future uses for the NTS and surrounding ranges will require controlled access: nuclear test readiness, nuclear and high explosive testing, research and technology development, radioactive waste management, Yucca Mountain site characterization, spill testing, security and monitoring operations, etc. The U.S. Air Force is proposing an indefinite public land withdrawal for the TTR and the Nellis Range, and while only a small fraction of the 3.1 million acres that encompasses these ranges is contaminated, restricted public access to both ranges is maintained. In 2000, the Air Force obtained congressional approval for the renewal of the Nellis Range for another 25 years, as required under federal law (P.L. 99-606).

Ongoing negotiations between the State, the Department of Defense, and DOE indicate these soil contamination areas would be remediated to a dose receptor limit of 25 millirem. According to the NTS EIS [p.4-96], these areas total about 1,670 acres. State officials recognize that clean closure of these sites would be cost prohibitive and generally impractical given both current and expected land uses. Since complete cleanup of the NTS is not considered cost effective or practical in the near term, the federal government will be required to maintain a long-term surveillance and maintenance program at the site for the foreseeable future.

To address the question of "how clean is clean for what use", DOE is developing a comprehensive Resource Management Plan (RMP) for the NTS. Development of the RMP was undertaken as part of the recently completed NTS Site-Wide Environmental Impact Statement (EIS). DOE also made a legal commitment in the NTS-EIS ROD to complete the RMP. In part, the RMP will address site closure of contaminated sites, at least in terms of major land-use categories. The plan will likely address the designation of alternative land-use areas such as "land-use zones" set aside for nuclear testing, radioactive waste management, alternative non-defense uses, and open space.

NDEP is currently negotiating with the Department of Energy and the Department of Defense (specifically the U.S. Air Force) to develop acceptable remediation standards based on a 25-mrem annual dose to current, as well as future, land users. RESRAD (version 5.61) was used to model industrial worker and construction worker scenarios. Values for the remaining scenarios used spreadsheet calculations, which were considered a more appropriate method since the Air Force personnel exposures have such short duration. These calculations assumed a Pu-239:Am-241 activity ratio of 12.7:1. Besides

the different proposed scenarios, differences between these proposed cleanup levels and the guideline levels developed for the Clean Slate sites include the use of various dose limits and the use of dose conversion factors from ICRP Publications 68 and 72.

Proposed Plutonium Cleanup Levels for the Nellis Air Force Range

Scenario	Annual Dose limit (mrem/yr)	Cleanup Level (pCi/g)
Industrial worker	25 (1)	54,000
Bomb detonation (USAF)	100 (2)	125,000
Bomb detonation (civilian child)	10 (3)	27,000
Munitions removal	100 (2)	700,000
Aircraft crew	100 (2)	825,000
Ground troops	100 (2)	2,000
Ordinance EOD (USAF)	100 (2)	150,000
Ordinance EOD (civilian child)	10 (3)	27,000
Construction worker	25 (1)	68,000
Offsite resident	10 (3)	10,000

(1) NRC radiation dose limits for members of the public
(2) Dose limit to members of the public from Air Force operations; dose limit to occupational Air Force workers is 5,000 mrem/year
(3) NESHAP 10 mrem/year dose criteria

The Nevada Risk Assessment Management Program is conducting an independent sensitivity analysis of the RESRAD model input parameters. NDEP has requested information and documentation from DOE as follows:

- air sampling data;
- resolution of the differences in values between the KIWI, flyovers, and the segmented gate system for residual soil contamination;
- the proposed remediation value and subsequent dose rates;
- Air Force (Brooks) written acceptance of DOE proposed actions;
- Air Force written acknowledgment of liability for proposed residual contamination to be left in place; and
- RESRAD parameters with justification.

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CASE STUDY: MELTON VALLEY WATERSHED – OAK RIDGE RESERVATION

Background

Since it was created as the Clinton Engineer Works in 1942, Oak Ridge has been a major contributor to the U.S. nuclear weapons and energy programs. The Oak Ridge Reservation is a direct outgrowth of facilities built for the Manhattan Project, the Army's top-secret program to develop nuclear weapons. The Army Corps of Engineers constructed three distinctly separate facilities on approximately 54,000 acres. They were identified as X-10 (extracted plutonium from irradiated fuel; currently known as the Oak Ridge National Laboratory), Y-12 (produced enriched uranium and weapons components), and K-25 (gaseous diffusion facilities; recently renamed the East Tennessee Technology Park).

The Melton Valley area of the Oak Ridge Reservation is located south of the Oak Ridge National Laboratory and encompasses 1062 acres. Primary drainage flows from the watershed to the Clinch River via White Oak Creek. A significant portion of the valley is contaminated with the diverse legacy of radioactive and hazardous waste. Contaminants of concern cover the entire radionuclide spectrum. From a soils clean-up perspective, Cesium 137 and Cobalt 60 are regarded as the most significant radionuclides because of the high energy of gamma radiation that these radionuclides emit and their prevalence in the soil.

The Melton Valley watershed contains numerous radioactive and hazardous waste units. These units include low level waste (LLW) trenches and pits, active waste storage areas, construction landfills, underground and above grade tanks, impoundments, deep well injection (hydrofracture), buried pipelines, and contaminated buildings. From 1943 to 1986, the valley was used for radioactive waste disposal and as the Southern Regional burial ground, the valley received waste from across the complex from 1955 to 1963. Since 1986, the area has been used for active waste management. A brief description of these units is provided below:

<u>LLW</u> - Areas of Melton Valley were used as early as 1943 for the shallow land burial of low level waste (LLW). Early procedures used unlined trenches and auger holes for waste disposal. When filled, these areas were covered with soil, or in some cases, concrete. Burial in the unlined trenches and auger holes was discontinued in 1986.

<u>Active Waste</u> - A portion of the valley is being used for storage of active waste management materials. These materials include TRU waste, low-level waste, and spent nuclear fuel. The materials are stored in concrete silos, above grade storage units, buildings, tents, and above grade tanks.

<u>Landfills</u> - There are several construction debris landfills in Melton Valley. These areas received bulk material and equipment that was not considered LLW.

<u>Tanks</u> - All tanks in Melton Valley are constructed of steel. The newer tanks have cathodic protection to prevent corrosion and have secondary containment. Older tanks are single walled steel tanks. These tanks received concentrated liquid LLW for underground storage. Several of the tanks have already been remediated under early actions and the rest are scheduled for remediation under the Bethel Valley ROD.

Impoundments - Several impoundments are located in Melton Valley. These impoundments were used to store wastewater and for direct storage of liquid LLW. Most of these impoundments are unlined.
Deep Well Injection - The Hydrofracture facility pumped over 1.5 million curies of radioactive material (primarily Cesium-137 and Strontium 90) into hydraulically fractured rock 800-1000 feet deep. Monitoring wells that were installed during operation are scheduled to be plugged to prevent upward migration of highly contaminated liquids.

Cleanup Level Development

Cleanup levels are specified for each project in a ROD. A CERCLA-based approach, using the RESRAD computer code to generate health-protective levels, is followed. The State, DOE, and EPA work together through the Federal Facilities Agreement, signed in 1992, to develop these cleanup levels and to consistently apply ARARs. The Clean Water Act, State Water Quality Control legislation, Clean Air Act, DOE Orders, and to some extent the Drinking Water Act are examples of ARARs considered for some cleanup levels.

The fact that there will be a period of effective institutional controls is factored into the development of cleanup levels for short-lived radionuclides. At the end of a set period of time, levels will be below the established acceptable risk. Consideration is also given to in-growth of progeny in long-lived radionuclides to establish acceptable risk beyond an institutional control period.

The Melton Valley ROD remediation level approach incorporates a concept of aggregating risk over an entire exposure unit. DOE has proposed, and the State of Tennessee and EPA have agreed, to identify exposure units within the boundary of Melton Valley over which the receptor is assumed to roam. Remediation levels are the lesser of risk-based and dose-base values calculated with RESRAD using agreed upon risk exposure assumptions for an industrial worker scenario. This scenario assumes a worker spends eight hours onsite per day for 250 a year over 25 years, inhales wind-generated dirt (8 hours/day), is exposed to external irradiation (8 hours/day), and has dermal contact with radionuclides.

For the industrial areas of Melton Valley, two important assumptions are made in the exposure scenario with regard to time. The first calculation is based upon the receptor's risk aggregated over the exposure unit for an entire working year (2000 hours per year). The second calculation is based upon the receptor being exposed to a particular location or hotspot (200 hours per year). The remediation level (soil cleanup level) will be determined by the most protective of the two calculations. The risk calculations will consider both decay and ingrowth of daughter radionuclides over the exposure duration. Where multiple radionuclides are encountered, the sum of fractions will be applied to develop appropriate cleanup numbers for each contaminant. In addition, any source, regardless of depth, that regulators determine is causing a significant impact to groundwater or surface water will be remediated. This approach provides for risk-based decisions on soil cleanup that can be adapted to a variety of sites with differing land uses and contaminants. Cleanup levels for various individual radionuclides are presented in the following table.

Oak Ridge – Melton Valley Cleanup Levels

Principal Contaminant of Concern	Risk-based remediation concentration - 1E-4 ELCR (pCi/g)	Dose-based remediation concentration - 25 mrem/year (pCi/g)	Basis of Selection	Selected Cleanup Level (pCi/g)
Cesium-137	14	40	Risk	14
Cobalt-60	7.4	8.4	Risk	7.4
Curium-244	2300	950	Dose	950
Europium-154	11	18	Risk	11
Lead-210	450	270	Dose	270
Radium-226	Alternative Concentration			5
Radium-228	Alternative Concentration			5
Strontium-90	1200	3400	Risk	1200
Thorium-228	Alternative Concentration			5
Thorium-232	Alternative Concentration			5
Uranium-233	5100	5500	Risk	5100
Uranium-234	6500	6000	Dose	6000
Uranium-235	81	170	Risk	81
Uranium-238	310	850	Risk	310

Consideration must be given to the fact that under this approach, cleanup numbers for a particular radionuclide may vary from one exposure unit to the next, but aggregate risk levels will be the same or similar.

Issues associated with implementation of field remediation of soils using this approach will require more work between the State, EPA, and DOE. Work plans will have to contain information on the field techniques that will be used to verify that cleanup has been achieved without imposing significant delays in the remedial actions.

Subsequent CERCLA documents at Oak Ridge are adopting variations of this approach for remediation of radioactively contaminated soils.

Remedial Activities

The Melton Valley ROD was signed on September 21, 2000. The ROD requires approximately $164 million dollars of remediation over the next decade. The remediation of Melton Valley will involve a complex mix of protective caps, hydraulic isolation, D&D, and soils removal.

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CASE STUDY: SRL SEEPAGE BASINS - SAVANNAH RIVER SITE

Background

The Savannah River Site (SRS) is one of several government-owned, contractor-operated sites in the U.S. Department of Energy's (DOE) nuclear defense complex. Construction for the SRS began on February 1, 1951, and the first facility, the heavy water plant, began operating in August 1952. The first production reactor started operating in December 1953. SRS was constructed to produce basic materials used in nuclear weapons, primarily tritium and plutonium-239. Five reactors were built to produce these materials by irradiating target materials with neutrons. Support facilities, including two chemical separations facilities, a heavy water production plant, a nuclear fuel and target fabrication facility, and waste management facilities, were also built. SRS produced about 36 metric tons of plutonium from 1953 to 1988. All five reactors are now shut down due to declining defense requirements. However, until fresh supplies of tritium are available, recycling and reloading of tritium will continue.

The SRS is located in south central South Carolina and occupies an area of approximately 310 square miles in Aiken, Barnwell, and Allendale counties. A marked property line establishes the site's boundary to the north, south and east. The Savannah River forms the site's western boundary for approximately 35 miles along the South Carolina/Georgia border.

The SRL Seepage Basins Operable Unit (OU) is located in the northwestern portion of the SRS near the Savannah River Technology Center (SRTC) in the Administration and Management (A/M) Area of the Savannah River Site. The seepage basins received low-level radioactive liquid wastewater from 1954 to 1982. Four unlined basins comprise the SRL Seepage Basins. Basins 1 and 2 began operation in 1954, Basins 3 and 4 were added in 1958 and 1960, respectively. The basins are rectangular in shape and are connected by a series of sequential overflow channels designed to receive wastewater by overflow from Basin 1 to Basin 4. Wastewater entered the western end of Basin 1 via the 10-inch diameter vitrified clay process sewer line. Wastewater seldom reached Basin 4 because evaporation and infiltration in Basins 1 through 3 was high enough to maintain the level of wastewater in the basins below the overflow channel to Basin 4. Wastewater discharged to the basins included uranium, plutonium, cesium, strontium, thorium, radium, cobalt, americium, curium, ruthenium, alpha (unidentified), beta-gamma (unidentified) and tritium; tritium was the most abundant radionuclide discharged to the basins. Nitrate, sodium, chlorine, calcium, and nickel were the primary inorganic constituents discharged to the basins. Process knowledge suggests that no significant quantities of chlorinated organic compounds were discharged to the seepage basins. Subsequent to the termination of operations in 1982, weeds, grasses, brush, and trees became established in the basins. This vegetation underwent a volume reduction process by chipping, and was bagged and staged within the basins pending dispositioning consistent with the basin soils. This early action achieved the removal objective of limiting the spread of contamination due to foliage drop and wind dispersion.
The conceptual site model for the SRL Seepage Basins OU identified several pathways for potential exposure to constituents released from the unit. Mechanisms identified for constituents to reach receptors were ingestion of contaminated media, inhalation of airborne dust and/or volatile emissions, biotic uptake, dermal contact with contaminated

media, and external radiation dose. Four exposure pathways were identified in the CSM: airborne (volatiles and dust), biota (biotic uptake), surface soil (direct contact with excavated subsurface soil), and groundwater (leaching). Soil, surface water and sediment, and groundwater sample results were used to evaluate potential exposures and risks for each of these.

Cleanup Level Development

On December 21, 1989, SRS was included on the National Priorities List. This inclusion created a need to integrate the established RCRA Facilities Investigation (RFI)Program with the CERCLA requirements to provide for a focused environmental program. In accordance with Section 120 of CERCLA, 42 USC Section 9620, DOE negotiated a Federal Facility Agreement (FFA) with the United States Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (SCDHEC) to coordinate remedial activities at SRS as one comprehensive strategy, which fulfills these dual regulatory requirements. DOE functions as the lead agency for remedial activities at SRS, with concurrence by EPA Region IV and SCDHEC.

The SRL Seepage Basins OU was identified as a solid waste management unit requiring investigation in the Natural Resources Defense Council Consent Agreement. This decree required SRS to submit various documents, including a closure plan for the units. A closure plan proposing the installation of a RCRA cap was written and submitted in 1993 using procedural requirements applicable to RCRA closure plans. Revision 0 of the closure plan received a Notice of Deficiencies/Warning from SCDHEC and was revised and reissued. Revision 1 received considerable comment from public stakeholders. After consideration of comments, SCDHEC determined that a more comprehensive evaluation of the unit and closure alternatives was warranted. DOE and SCDHEC decided that the SRL Seepage Basins Operable Unit should be evaluated under the RCRA/CERCLA process, which considers remedial alternatives against the nine CERCLA criteria to select a remedy protective of human health and the environment.

As part of the investigation/assessment process for the SRL Seepage Basins Operable Unit, a Baseline Risk Assessment (BRA) was performed using data generated during the investigation phase. This evaluation identified the contaminants of concern (COCs) and the presence of Principal Threat Source Material (PTSM), and therefore provided the basis for remedial action. PTSM is defined as source material that is highly toxic and/or mobile at levels that pose a risk to human health greater than 1×10^{-3} (Industrial Worker Scenario) should exposure occur.

Remedial action objectives (RAOs) are established to identify the clean up objectives for a given waste unit. The RAO for the SRL Seepage Basins is to ensure the protection of human health and the environment. This will be achieved by eliminating (1) surficial soil exposure, (2) potential leachability to groundwater, and (3) to remove or treat all principal threat source material (PTSM). Remedial goal options (RGOs) are developed to achieve the remedial action objectives. RGOs are concentration goals for individual chemicals in specific media and land use combinations. They are designed to provide conservative, long-term targets for the selection and analysis of remedial alternatives. Human health RGOs estimate protective remedial levels for COCs based on risk to human receptors. In a similar manner, ecological RGOs are based on risks to ecological

receptors. Contaminant migration RGOs are based on risk from contaminants in soil leaching to groundwater above an MCL. Final remedial levels for the COCs, which will be selected by risk managers, are to be protective of human health and ecological receptors and comply with Federal and South Carolina applicable or relevant and appropriate requirements (ARARs).

Excess lifetime cancer risk (ELCR) was calculated for unit-related radionuclides using EPA exposure factors and slope factors from the Health Effects Assessment Summary Tables (HEAST). Total media risk or TMR (e.g., total carcinogenic risk for surface soil) was determined by summing the individual constituent risks within the particular media. This TMR value was then used to determine the need for remedial action. Since human health and PTSM COCs were identified at the SRL Seepage Basins, and the TMR for surface soils was 2 X 10^{-1} for the Industrial scenario, RGOs were then back-calculated for the respective risk levels (10^{-6}, 10^{-5}, 10^{-4} and 10^{-3} Industrial for PTSM). Based on risk-management decisions, remedial goals (RGs) were then determined from the RGOs.

Remediation Goals (RGs) for the SRLSB Soil

COC (Radionuclides)	Human-Health RG (1) (pCi/g)	PTSM RG (2) (pCi/g)
Actinium-228	0.07	70
Americium-241	8.08	8,080
Cesium-137	0.11	110
Cobalt-60	0.02	20
Curium-243/244	1.6	1,600
Lead-212	0.7	700
Neptunium-239	0.9	900
Plutonium-238	10.857	10,857
Plutonium-239/240	10.130	10,130
Radium-228	0.067	67
Strontium-90	57.130	57,130
Thorium-228	0.035	35
Thorium-230	85.38	85,380
Thorium-232	98.0	98,000
Uranium-233/234	71.0	71,000
Uranium-235	0.83	830
Uranium-238	3.1	3,100

(1) RG based on Human Health Industrial (1 X 10^{-6})
(2) RG based on PTSM criteria (1 X 10^{-3} ELCR, Industrial Worker Scenario

Selected Remedy

The preferred remedial response/technology was soil removal with off-SRS disposal and backfilling the basins with an earthen cover. Details are as follows:

- Estimated cost: $3,550,000.
- Estimated construction time to complete: 18 months.
- Excavation, removal and disposal of all principal threat source material (soil above 1×10^{-3} industrial risk) at a licensed off-SRS facility. Approximately 3207 m^3 of soil would be removed.
- Earthen cover placed over open basins and graded to provide a structural fill barrier (minimum of nine feet, measured from waste remaining in basin to ground surface). The cover would eliminate risk due to residual contamination left in place greater than 1×10^{-6} but less than PTSM levels.
- Institutional controls would remain in place and preclude residential development and disturbance of the cover.

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CASE STUDY: CHEMICAL PLANT AREA-WELDON SPRING SITE

Background

From 1941 to 1945, as part of the World War II defense effort, the U.S. Army produced explosives at the Weldon Spring Ordnance Works, a 17,000-acre facility in St. Charles County, Missouri, northwest of St. Louis. After the war, the government transferred ownership of some of this land to the State of Missouri and to the University of Missouri, with the Army retaining most of the remainder for use as a training area.

In 1955, the Army transferred 205 acres to the Atomic Energy Commission (AEC) for construction of the Weldon Spring Uranium Feed Materials Plant. From 1957 to 1966, the feed materials plant processed uranium ore concentrates and a small amount of thorium. Wastes generated during these operations were stored in four open air lagoons called the raffinate pits. From 1963 to 1969 the AEC disposed of uranium residues and a small amount of thorium residue in the Weldon Spring Quarry. Material placed in the quarry during this time includes uranium and radium-contaminated building rubble and soils from the demolition of a uranium ore processing facility in St. Louis. Other radioactive materials in the quarry included drummed wastes, uncontained wastes, and contaminated pieces of manufacturing equipment.

The feed materials plant was shut down in 1966, and in 1967 the AEC returned the facility to the Army for use as a defoliant production plant to be known as the Weldon Spring Chemical Plant. In 1968, the Army started removing equipment and decontaminating several buildings. However, the defoliant project was canceled in 1969 before any process equipment was installed. The Army retained responsibility for the land and facilities of the chemical plant, but the raffinate pits were transferred back to the AEC. By direction of the Office of Management and Budget, the U.S. Department of Energy (DOE) was to assume responsibility for custody and control of the site and in 1985 custody was transferred from the Army to the DOE. In 1985, the DOE proposed designating control and decontamination of the chemical plant, raffinate pits, and quarry as a major project to be called the Weldon Spring Site Remedial Action Project (WSSRAP). The quarry was placed on the EPA's National Priorities List (NPL) in July 1987; the chemical plant and raffinate pits were added in March 1989.

Cleanup Level Development

Cleanup at the Weldon Spring Site is being conducted in accordance with both CERCLA and the National Environmental Policy Act (NEPA). In addition, other standards and guidelines are considered applicable or relevant and appropriate. Non-specific radiological dose standards, such as the 100 mrem/year CEDE limit to the general public in DOE Order 5400.5, are considered applicable. EPA's NESHAPS restrict airborne emissions to an effective dose equivalent of 10 mrem/year. Missouri Radiation Regulations limit the maximum whole-body dose to an individual in uncontrolled areas to: 2 mrem/hour, 100 mrem in any 7 consecutive days, and 500 mrem in any year. The greatest dose at the site is associated with radium-226 because this radionuclide and its decay products account for most of the total dose at the site from both external gamma irradiation and inhalation of radon.

The Missouri Radiation Regulations provide for a 1 pCi/L limit for radon-222 and 10 pCi/L for radon-220, averaged quarterly, in areas without access restrictions. These standards compare with DOE Order 5400.5, which limits both radon-222 and radon-220 to 3 pCi/L, averaged annually, in uncontrolled areas

Although the EPA-promulgated standards in the Uranium Mill Tailings Remedial Action do not apply to the site, they are considered relevant and appropriate, since the material at the site is similar to mill tailings. DOE guidelines include the EPA standards for radium and establish similar standards for the thorium isotopes for soil in areas of unrestricted access. These radionuclides are not to exceed background concentrations by more than 5 pCi/g in the upper 15 cm (6 in.) of soil or 15 pCi/g in each 15-cm layer beneath the surface, averaged over an area of 100 m^2. Since the background concentration of these radionuclides in the vicinity of the site is 1.2 pCi/g, the surface and subsurface standards for radium and thorium are 6.2 pCi/g and 16.2 pCi/g respectively.

Uranium is the primary radioactive contaminant in soil at the site. Low levels of uranium-238 are widespread, mostly in the upper 6 inches (15 cm) of soil. No federal or state ARARs were identified for uranium in soil, so results of a site-specific risk assessment were used in conjunction with a preliminary ALARA analysis to develop site-specific cleanup criteria for uranium-238. The RESRAD computer code was used to evaluate a farmer scenario against pre-remedial concentration levels. Pathways included in this analysis were external gamma irradiation, inhalation, and ingestion of soil, groundwater, plants, meat, and milk. The Ash Pond area, a 10-acre site, was chosen for evaluation because of its relatively high radionuclide concentrations. The average of residual uranium concentrations was estimated, using kriging techniques, to be 190 pCi/g. From this average residual concentration, RESRAD calculated a 42 mrem/year dose to a hypothetical farmer, 60% of which is derived from external gamma irradiation. RESRAD was then used to calculate doses associated with four residual concentration levels of 120, 60, 30, and 15 pCi/g. Cleanup costs associated with these cleanup levels were also estimated. A cleanup criterion of 120 pCi/g (without clean backfill) was selected for uranium-238 because this level of residual concentration would result in a dose of about 25 mrem/year, which has been identified by the EPA as "an acceptable dose limit for managing uranium and thorium by-product material" (DOE, 1992). A site-specific ALARA goal of 30 pCi/g was chosen because field instruments are able to detect uranium-238 concentrations at that level, but a level of 15 pCi/g would require collection of soil samples for laboratory analysis at a much higher cost. This ALARA goal corresponds to an annual dose of 6.7 mrem.

An assessment of risks associated with the selected cleanup criteria was developed assuming the absence of access restrictions in the future. Potential future land users are considered a recreational visitor, wildlife area ranger, resident, and resident farmer. These scenarios are described as:

Recreational visitor:	20 site visits per year, 4 hours per visit, for 30 years
Ranger:	Works outdoors and in an on-site station 8 hours per day, 250 days per year, for 25 years
Resident:	Lives in a house on-site 24 hours per day, 350 days per year, for 30 years; ingests groundwater

Farmer:	Lives on a farm on-site 24 hours per day, 350 days per year, for 30 years; ingests groundwater and plants grown on contaminated soil.

For the purpose of developing soil cleanup criteria protective of human health, future residential land use is considered to represent the RME scenario. Exposure parameters applied to future use scenarios reflect current conditions, a conservative application since natural processes should decrease contaminant levels over time. The only exception to this generality is the ingrowth of Rn-222 from uranium, which would produce a peak concentration about 200,000 years in the future.

In order to determine potential carcinogenic risks from radiological exposures, radiation doses were first calculated using ICRP's dose conversion factors (DCFs). Radiological risks were calculated by multiplying the doses by specific risk factors to estimate the probability of cancer induction per unit dose. Three separate risk factors were used: 1) 3.5×10^{-4}/working-level month (WLM) for inhalation of Rn-222; 2) 1.2×10^{-4}/WLM for inhalation of Rn-220; 3) 6×10^{-7}/mrem for all other exposure routes.

The ALARA analysis conducted at the Weldon Spring site is very site-specific. "Applying the ALARA process at another site, with different contaminant conditions and likely exposure scenarios, would be expected to produce different results." (DOE, 1992) Application of the ALARA concept at the Weldon Spring site includes both a planning component and a field component. ALARA goals are first estimated for residual soil contamination across the site on the basis of hypothetical exposures. These target levels supported the implementation of ALARA in the field during excavation allowing additional contamination to be removed below the cleanup criteria determined in the planning phase. During the planning phase or Feasibility Study (DOE, 1992), information about the local radiological background levels was incorporated into the development of the cleanup criteria so that estimated exposures could be considered in the context of natural contaminant levels. For radionuclides, the risks associated with natural levels of radioactivity in area soils greatly exceed the upper limit of EPA's target range (10^{-4}). For a future resident or farmer, the background radiological risk is 3×10^{-3}, which is considered a more appropriate benchmark for radioactive contaminants. Therefore, the ALARA concept was applied to the radionuclides of concern to determine how far below current levels they could be reduced, considering technical practicability. Other key factors that were considered in performing an ALARA analysis may not necessarily be relevant at other sites. For example, concentrations and volumes of radionuclides in soil are relatively small, especially in comparison to the concentrations and volumes of other waste, particularly the raffinate pit sludge.

Weldon Spring Site - Estimated Radiological Risks Associated with Soil Cleanup Levels

Radionuclide/ Criterion	Soil Concentration (pCi/g)	Risk to Hypothetical Receptor		
		Recreational Visitor	Ranger	Resident
Ra-226				
Cleanup criteria	6.2	5E-05	8E-04	2E-02
ALARA goal	5.0	4E-05	6E-04	8E-03
Background	1.2	9E-06	2E-04	2E-03
Ra-228				
Cleanup criteria	6.2	2E-05	2E-04	1E-03
ALARA goal	5.0	1E-05	2E-04	8E-04
Background	1.2	3E-06	5E-05	2E-04
Th-230				
Cleanup criteria	6.2	3E-07	4E-06	8E-06
ALARA goal	5.0	2E-07	3E-06	6E-06
Background	1.2	6E-08	8E-07	2E-06
Th-232				
Cleanup criteria	6.2	2E-06	2E-05	4E-05
ALARA goal	5.0	1E-06	2E-05	3E-05
Background	1.2	3E-07	4E-06	7E-06
U-238				
Cleanup criteria	120	2E-05	2E-04	5E-04
ALARA goal	30	4E-06	5E-05	1E-04
Background	1.2	2E-07	3E-06	8E-06

Weldon Springs Site Cleanup Levels (pCi/g)

Radionuclide	Surface [c]		Subsurface [d]	
	Criteria	ALARA goals	Criteria	ALARA goals
Radium-226 [a,b]	6.2	5.0	16.2	5.0
Radium-228 [a,b]	6.2	5.0	16.2	5.0
Thorium-230 [a]	6.2	5.0	16.2	5.0
Thorium-232 [a]	6.2	5.0	16.2	5.0
Uranium-238	120	30	120	30

(a) If both Th-230 and Ra-226, or both Th-232 and Ra-228, are present and not in secular equilibrium, the cleanup criterion applies for the radionuclide with the higher concentration.
(b) At locations where both Ra-226 and Ra-228 are present, the cleanup criteria for both surface and subsurface soil applies to the sum of the concentrations of these two radionuclides.
(c) Surface soil values apply to contamination within the upper 15 cm (6 in.) of soil.
(d) Subsurface soil values apply to contamination in each 15 cm (6 in.) layer of soil more than 15 cm below the surface.

These cleanup standards trigger remedial actions and guide confirmation sampling decisions following remediation. Confirmation samples are collected from the upper 6 inches of soil and these surface soil samples are considered representative of the subsurface as well. Areas of the Site that are potentially contaminated or have been remediated are divided into confirmation units. These units are 2,000 m^2, a size approximately the same as the exposure units used in the risk assessment for a future residential lot. The mean of the samples across each confirmation unit is compared to the ALARA goals. The mean is used since average exposure is the guiding principle for the risk assessment and because there should be little spread in the data after remediation. A second decision rule evaluates "hotspots." The average radiological contaminant

concentration in each 100 m^2 area will be compared to the cleanup criteria according to the formula:

$$\text{Maximum concentration} = \text{cleanup criteria} \times (100/A)^{1/2}$$

where A is the area of the "hotspot" in square meters. In addition, a minimum "hot spot" size (25 m^2), uncertainty parameters, and minimum sample sizes are all established.

Remedial Action

A ROD for the management of the quarry bulk wastes was established in 1990 and the ROD for the remediation of the Chemical Plant Area in 1993. These RODs were developed by DOE in consultation with and with the concurrence of the EPA Region VII and the State of Missouri.

The mission of the project to remediate the Chemical Plant Area is to eliminate potential hazards to the public and environment and to make surplus real property available for other uses to the extent possible. The resulting remedy includes an onsite disposal cell, which has a 45-acre footprint. The scope of work includes dismantling 44 chemical plant buildings and structures and disposing of both radiologically and chemically contaminated structural materials and soils. It also includes disposing of as much material as possible from the raffinate pits, quarry, and nearby properties (including water, sludge, abandoned waste materials, and structural materials). As of the end of 2000, soil removal and placement into the on-site cell had been completed. A small section of the cell remains open to accept additional material, mostly from remaining on-site structures. The disposal cell cap should be completed during the 2001 construction season. Sampling of the confirmation units is nearly completed.

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Table 1 - Major U.S. Radiation Standards

Standard	Agency[a]	Numerical limits[b]
General public (10 CFR 20)	NRC	100 millirem/year
Uranium mill tailings (40 CFR 192; 10 CFR 40, App. A)	EPA; NRC	Ra-226/228: 5 pCi/g (surface) 15 pCi/g (subsurface) Rn-222: 20 pCi/m^2-sec
High-level waste operations (10 CFR 60)	NRC	100 millirem/year
Spent fuel, high-level waste, transuranic waste disposal (10 CFR 191)	EPA	All pathway: 15 millirem/year Groundwater: 4 millirem/year[c]
Low-level waste (10 CFR 61)	NRC	25 millirem/year
Drinking water (40 CFR 141.15 and 141.16)	EPA	Radium: 5 pCi / L Gross alpha: 15 pCi / L Beta/photon: 4 millirem/year[c]
Uranium fuel cycle (40 CFR 190)	EPA	25 millirem/year
Superfund (CERCLA) cleanup (40 CFR 300)	EPA	1 in 10,000 to 1 in 1,000,000 excess lifetime risk of getting cancer
Decommissioning (10 CFR 20)	NRC	25 millirem/year
Occupational standards (29 CFR 1910; 10 CFR 20; 10 CFR 835)	OSHA; NRC; DOE	5,000 millirem/year

[a] NRC = Nuclear Regulatory Commission
EPA = Environmental Protection Agency
OSHA = Occupational Safety and Health Administration
DOE = Department of Energy
[b] A picocurie (pCi) is a trillionth of a curie, a unit of radioactivity.
A millirem is a thousandth of a rem, a unit of dose.
[c] Radioactivity from human-made radionuclides in community drinking water systems.

Table 2 - Soil Cleanup Levels for Plutonium

Site	Scenario	Cleanup Level (pCi/g)	Date	Comments
Enewetak Atoll	Residential Agricultural Food-gathering Subsurface	40 80 160 400	*1973*	DOD-DNA/DOE
Fernald EMP	Park user (on-site) Resident farmer (off-site)	77 9	*1995*	DOE/EPA/OEPA; 10^{-6} risk
Ft. Dix, NJ		8	*1992*	USAF; BOMARC missile accident; 4 mrem/year
Hanford Reservation	Rural resident Commercial/Industrial	34 245	*1995*	WDOH; 15 mrem/year; used RESRAD ver. 5.7; considered guidance for interim actions only and will be updated
Johnston Atoll		13.5	*1988*	Soil Screening Level representing a 10 mrem/yr dose based on EPA draft guidance
	Fish & Wildlife researcher Resident EcoTourist Homesteader	2.1 – 210 1.9 – 190 38 – 3800 .32 – 32	*2000*	DOD-DTRA; 10^{-6} – 10^{-4} risk range; used RESRAD ver. 5.82
Rocky Flats:				
Cleanup Agreement	Office worker Open space Resident	1088 1429 252	*1996*	DOE/EPA Reg. VIII/CDPHE; 15 mrem/year; used RESRAD ver. 5.61
Oversight Panel	Resident rancher Industrial worker	35 90	*2000*	RAC; 15 mrem/year; used RESRAD ver. 5.82; reduced by sum-of-ratios to account for dose from associated americium
Preliminary Remediation Goals	Office worker Open space	10 17.5	*2000*	DOE/EPA/CDPHE; 10^{-6} risk
Tonapah Test Range	Resident rancher/farmer	200	*2000*	DOE; based on several independent studies showing that this activity level would result in < 100 mrem/yr to a rancher or farmer and <15 mrem/yr to a rural resident or industrial worker

CDPHE – Colorado Dept. of Public Health & Environment
EPA – U.S. Environmental Protection Agency
DNA – Defense Nuclear Agency
DOD – U.S. Department of Defense
DOE – U.S. Department of Energy
DTRA – Defense Threat Reduction Agency
OEPA – Ohio Environmental Protection Agency
RAC – Risk Assessment Corporation
USAF – U.S. Air Force
WDOH – Washington Department of Health

Table 3 - Soil Cleanup Levels for Uranium

Site	Scenario	Cleanup Level (pCi/g)	Date	Comments
Fernald EMP	Park user (on-site):		*1995*	EPA/DOE/OEPA; 10^{-6} risk; dependent on leachability (K_1)
	total U (K_1=325 L/kg)	82 ppm		
	total U (K_1=15 L/kg)	20 ppm		
	Resident farmer (off-site)			
	total U (K_1=325 L/kg)	50 ppm		
New Jersey	Unrestricted use:		*2000*	New Jersey Commission of Radiation Protection; represents 15 mrem/year TEDE in a 1-ft. thickness of soil at the surface with no cover
	U-234	62		
	U-235	29		
	U-238	54		
	Limited restricted use:			
	U-234	69		
	U-235	37		
	U-238	64		
	Restricted use:			
	U-234	81		
	U-235	62		
	U-238	82		
Hanford Reservation	Rural resident:		*1997*	WDOH; 15 mrem/year; used RESRAD ver. 5.61
	U-234	160		
	U-235	26		
	U-238	85		
	Commercial/Industrial			
	U-234	1200		
	U-235	100		
	U-238	420		
Linde Site	Industrial / commercial	600	*2000*	USACE; 10^{-5} risk; FUSRAP site
	Subsurface	3,021		
Rocky Flats:				
Cleanup Agreement	Industrial Use (U-234)	1627	*1996*	DOE/EPA Reg. VIII/CDPHE; 15 mrem/year; used RESRAD ver. 5.61;
	Industrial Use (U-235)	113		
	Industrial Use (U-238)	506		
	Open space (U-234)	1738		
	Open space (U-235)	135		
	Open space (U-238)	586		
	Resident (U-234)	307		
	Resident (U-235)	24		
	Resident (U-238)	103		
Oversight Panel	Resident rancher:		*2000*	RAC; 15 mrem/year; used RESRAD ver. 5.82
	-with groundwater	10		
	-without groundwater	80		

Preliminary Remediation Goals	Office worker (U-233)	68	*2000*	DOE/EPA Reg. VIII/CDPHE; 10^{-6} risk; uses Federal Regulatory Guide 13 slope factors
	Office worker (U-234)	69		
	Office worker (U-235+D)	0.8		
	Office worker (U-238+D)	3.8		
	Open space (U-233)	122		
	Open space (U-234)	123		
	Open space (U-235+D)	4.2		
	Open space (U-238+D)	17.8		
	Resident (U-233)	4.43		
	Resident (U-234)	4.86		
	Resident (U-235+D)	0.76		
	Resident (U-238+D)	0.33		

CDPHE – Colorado Dept. of Public Health & Environment
EPA – U.S. Environmental Protection Agency
DOE – U.S. Department of Energy
OEPA – Ohio Environmental Protection Agency
RAC – Risk Assessment Corporation
USASCE – U.S. Army Corps of Engineers
WDOH – Washington Department of Health

Table 4 – Comparison of Key Residential RESRAD Input Parameters

Parameter	Units	Hanford Site	Johnston Atoll	Clean Slate Sites, Nevada	Rocky Flats Cleanup Agreement	Rocky Flats Oversight Panel
Dose Limit [or risk range]	mrem/year	15	[10^{-4} – 10^{-6}]	100	15	15
RESRAD version		5.7	5.82	5.61	5.61	5.82
Exposure Pathways:						
1-External Gamma		Active	Active	Active	Active	Active
2-Inhalation		Active	Active	Active	Active	Active
3-Plant Ingestion		Active	Active	Active	Active	Active
4-Meat Ingestion		Active	Suppressed	Active	Suppressed	Active
5-Milk Ingestion		Active	Suppressed	Active	Suppressed	Active
6-Aquatic Foods		Active	Suppressed	Suppressed	Suppressed	Active
7-Drinking Water		Active	Suppressed	Active	Suppressed	Active
8-Soil Ingestion		Active	Active	Active	Active	Active
9-Radon		Suppressed	Active	Active	Suppressed	Suppressed
Plutonium form		Soluble	Insoluble	Soluble	Insoluble	Insoluble
Distribution Coefficients (K_d):						
Americium	cm^3/g	200	10,000	1900	76	2300*
Plutonium	cm^3/g	200	230,000	550	218	218*
Uranium	cm^3/g	25	50	35	50	218*
Area of Contaminated Zone	m^2	10,000	98,000	248,000	40,000	*
Thickness of Contaminated Zone	m	4.6	0.61	0.05	0.15	0.2
Inhalation Rate	m^3/yr	7300	8400	6820	7000	10800
Mass Loading (Inhalation)	g/m^3	0.0001	0.0002	.000015	.000026	.007*
Exposure Duration	yr	30	10	30	30	70
Inhalation Shielding Factor		0.4	1	1	1	1
External Gamma Shielding Factor		0.8	0.5	0.7	0.8	0.7
Indoor Time Factor		0.6	0.25	0.58	1	0.6
Outdoor Time Factor		0.2	0.75	0.0155	0	0.4
Wind Speed	m/s	--	9	--	--	4
Fruits, Vegetables, Grain	kg/yr	110	1	120.5	40.1	190
Leafy Vegetables	kg/yr	2.7	1	10	--	64
Soil Ingestion	g/yr	36.5	73	37.4	70	75
Drinking Water Intake	L/yr	730		444.6	--	730
Drinking/Household Water Fraction from Groundwater		1	--	1	--	1
Depth of Soil Mixing Layer	m	0.15	--	0.15	0.15	0.03

Parameter	Units	Hanford Site	Johnston Atoll	Clean Slate Sites, Nevada	Rocky Flats Cleanup Agreement	Rocky Flats Oversight Panel
GI Absorption Factor (f_1):						
Am-241			1E-3			5E-4
Pu-239			1E-3			5E-4
U-238+D			5E-2			2E-2
Ingestion Slope Factor:	Risk / pCi					
Am-241			3.28E-10			
Pu-239			3.16E-10			
U-238+D			6.20E-11			
Inhalation Slope Factor:	Risk / pCi					
Am-241			3.85E-8			
Pu-239			2.78E-8			
U-238+D			1.24E-8			
External Exposure:	Risk/yr per					
Am-241	pCi/g		4.59E-9			
Pu-239			1.26E-11			
U-238+D			5.25E-8			
Dose Conversion Factors:	mrem /					
(inhalation / ingestion)	pCi					
Am-241				4.40E-1 / 3.64E-3	4.44E-1 / 3.64E-3	1.55E-1 / 7.4E-4
Pu-239				4.29E-1 / 3.54E-3	3.08E-1 / 5.18E-5	5.9E-2 / 9.3E-4
U-234				1.32E-1 / 2.83E-4	1.32E-1 / 2.83E-4	3.5E-2 / 1.8E-4
U-235+D				1.23E-1 / 2.67E-4	1.23E-1 / 2.67E-1	3.1E-2 / 1.7E-4
U-238+D				1.18E-1 / 2.69E-4	1.18E-1 / 2.69E-4	3.0E-2 / 1.7E-4
Pathway Percentages:						
Inhalation		30%	5%	30%	93%	
Soil Ingestion		23%	87%	31%	6%	
Water		0%	0%	0%	0%	
Plant Ingestion		45%	0%	29%	1%	
Other		1%	8%	10%	0%	

* Derived probabilistically using distributions of data

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Revision 1- November 8, 2000

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
999 18TH STREET - SUITE 500
DENVER, CO 80202-2466
http://www.epa.gov/region08

Ref: 8EPR-F

Attachment 1

MEMORANDUM

TO: Whom it may concern

FROM: Tim Rehder, Rocky Flats Team Leader

SUBJECT: Radiation Risk and Radiation Dose, How Do They Relate?

During the long public debate that has surrounded the radiological soil action levels (RSALs) for Rocky Flats, questions have routinely come up on the issues of radiation dose and radiation; questions like what is a safe dose, what risk level does that dose equate to? Unfortunately, the answers to these questions are not always straight forward. The EPA Guidance Document "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," August 1997, says that a 15 mRem dose/yr is approximately equal to a risk of 3×10^{-4}. This is an over simplification that has lead to much of the confusion stakeholders, public officials and regulators have experienced on this issue. In fact, the level of risk associated with a given dose depends on a number of factors such as: 1) the method used to convert dose to risk, 2) the radionuclide of interest and 3) the route(s) of exposure.

Let's talk first about the methods used to calculate the risk posed by exposure to radioactive materials. There are basically two methods for doing so; 1) calculating the Effective Dose Equivalent (EDE) and then converting that dose into a risk number, or 2) calculating a risk using cancer Slope Factors.

The Dose Conversion Method

The oversight panel is familiar with the concept of dose assessment. It is an assessment performed to answer the question "how much dose will an individual receive when exposed to a specified amount of radioactive materials?" When we talk about dose we are generally referring to the effective dose equivalent (EDE), which is a unit of measure developed by the International Commission on Radiologic Protection (ICRP) to normalize radiation doses by considering the adverse effects on a total body basis for the purpose of regulation of occupational exposure. In an ideal system , the risk associated with receiving, for example, a 1,000 mRem dose from Plutonium is equal to the risk associated with receiving 1,000 mRem from Radium, Cesium or any other radionuclide. EDE is derived by multiplying a dose conversion factor (DCF) for a given radionuclide by the unit intake of exposure to that radionuclide (i.e. ingestion, inhalation or external exposure). The following factors are considered in the development of dose conversion factors for the various radionuclides:

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type of radiation
relative strength (or energy) of the radiation
different radionuclides will target different organs or tissues
different organs or tissues will exhibit different cancer induction rates.

A simple example that illustrates how dose is calculated is a man who breathes **20 m^3 per day** and lives year round at a location where the concentration in air of Plutonium is **0.1 pCi/m^3**. In this scenario the man is neither drinking contaminated water, eating contaminated foodstuffs, nor ingesting contaminated dirt. Assuming all the airborne Plutonium is respirable, and for this example using a DCF for inhalation of Pu of **0.308 mRem/pCi**, the equation would look like:

example 1

(365 days/year)(20 m^3/day) (0.1 pCi/m^3) (0.308 mRem/pCi) (30years) = **6750 mRem**
(days/yr)(breathing rate)(Pu conc. in air)(dose/unit exposure)(exposure duration)

Since different radionuclides have different DCFs, if we changed the radionuclide in the equation above, the resulting dose would be different. Similarly, different routes of exposure have different DCFs. If we considered ingestion rather than inhalation in the equation above, the resulting dose would be different.

Most health physicists don't calculate the risk that is associated with a given dose. They simply compare the dose to accepted national standards : e.g. 100 mRem/yr for public exposure or 5,000 mRem/yr for occupational exposure. However, risks can be calculated using a two-step method. The first step being the dose calculation as demonstrated in example 1 above. The next step is to convert the dose to a risk value using a **probability coefficient**. ICRP has developed probability coefficients that allow dose to be expressed in terms of risk. The 1990 Recommendations of the ICRP says the probability coefficient from fatal cancers, non-fatal cancers and severe hereditary effects is 7.3 x 10^{-2}/sievert (1 sievert = 100,000 mRem). This risk coefficient is based on low LET (Gamma) radiation (which is clearly not the case for plutonium) and considers all cancers. Using that coefficient, the next step in calculating risk is:

example 1 -step 2

(6750 mRem)(7.3 x 10^{-2}/sievert)(10^{-5}sievert/mrem) = 5 x 10^{-3}.
(total dose)(risk/unit dose)(Sievert to millirem conversion factor)

Slope Factor Method

A slope factor is similar to a dose conversion factor, but instead of assigning a unit dose for every unit of exposure (i.e. mRem/pCi) a unit of **RISK** is assigned for every unit of exposure (i.e.

probability of adverse effect/pCi). Using an inhalation slope factor for Plutonium of 2.78 x 10^{-8}/pCi we can go back to the above example and calculate a risk:

example 2

(365 days/year)(20 m^3/day)(0.1 pCi/m^3)(3.33 x 10^{-8}/pCi)(30 years) = 7.2 x 10^{-4}
(days/yr)(breathing rate)(Pu conc. in air)(slope factor)(exposure duration)

Note that this result is lower than the risk calculated in example 1 using the Dose Conversion Method. EPA believes that for internal exposures to alpha and beta emitters, the Slope Factor Method produces a more reliable estimate of risk.

EPA has calculated slope factors for most of the radionuclides and just as different radionuclides have different DCFs, different radionuclides generally have different slope factors. The slope factors also vary depending on route of exposure. Therefore, risk associated with inhaling 1,000 pCi of Uranium is different from that of inhaling 1,000 pCi of Cesium. Also the risk associated with inhaling 1,000 pCi of Radium is different from that of ingesting 1,000 pCi of Radium via drinking water.

Summary

There are two methods for calculating the risk associated with radiation exposure:

1) The Dose Conversion Method where a dose is calculated by multiplying a dose conversion factor (expressed in terms of unitdose/unit intake) for a given radionuclide by the total intake of exposure to that radionuclide (i.e. ingestion, inhalation or external exposure). The dose is multiplied by a probability coefficient to arrive at a risk value.

2) The Slope Factor Method where risk is calculated directly by assigning a unit of **RISK** for every unit of exposure (i.e. probability of adverse effect/pCi), and multiplying that by the total exposure. This method is basically the same method that EPA uses to calculate the risks associated with non-radioactive carcinogens.

EPA believes that the Dose Conversion Method is fine for calculating the risks of exposure to low LET radiation (i.e. gamma radiation), but does not work well for internal exposure to alpha and beta emitting radionuclides. In the case of internal exposure, the Dose Conversion Method generally overestimates the risk as seen in the two example calculations above.

The risk associated with 15 mrem/year, as stated in recent EPA guidance documents is based on the ICRP risk value of .073/Sv for external low LET radiation. All external low LET radiation can use this value. (A new EPA calculated value is closer to .08/Sv) The the calculation for deriving the 3 x 10^{-4} number is as follows:

$$(15\ \text{mRem/yr})(30\ \text{yrs})(7.3 \times 10^{-2}/\text{sievert})(10^{-5}\text{sievert/mrem}) = 3 \times 10^{-4}$$

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RSALs trigger cleanup actions

CLEANUP ACTIONS

- Each Individual Hazardous Substance Site or Pot
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- RSAL represents minimum cleanup case – some
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- Cleanup may be more extensive than that mandat
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- Surface water protection and stewardship require
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- Major IHSSs remaining include 903 Pad, Industr

SW protection considered in IHSS remedies

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Surface water management plan incorporates pond management, Actinide migration, soil erosion modeling, water balance, endangered species, etc.
Initial development during 2001

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- Is both a factor considered up front in the alternatives anal
- A broad set of considerations after the current phase of cle
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Between RSALs, Water Quality, Cleanup and Stewardship

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[redacted]

RFCA Stakeholder Focus Group
Attachment E

Title:	Radionuclide Soil Action Level Regulatory Analysis, Revision 2
Date:	January 24, 2001
Author:	Tim Rehder U.S. Environmental Protection Agency, Region VIII
Phone Number:	(303) 312-6293
Email Address:	rehder.timothy@epa.gov

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RFCA Stakeholder Focus Group
Attachment E

Attachment 1

ADMIN RECORD

RFCA Stakeholder Focus Group
Attachment E

Attachment 2

RADIONUCLIDE SOIL ACTION LEVEL REGULATORY ANALYSIS

PURPOSE

The Department of Energy (DOE), the Environmental Protection Agency (EPA) and the Colorado Department of Public Health and the Environment (CDPHE) are currently reevaluating the Radionuclide Soil Action levels (RSALs) that will govern much of the cleanup at Rocky Flats. Among the reasons for the reevaluation are that the draft EPA Radiation Sites Cleanup Rule that was used as a basis for the current RSALs is defunct and DOE, EPA and CDPHE are also considering the recommendations of the Radionuclide Soil Action Level Oversight Panel regarding its review of the RSALs.

This paper discusses relevant regulatory and guidance developments and makes a proposal as to what should form the basis of a new RSAL. This analysis is specific to the Rocky Flats Environmental Technology Site and The Rocky Flats Cleanup Agreement (RFCA), signed by DOE, CDPHE and EPA in 1996, and is not intended to represent any agency's positions with respect to other sites or other cleanup agreements.

In many instances this paper summarizes or paraphrases specific RFCA or regulatory language, to (hopefully) improve readability. The interested reader should refer to the cited authority for the specific text.

BACKGROUND

In October of 1996 DOE, EPA and CDPHE established an action level for radionuclide contamination in soils at Rocky Flats[b]. In short, An action level is a numeric level that, when exceeded, triggers an evaluation, remedial action, and/or management action. The radionuclide soil action level (RSAL) is expressed in terms of the amount of radioactivity per unit mass of soil; specifically picocuries/gram (pCi/g). Having an RSAL that is protective of human health is a key element in planning and executing the overall cleanup of Rocky Flats.

When developing the current RSAL in 1996 DOE, EPA and CDPHE used the draft EPA Radiation Site Cleanup Regulation, 40 CFR 196, as the basis for the action level. At that time, EPA had only announced its intent to propose this regulation; it had not been finalized. However, since all three parties anticipated that it would be finalized and that there was nothing else in existence resembling a national standard for radiation cleanup, DOE, EPA and CDPHE believed the draft regulation was a reasonable basis for an RSAL.

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[b] **See, "Action Levels for Radionuclides in Soils for the Rocky Flats Cleanup Agreement", Final 10/31/1996**

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40 CFR 196 stated that a radioactively contaminated site should be cleaned up such that any remaining contamination would result in a radiation dose to a member of the public no greater than 15 millirem/year (mRem/yr). The draft rule went on to say that if institutional controls (i.e. legal controls that restricted Site access) were utilized to meet the 15 mRem/yr limit, the Site must, at a minimum, be cleaned up to levels that ensure individuals do not receive doses greater than 85 mRem/yr in the event the institutional controls failed (e.g. a property zoned for industrial use is later zoned for residential use).

To determine what soil action level would meet the 15/85 mRem/yr requirements of the draft rule, DOE, EPA and CDPHE used the generally accepted software program called RESRAD to calculate the amount of radioactivity in the soil that would result in a 15 mRem/yr or 85 mRem/yr dose to a future site user. In order to make that calculation, assumptions were made as to how the land will be used in the future. The assumption as to the future use of a site is one of the most important factors in assessing the risk posed by a contaminated site because a person who lives on a contaminated site will have a much higher dose than a person who occasionally visits the site. RFCA envisioned that future use of Rocky Flats would consist of commercial/light industrial activity in the southern portion of the 400-acre Industrial Area that lies at the center of the Rocky Flats property and open space/recreational activity in the surrounding Buffer Zone. Using these land-use assumptions as a guide, the parties calculated the amount of contamination that would result in a 15 mRem/yr dose to an office worker in a commercial setting and a recreational open space user. Since these two future use assumptions were predicated on the idea that legal controls would be put in place precluding other types of land use, the parties had to satisfy the second part of the draft EPA rule: that in the event those legal controls fail, future site users do not receive a dose in excess of 85 mRem/yr. It was assumed that if there were no restrictions on the use of Rocky Flats, a subdivision similar to Rock Creek would be constructed. So the parties calculated the level of contamination that would equate to an 85 mRem/yr dose to a suburban resident.

The calculated RSALs for these various scenarios are given below:

Scenario	Specific Activity Pu-239[i]
15 mRem/yr Dose to Office Worker	562 pCi/g
15 mRem/yr Dose to Open Space User	**4,145 pCi/g**
85 mRem/yr Dose to Suburban Resident	**651 pCi/g**

To set an RSAL for the Industrial Area, the parties compared the office worker at 15 mRem/yr to the hypothetical future suburban resident at 85 mRem/yr, and chose the most conservative value. Similarly, for the Buffer Zone RSAL, the open space user at 15 mRem/yr was compared to the hypothetical future suburban resident at 85 mRem/yr. This is how the current RSALs of 562 pCi/g Pu-239 in the Industrial Area and 651 pCi/g

[i] The specific activity given is a sum-of-the-ratios number that assumes Am-241 is present and the ratio of Am-241 to Pu-239 is 0.18.

Pu-239 in the Buffer Zone were chosen.

DOE, EPA and CDPHE also established a lower tier of RSALs that would trigger a different type of action than the "Tier 1 RSALs" discussed above. When contaminants are found to exceed the Tier 1 action level, it will generally trigger an action such as removal or stabilization in place. Exceeding the Tier 2 value would generally trigger a less aggressive action which may include "hotspot" removal, capping or access restrictions. The Tier 2 RSAL for Pu-239 is based on a 15 mRem/yr dose to a suburban resident and comes out to 115 pCi/g.

CHANGES IN THE REGULATORY LANDSCAPE

Introduction

The EPA Radiation Sites Cleanup Regulation was never finalized, and has been officially dropped from consideration. In the meantime, another national regulation on radiation cleanup was finalized as well as some EPA policy documents on the subject. These developments called the regulatory basis for the current RSALs into question.

The RFCA parties as part of this review are considering two principal regulatory authorities as the basis for revised RSALs. These are the NRC Decommissioning Rule and the guidance and policy promulgated by the Environmental Protection Agency to implement the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA.) This paper reviews these sources at some length. For the purposes of setting an RSAL, these sources can at times be ambiguous. Both of these sources address action levels – the level of contamination that triggers a remedial action – and cleanup levels, which is the level of contamination remaining after an action has been taken. The specific charge of this review is to consider changes to RSALs, but any discussion of RSALs must also be accompanied by discussion on how ultimate cleanup levels will be determined. Both sources of new regulatory guidance address action levels and cleanup levels simultaneously.

The NRC Rule

In 1997, the NRC promulgated a cleanup regulation (commonly referred to as the Decommissioning Rule)[c] which governs the cleanup of facilities that are licensed by the NRC, or by States that have had that authority delegated to them. The NRC cleanup regulation states that a site will be considered acceptable for unrestricted use if residual radioactivity, distinguishable from background, results in a dose to the average member of the critical group[ii] no greater than 25 mRem/yr, and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). The rule goes on to

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[c] **See, 10 CFR 20, subpart E.**

[ii] The term "critical group" is defined in CFR 20.1003. It means the group of individuals reasonably expected to receive the greatest exposure to residual activity for any applicable set of circumstances.

say a site will be considered for license termination under restricted conditions if:

- Residual levels associated with restricted conditions are ALARA.

- The licensee has made provisions for legally enforceable institutional controls.

- The licensee has provided financial assurance for control and maintenance of the site.

- The licensee has prepared a "License Termination Plan" and has solicited public comment on that plan.

- Residual radioactivity at the site has been reduced so that if institutional controls were no longer in effect, members of the public will not receive a dose greater than 100 mRem/yr or, under certain circumstances, 500 mRem/yr.

The NRC does not have regulatory authority over a DOE facility such as Rocky Flats so the NRC rule is not directly applicable to Rocky Flats. However, the State of Colorado has adopted the NRC rule as a State regulation and while the rule is not applicable to Rocky Flats the State has identified the rule as relevant and appropriate[d]; and therefore, the substantive provisions should be used to govern the cleanup of the site. EPA and DOE agree.

Here's how EPA, CDPHE and DOE interpret the decommissioning rule, and intend to apply the standards in the rule based upon the significant factors present at Rocky Flats:

> Cleanup to levels that allow for unrestricted use are generally preferred to cleanups that result in restricted use. (Please note that at Rocky Flats, use restrictions may nonetheless be required for purposes other than limiting dose.) The rule does not explicitly require cleanup to unrestricted use, but the RFCA parties believe that an analysis of actions that would be needed to achieve unrestricted use is required.
>
> To be acceptable for unrestricted use, the residual radioactivity levels must be "as low as reasonably achievable ("ALARA")," AND in any case may not exceed 25 mRem/yr. Put another way, if it is reasonable to achieve a level of residual contamination that results in a lower does than 25 millirems/**yr**, then the rule requires the additional cleanup action.
>
> A site may be cleaned up to less stringent levels that do not allow for unrestricted use only if the required analysis of actions to achieve unrestricted use demonstrates either (1) that the additional cleanup necessary to remove residual

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[d] **A discussion of CERCLA's Applicable or Relevant and Appropriate Requirements is contained in paper by Dan Miller, Colorado Attorney General's Office, "Response to questions presented at 11/8/00 meeting", dated November 16, 2000. Available online at** www.rfets.gov, **under Focus Group.**

radioactive materials to achieve a dose that does not exceed 25 millirems per year (assuming unrestricted use) would cause net public or environmental harm, or (2) that the residual levels of contamination associated with restricted use are ALARA.

If a site is cleaned up to restricted use levels, residual contamination must be ALARA AND in no case may exceed 25 millirems per year, assuming the institutional controls are in place, AND may not exceed 100 millirems per year, assuming the institutional controls fail.

The NRC rule does provide that alternative decommissioning criteria (i.e., it allows establishment of a number different from 25 mRem/year) may be established for "difficult sites with unique decommissioning problems". Alternative criteria are allowed only in the following circumstances:

- Residual contamination is reduced to levels that are ALARA.
- The person seeking the alternative criteria has demonstrated that it is unlikely the TEDE to the average member of the critical group would exceed 100 mRem/yr; and
- Durable, enforceable institutional controls have been imposed to minimize exposures.

It is important again to emphasize the difference between a cleanup level as discussed in the NRC (and state) rule and the soil action level that is being developed by the RFCA parties. Action levels are the levels of contamination that trigger a remedial action and cleanup levels are the levels of contamination remaining after an action has been taken. In order to comply with the NRC rule as an ARAR, an analysis would be required using the ALARA concept to determine whether cleanup to unrestricted levels or to levels approaching unrestricted use is reasonably achievable for a particular remedial action.

CERCLA Guidance

While EPA agrees that the Decommissioning Rule is relevant and appropriate to the cleanup at Rocky Flats, it believes that the dose limits in the rule may not, in some circumstances, be sufficiently protective of human health. This concern is discussed in the EPA Guidance Document "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination," August 1997. This document makes the following points relevant to the RSAL debate at Rocky Flats:

> Cleanup actions at Superfund sites (such as Rocky Flats) must be protective of human health and the environment and comply with applicable or relevant and appropriate requirements (ARARs).
>
> EPA generally defines "protective of human health" as a level that represents an

excess cancer risk to an individual in the range of 10^{-4} to 10^{-6} (1 in 10,000 to 1 in 1,000,000)

Cancer risks for radioactive contamination should generally be estimated using the slope factor methodology put forth in the EPA risk assessment manual.[iii] **(Please see attached memo on Radiation Risk and Dose for more information on the issues of slope factors and converting dose to risk.)**

EPA has determined that the dose limits in the NRC rule are generally not protective of human health. *The word "generally" is important here because each radionuclide has a different cancer slope factor so for some radionuclides the lifetime cancer risk associated with a 25 mRem/yr dose will be within the acceptable risk range, but for most radionuclides the risk associated with a 25 mRem/yr dose is outside the risk range.*

The NRC Rule must be met (or waived) at sites where it has been determined to be applicable or relevant and appropriate. Cleanup at these sites will typically have to be more stringent than required by the NRC dose limits. *The word "typically" is used for the same reason the word "generally was used in the preceding paragraph.*

If a dose assessment is conducted at the site, *as was done at Rocky Flats in setting the current RSALs*, 15 mRem/yr should generally be the maximum dose limit for humans. This dose limit equates to approximately 3×10^{-4} (3 in 10,000) lifetime risk. **(Please see attachment 1 for discussion of how the value 3×10^{-4} was calculated)**

Despite these concerns, EPA expects that NRC's implementation of the decommissioning rule will result in cleanups within the Superfund risk range at the vast majority of NRC regulated sites.

WHERE WITHIN THE RISK RANGE (Should a Cleanup Level Fall)?

There is a lot of room for discussion when a range covers two orders of magnitude as the acceptable risk range does. EPA regulations and policies indicate that cleanups which

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[iii] U.S. EPA, "Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final," EPA/540/1-89/002, December 1989. U.S. EPA, "Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals", EPA/540/R-92/003, December 1991.

result in site risks being reduced to levels anywhere within the range are acceptable. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) says the 10^{-6} risk level will be used as the point of departure for determining remediation goals for alternatives when ARARs are not available. The EPA OSWER Directive 9355.0-30, Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions, states that where the cumulative carcinogenic site risk to an individual based on the reasonable maximum exposure for both current and future land use is less than 10^{-4} and the non-carcinogenic hazard quotient is less than 1, action is generally not warranted unless there are adverse environmental impacts. This indicates that cleanup that reduces site risks to a level of 10^{-4} is perfectly acceptable. On the other hand, the same directive says once a decision has been made to take an action, the Agency has expressed a preference for cleanups achieving the more protective end of the range (i.e. 10^{-6}). In other words, if you are conducting an action to address a site risk greater than 10^{-4}, explore options for reducing the risk well beyond 10^{-4}. This idea is consistent with the concept of "As Low As Reasonably Achievable" (ALARA) which says that all reasonable efforts should be made to reduce potential exposure to radiation even if the regulatory safety limit is already being met.

When choosing a remedy and the risk level that remedy will achieve, EPA considers the CERCLA balancing criteria: (short-term effectiveness; long-term effectiveness and permanence; reduction of toxicity, mobility or volume through treatment; implementability; and cost), and the modifying criteria (community acceptance; and state acceptance)[e]. Obviously, cost and implementability are two factors that generally tend to push remedies toward the less stringent end of the risk range. The effect of the other factors may change from one case to another.

LAND USE AND INSTITUTIONAL CONTROLS

As discussed previously, the assumptions made as to how Rocky Flats will be used in the future are very important considerations in the calculation of an RSAL. The current RSALs were developed under the assumption that the southern portion of the Industrial Area would see commercial reuse while the surrounding Buffer Zone supported open space recreation. When DOE, EPA and CDPHE were negotiating RFCA back in 1995, these two future use scenarios seemed the most likely. At that time, there was a significant level of support in the surrounding communities for these two scenarios. So the parties wrote them into the agreement. The Agencies, in drafting the RFCA, also designated certain parts of the Industrial Area as "restricted open space," although the Agreement doesn't really discuss the implications of that designation. Now that Senator Allard and Congressman Udall have introduced legislation that would turn Rocky Flats into a wildlife refuge, it appears a wildlife refuge worker may be the person most directly impacted by residual contamination at Rocky Flats. If the future land use assumptions change, it would probably require a revision of the RFCA.

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[e] See, 40 CFR 300.430(e).

Making decisions on the degree of cleanup based upon the anticipated future land use is consistent with EPA regulations and policy. The preamble to the National Contingency Plan (NCP)[f] states that the EPA will consider future land use as residential in many cases. In general, residential areas should be assumed to remain residential; and undeveloped areas can be assumed to be residential in the future unless the sites are in areas where residential land use is unreasonable. The NCP goes on to say "the assumption of future residential land use may not be justifiable if the probability that the site will support residential use in the future is small." The EPA guidance document "Land Use in the CERCLA Remedy Selection Process," May 25, 1995, says that in general, objectives should be developed that would achieve cleanup levels associated with the reasonably anticipated future land use over as much of the site as possible. This guidance was written, at least partly, in response to criticism that EPA was too often assuming that future use of a contaminated site would be residential. Many contaminated sites being addressed in the Superfund program were industrial sites in large industrial areas that had little potential for residential redevelopment. So it was often argued that it was not cost effective for those sites to be cleaned up to a degree that would support residential use.

The NRC Decommissioning Rule does not discuss developing a cleanup level consistent with the anticipated future land use in the same way that EPA guidance does. However, the definition of the average member of the "critical group", to which the dose rate standard applies, refers to the "applicable set of circumstances" that leads to the dose. Such circumstances include the anticipated future land use. The Preamble to the Decommissioning Rule indicates that a rural farmer future use scenario could be an "applicable set of circumstances" to calculate unrestricted use levels for an average member of the critical group in an unrestricted use scenario. The Rule says cleanup levels that allow unrestricted use are generally preferable to levels that require restricted use. DOE agrees that unrestricted use is preferable, but believes the clear intent of the rule to allow restricted use must be acknowledged and those provisions be implemented as appropriate.

If the amount of residual contamination at a site precludes unrestricted use in the future, institutional controls (legal controls) must be put in place to assure that the anticipated land use doesn't change to an inappropriate one (e.g. residential development of property slated to be industrial). When RFCA was signed, DOE, EPA and CDPHE assumed that controls would be utilized to limit future activities on site to commercial reuse of the industrial area and recreational use of the Buffer Zone. Continued Federal ownership was one of the controls contemplated for making that assurance. Designation as a National Wildlife Refuge would assure Federal Ownership into the foreseeable future and would effectively limit the type of activities that could occur on site.

The draft EPA Radiation Sites Cleanup rule anticipated the potential failure of institutional controls when it said if institutional controls were utilized to meet the 15 mRem/yr limit, the site must be cleaned up to levels that ensure individuals are not

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[f] **Suggest putting in citation.**

exposed to doses greater than 85 mRem/yr in the event of institutional control failure. The Decommissioning Rule addresses the possible failure of institutional controls in a manner similar to the draft EPA rule. It says that a site will be considered for license termination under restricted conditions if, in addition to other conditions, residual radioactivity at the site has been reduced so that if institutional controls were no longer in effect, members of the public will not receive a dose greater than 100 mRem/yr or, under certain circumstances, 500 mRem/yr. The anticipation of failure is not required under the Superfund law or any of pa's policy documents. Instead, the possibility that institutional controls can fail is addressed through the requirement that five year reviews be conducted at any site where contamination is left at levels that don't allow for unrestricted use. Such reviews should analyze the implementation and effectiveness of institutional controls with the same degree of care as other parts of the remedy. EPA also believes emphasis must be placed on starting out with a good set of controls as discussed in the new guidance "Institutional Controls: A Site Manager's Guide to Identifying, Evaluating and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups," EPA, September 2000.

It should be noted that neither DOE, CDPHE nor EPA currently envision a cleanup at Rocky Flats that would result in totally unrestricted use of the entire site. Even if cleanup of contaminated soil could be performed to a level that would allow for unrestricted use of the 6,000 plus acres, certain features would remain that would mandate institutional controls. These features include: municipal waste landfills that will be capped and left in place, a cap over the former solar evaporation ponds, at least three passive ground water treatment systems, contaminated ground water plumes and some number of detention ponds or other engineered controls for surface water.

AS LOW AS REASONABLY ACHIEVABLE (ALARA)[iv]

The concept of ALARA has been around for many years in the worlds of nuclear power and nuclear weapons. Until recently it was primarily applied in the context of worker protection. It was employed in the planning of work and, as the name would imply, was an attempt to reduce radiation exposure as much as possible, considering factors such as the specific circumstances necessitating the exposure and the resources available. An example of the ALARA concept would be a nuclear power plant worker who needs to complete a task in an area near the fuel rod assembly. An analysis of the situation could determine that given the level of radioactivity measured in the area and the length of time necessary for the worker to complete the task, the dose to the worker from performing the task would be well below the occupational limit. The ALARA analysis would ask the question "what additional steps can be taken to further reduce the projected dose?" For example:

> Is there protective clothing, beyond what is currently in use, that would reduce the worker's dose?

[iv] The regulatory definition of ALARA is found in 10 CFR 20.1003

Could the work be sequenced differently to allow the task to be completed quicker?

Could shielding (lead bricks) be placed between the worker and the fuel rod assembly thereby reducing exposure?

Does the worker have the best tools for the job?

Only in recent years has the concept of ALARA been used in association with environmental restoration. The Decommissioning Rule says a site will be considered acceptable for unrestricted use, if radioactivity results in a dose no greater than 25 mRem/yr, and the radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). Thus, in addition to meeting the minimum cleanup level, all reasonable steps should be taken to reduce the contamination level even further. In practice this would mean that in the design of a particular cleanup project, DOE would evaluate additional measures aimed at reducing the contamination levels beyond that called for by the RSAL. Additional measures could include excavation of areas where the contamination is below the RSAL. Such an evaluation could conclude that for a relatively small increase in cost and time they could remove significant amounts of additional contamination.

Of course a key challenge in applying the ALARA process is it's inherently subjective nature; what seems reasonably achievable to one may not to another. An ALARA analysis will have to take a number of issues into consideration:

How much dose could be avoided by doing work beyond that required to meet the RSAL?

How much would the additional work cost?

Is it technically feasible?

What are the risks to workers and to the public of performing additional work?

Will natural resources/habitat be affected?

What are the offsite risks associated with additional work (e.g. risk from transportation, risks at the disposal facility).

The rules as to when you do additional work in accordance with ALARA are not hard and fast. The NRC Draft Regulatory Guide DG-4006, "Demonstrating Compliance with the Radiological Criteria for License Determination," does contain formulas for use in ALARA analyses. These formulas try to quantify the benefits of additional cleanup work

by assigning a monetary amount to a unit of averted dose (e.g. the benefit of avoiding a dose of 1 Rem is given a value of $2,000). The benefits are then compared to the cost of conducting cleanup beyond that necessary to comply with the dose standard. The NRC guidance on ALARA says that, based on NRC's analysis, additional soil cleanup will generally not be cost effective if the cleanup already meets the goal of 25 mRem/yr to an unrestricted land use scenario.

The concept of ALARA is consistent with the RFCA Vision which states where possible, the site will be cleaned up to the maximum extent feasible.

PROPOSED FRAMEWORK FOR RSALS AND CLEANUP DECISIONS

With respect to the regulatory foundation upon which an RSAL will be constructed the key factors are acceptable dose and/or acceptable level of risk, future land use assumptions and ALARA.

Acceptable dose and/or acceptable risk.

As previously discussed, the Decommissioning Rule is one of the key requirements that will govern the cleanup at Rocky Flats. So at a minimum the cleanup will have to reduce the contamination to meet the dose limits in the Rule. Dose assessments will be performed to calculate an RSAL that meet the 25 mRem/yr dose limit to a future user. Given the concern that the 25 mRem/yr dose limit may not be protective of human health, at least for some radionuclides, the DOE, EPA and CDPHE will also calculate RSALs based on risk, and choose the more conservative value between dose and risk. So the only way the RSAL will be based on the 25 mRem/yr dose would be if the risk associated with the dose fell within the risk range. DOE, CDPHE and EPA are considering the idea of choosing a specific value within the risk range upon which to base a RSAL. However, since we are not prepared at this time to choose a specific value, the Agencies will calculate levels of residual contamination corresponding to the risk levels of 10^{-4}, 10^{-5} and 10^{-6}.

ALARA

In accordance with the decommissioning rule, an ALARA analysis will be required for each cleanup project. This analysis will be performed at the time the time the project is being designed, when all the necessary characterization data and historical information has been compiled. DOE will develop a detailed protocol for how these analyses will be conducted, in consultation with CDPHE, EPA, Local Communities and the Public, which will outline factors to be considered and how those factors will be weighted in the final analysis. This process for determining ALARA will incorporate CERCLA balancing and modifying criteria discussed earlier. The ALARA analysis will be part of the regulatory decision document for each cleanup project. The results of the analysis and the proposed action based upon the consideration of the analysis are subject to the normal decision

document review and regulatory approval process. This includes consideration of any public review comments

Future Land Use Assumptions

The Decommissioning Rule states that a site may be released for unrestricted use if residual radioactivity that is distinguishable from background is ALARA, and would not result in a dose in excess of 25 mRem/yr to a future user in an unrestricted scenario. The Rule says a site may be cleaned up to a less stringent level if the party performing the cleanup can demonstrate either: (1) the additional cleanup necessary to qualify for an unrestricted release would cause net public or environmental harm, or (2) the contamination levels associated with restricted use are ALARA. Thus, the RFCA Parties will consider both restricted and unrestricted scenarios in the development of RSAL and cleanup levels. The RFCA parties have chosen eight scenarios to be evaluated as shown in the table below.

The table will be completed and distributed as part of the task 3 report and will list a specific activity in pCi/g for each scenario and associated dose/risk level. The table will be used to choose an RSAL, based on an anticipated future user, and to determine the level that represents an unrestricted future land use scenario. In addition, the table may be a useful tool in guiding stewardship and post-closure stewardship discussions and decisions.[v]

RSAL TABLE FOR SELECTED SCENARIOS, DOSE AND RISK

Land Use Scenarios	25 mRem/yr	Lifetime Risk=10-4	Lifetime Risk= 10-5	Lifetime Risk= 10-6
Restricted				
Open Space User - Adult				
Open Space User - Child		----------	----------	----------
Office Worker				
Wildlife Refuge Worker				
Unrestricted Scenarios				
Suburban Resident - Adult				
Suburban Resident - Child		----------	----------	----------
Resident Rancher - Adult				
Resident Rancher - Child		----------	----------	----------

The values for this table will be calculated and distributed as part of the Task 3 Report

The open space user scenario was chosen because it is currently contemplated in the RFCA, and it is quite possibible that members of the public would use the Site for open-space recreation should the site be designated a National Wildlife Refuge. The Office Worker scenario was selected because it too is currently contemplated in the RFCA; however at this time commercial reuse of the site does not appear likely. Wildlife refuge

[v] The RFCA Parties have not had substantive discussions on the value of retaining the existing two-tiered system for RSALs, but we may wish to discuss the issue at a future Focus Group meeting.

worker was chosen because this is the reasonably anticipated future user. We chose the suburban resident because we believe this is the land use that would most likely occur if the site were opened up for unrestricted use. Finally, the resident rancher scenario was chosen so the values calculated could be compared against those calculated by RAC. DOE, CDPHE and EPA do not believe the resident rancher scenario is likely as long as the Front Range is a thriving metropolitan area.

Proposal for the RSAL and Cleanup Decisions

We propose that the RSAL be based on the reasonably anticipated land user; the refuge worker. The RSAL will be used to determine where cleanup actions will be taken at Rocky Flats. Once an action has been determined to be necessary (i.e. contamination is present in excess of the RSAL), the alternatives analysis, including application of the ALARA process, for that action will include cleanup to a level that supports unrestricted use; the suburban resident scenario. In other words, for each area of the site where contamination exceeds the RSAL, DOE will perform an evaluation to determine what level of contamination removal is reasonably achievable. While we have serious doubts that the entire site can be cleaned to unrestricted use, it is certain that such a level can be achieved for many of the contaminated areas at Rocky Flats. The first ALARA analysis will occur in conjunction with planning for the 903 pad remedial action and will give careful consideration to the issue of surface water protection.

SUBSURFACE RSALS AND SURFACE WATER PROTECTION

The RSAL we plan to develop using the framework above is meant to be protective of the anticipated future user and will only be used to address surface contamination. Calculations as to what an appropriate RSAL for buried contamination in the Industrial Area will be performed at a later time when more is known about the nature and extent of such contamination, and the possible routes of exposure. Furthermore, the proposed RSAL is not meant to be protective of the surface water standards. . Meeting the RSAL will in no way guarantee that the surface water standard won't be violated. DOE is obligated under the RCA to meet the surface water standard, and will have to take the necessary steps to do so. This could include excavation of contamination to levels below the RSAL, re-contouring of areas in and around the industrial area, stabilization measures or the construction of engineered controls. Attachment 2 illustrates many of the factors to be considered in decisions made for the protection of surface water standards.

Actions Items for 1/31/01 RFCA Focus Group meeting

John Marler will check with the RFCLOG to see if the interested members of the community can be copied on the RSAL Review Working Group Meeting Summaries developed for RFCLOG members. If the RFCLOG agrees, Christine Bennett will then email them to the RSAL Review list.

A working group was formed to develop detailed designs for the RSAL workshops. They will present their proposed design to the Focus Group at the January 31, 2001 RFCA Focus Group meeting.

DOE will identify the guidance used in selecting land use scenarios for RSAL development (Jeremy Karpatkin)

ADMIN RECORD

February 7, 2001

Dear Stakeholder:

The Rocky Flats Cleanup Agreement (RFCA) Stakeholder Focus Group will meet at the Broomfield City Hall, Bal Swan and Zang's Spur Rooms, on Wednesday, February 14, 2001 from 3:30 to 6:30 p.m.

The agenda for the February 14, 2001 meeting is enclosed (Attachment A). We will discuss the following topics:

- Regulatory Analysis Report, Revision 2 – Discussion
- Review of RESRAD 6.0 approach to air pathway
- Report-back from Workshop Design Group

The meeting minutes for the January 31, 2001 meeting are enclosed as Attachment B.

If you need additional information to prepare you for the Focus Group discussion on January 31, 2001, please contact Christine Bennett of AlphaTRAC, Inc. at 303 428-5670 (cbennett@ alphatrac.com). Christine will help to find the appropriate resource for you.

You may call either Christine or me if you have any questions, comments, or suggestions concerning the RFCA Stakeholder Focus Group or the upcoming meeting.

Sincerely,

C. Reed Hodgin, CCM
Facilitator / Process Manager

ADMIN RECORD

Wildlife Refuge Worker Scenario Description

Diane Niedzwiecki, Ph.D.
CDPHE, Disease Control and Environmental Epidemiology

ADMIN RECORD

1/9

[redacted]

Wildlife Refuge Worker Scenario Description

- If Rocky Flats becomes a National Wildlife Refuge, this receptor likely will be significantly exposed to any contamination remaining on site.
- This scenario may become the driver for Soil Action Levels for this site.

Types of job categories included

- Secretaries, who may spend 100% of their time at work inside.
- Scientifically trained personnel such as biologists, foresters, habitat management specialists, and various interns or trainees.
- Maintenance workers, equipment operators and mechanics.

Amount of time spent outside

- Weather dependent.
- For scientifically trained personnel:
  - at least 50% of their time during spring, summer and fall.
  - Less time during the winter.

- Maintenance personnel or equipment operators:
  - often spend greater periods of time outdoors or in shops open to the outside air.

Size of exposure unit depends upon type of work

- Examples:
  - When doing road surveys of various types of wildlife, the worker may be exposed to the entire site over a several day period.
  - When trapping small mammals, the entire study may be spent on a 100 m^2 area.

Examples of specific tasks

- Planning and interpreting studies, planning prescribed burns, writing management plans.
- Performing wildlife or vegetation surveys.
- Performing prescribed burns.
- Applying pesticides or herbicides.
- Plowing, harrowing, and planting during revegetation programs.
- Fence building and maintenance.
- Building sheds.
- Guiding tours for the public.

Anticipated Sensitive Pathways for Radionuclide Exposure

- Incidental ingestion of surface soil, subsurface soil, and sediment.
- Inhalation of surface soil particulates.
- External exposure to gamma radiation.

Anticipated Sensitive Pathways for non-radionuclide exposure

- Incidental ingestion of surface soil, subsurface soil, and sediment.
- Dermal exposure, especially to some semivolatile contaminants in surface soil, subsurface soil, or sediment.
- Inhalation of indoor air contaminated by volatile organic compounds over groundwater plumes.
- Inhalation of surface soil particulates.

Wildlife refuge worker summary

- Because of the type of potential exposures to different media that this receptor could potentially have, this receptor may drive the Soil Action Levels at Rocky Flats.

Scenario #4: Rural Resident

- Adapt to site specific conditions
- 2 - 10 acre farmette / ranchette
- Surface soil undeveloped
- Majority of time onsite
- Homegrown fruit/vegetables
- adult and child cases

ADMIN RECORD

Anticipated Sensitive Pathways

- Ingestion of surface soil
- Inhalation of surface soil particulate
- Ingestion of homegrown plant material
- Incidental external exposure to gamma radiation

Rural Resident Summary

- Absence of institutional controls
- Most conservative of the realistic parameters
- Distributions for most sensitive parameters
- Deterministic values for slightly sensitive parameters

Scenario #5: Resident Rancher

- Described in RAC Task 5 report
- Will use all possible inputs identical to RAC's
- Muse use alternate approximations for:
  - area of contaminated zone
  - mass loading
  - average wind speed

Resident Rancher cont.

- Shallow groundwater pathway turned on
- adult and child cases
- results will not be directly comparable to RAC's

Anticipated Sensitive Pathways

- Ingestion of surface soil
- Inhalation of surface soil particulate
- Ingestion of homegrown plant material
- Ingestion of homegrown meat

Anticipated Pathways cont.

- Shallow groundwater pathway turned on
- Incidental external exposure to gamma radiation

Resident Rancher Summary

- Several aspects not deemed credible
- represents a more hypothetical extreme
- will be modeled as closely to RAC approach as possible
- For comparative purposes only

Hello everyone,

I read over John Corsi's message that was attached to this email. I wasn't able to attend the January 18 meeting. I'd like to get more information on the difficulties in running RAC's resident rancher scenario in a manner similar to the other RFCA scenarios. Would it be possible to have this information emailed to the Focus Group prior to next week's meeting? I think it would be helpful if we are planning a discussion on modifying the RAC resident rancher scenario.

Thanks,
John Marler
Rocky Flats Coalition of Local Governments

From John Corsi:

> There has been some confusion as to what was agreed to during the last
> RSAL working group meeting.
>
> During a focus group meeting, the agencies committed to run the resident
> rancher scenario in a manner similar to the other scenarios being run.
> During a subsequent RSAL working group meeting, technical staff pointed
> out several difficulties in running the RAC-created resident rancher
> scenario in a manner similar to how the open space, office worker,
> wildlife refuge worker and surburban resident scenarios will be run. To
> achieve an "apples-to apples" comparison of all of the scenarios, the
> resident rancher will need to be described somewhat differently than RAC
> described it.
>
> Since taking the RAC scenario off the shelf and applying it without
> modification is not achievable, we want to be sure that the scenario we
> use enables direct comparison to the other agency scenarios while
> faithfully representing the resident rancher scenario. In order to ensure
> the resident rancher scenario is described in a manner acceptable to the
> focus group, we will need further discussion with the focus group on how
> to make the necessary modifications.
>
>

ADMIN RECORD

Hello everyone,

I read over John Corsi's message that was attached to this email. I wasn't able to attend the January 18 meeting. I'd like to get more information on the difficulties in running RAC's resident rancher scenario in a manner similar to the other RFCA scenarios. Would it be possible to have this information emailed to the Focus Group prior to next week's meeting? I think it would be helpful if we are planning a discussion on modifying the RAC resident rancher scenario.

Thanks,
John Marler
Rocky Flats Coalition of Local Governments

ADMIN RECORD

PRELIMINARY DRAFT
MAXIMUM SENSITIVITY PARAMETERS
PARAMETER SENSITIVITY ANALYSIS
WITH DEFAULT PARAMETERS AS BASELINE PARAMETER VALUES
PU-239

RESRAD 6.0 PARAMETER (1)	UNITS	BASELINE PARAMETER VALUE (a)	MINIMUM PARAMETER VALUE (b)	MAXIMUM PARAMETER VALUE (c)	CHANGE IN PARAMETER VALUE (2) (d) = (c - b)	RADIATION DOSE AT BASELINE VALUE (mrem) (e)	RADIATION DOSE AT MINIMUM PARAMETER VALUE (mrem) (f)	RADIATION DOSE AT MAXIMUM PARAMETER VALUE (mrem) (g)	CHANGE IN RADIATION DOSE (mrem) (h) = (g - f)	SENSITIVITY COEFFICIENT (a*h)/(e*d)
Contaminated Zone Parameters										
Area of Contaminated Zone	square meters	10000	3333.3	30000	26666.7	0.1102	0.1098	0.1107	0.0009	0.003
Thickness of Contaminated Zone	meters	2	0.67	6	5.33	0.1102	0.089	0.1102	0.0212	0.072
Cover and Contaminated Zone Hydrological Data										
Wind Speed	meters/sec	2	0.67	6	5.33	0.1102	0.129	0.108	-0.021	-0.072
Occupancy, Inhalation and External Gamma Data										
Inhalation Rate	cubic meters/year	8400	4200	16800	12600	0.1102	0.1083	0.114	0.0057	0.034
Mass Loading for Inhalation	grams/m^3	0.0001	0.000033	0.0003	0.000267	0.1102	0.1078	0.1178	0.01	0.034
Indoor Dust Filtration Factor		0.4	0.2	0.8	0.6	0.1102	0.1094	0.1119	0.0025	0.015
Indoor Time Fraction		0.5	0.25	1	0.75	0.1102	0.101	0.129	0.028	0.169
Outdoor Time Fraction		0.25	0.083	0.75	0.667	0.1102	0.103	0.132	0.029	0.099
Ingestion Pathway, Dietary Data										
Fruit, Vegetable and Grain Consumption	kg/year	160	53.3	480	426.7	0.1102	0.06	0.26	0.2	0.681
Leafy Vegetable Consumption	kg/year	14	4.67	42	37.33	0.1102	0.106	0.1235	0.0175	0.060
Soil Ingestion	gram/year	36.5	12.17	109.5	97.33	0.1102	0.093	0.161	0.068	0.231
Contaminated Fraction, Plant Food (3)		-0.5	-0.25	-1	-0.75	0.0292	0.03	0.11	0.08	1.826
Ingestion Pathway, Nondietary Data										
Depth of Roots	meters	0.9	0.3	2.7	2.4	0.1102	0.11	0.089	-0.021	-0.071
Plant Factors, Wet Weight Crop Yield, Non-Leafy	kg/m^2	0.7	0.23	2.1	1.87	0.1102	0.1104	0.1102	-0.0002	-0.001
Plant Factors, Translocation Factor, Non-Leafy		0.1	0.033	0.3	0.267	0.1102	0.1102	0.1104	0.0002	0.001
Plant Factors, Weathering Removal Constant, Non-Leafy	1/year	20	10	40	30	0.1102	0.1103	0.1102	-1E-04	-0.001
Plant Factors, Dry Foliar Interception Fraction, Non-Leafy		0.25	0.083	0.75	0.667	0.1102	0.1102	0.1104	0.0002	0.001
Plant Factors, Weathering Removal Constant, Leafy	1/year	20	10	40	30	0.1102	0.1103	0.1102	-1E-04	-0.001

(1) - The significant exposure pathways of soil inhalation, soil ingestion and plant ingestion were assessed.
(2) - Parameters were varied by a factor of 3 unless this would exceed parameter range. If parameter range exceeded with factor of 3, parameter was varied to the maximum extent within its prescribed range.
(3) - Default parameter set at upper end of sensitivity range.

N/A - Not Applicable

ADMIN RECORD

Task 3 Update

Scenarios

ADMIN RECORD

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Site Scenario List

- Office Worker Scenario
- Open Space User Scenario
- Wildlife Refuge Worker Scenario*
- Rural Residential
- Residential Rancher

Scenario #1: Office Worker (OW) Scenario Description

- The OW scenario is designated in RFCA
- OW(s) will be indoors most of the time
  - outside occasionally at lunch time
  - drive on and office site daily (M-F)
- OW(s) will not be in direct contact with soil

Anticipated Sensitive Pathways:

- Incidental ingestion of surface soil
- Inhalation of surface soil particulate
- External exposure to gamma radiation

Office Worker Summary

- The office worker Scenario is described by RFCA.
  - there are currently no plans for such use.
- Distributions will be used for the most sensitive parameters within a given sensitive pathway.
- It is not expected that this scenario will drive the Soil Action Levels at the site.

DISCUSSION PAPER ON VERIFYING RAC RSAL CALCULATIONS USING RESRAD 6.0

Prepared by USEPA

The Citizen's Advisory Board has requested that the RSAL Working Group perform computations of RSALs for the most restrictive scenario modeled by the Risk Assessment Corporation (RAC) in their Task 5 Final Report (resident rancher). In the process of addressing this request, the RSAL Working Group selected the most recent version of RESRAD, Version 6.0, which has the capability of performing Monte Carlo probabilistic calculations using input parameter distributions when desirable. This feature of RESRAD makes it possible to use "realistic" approximations of parameters which are important to the modeling calculations, for which it is difficult or unsound to select a single value (eg. a wide range of values is possible, high uncertainty exists, etc.). Since RAC made extensive use of the Monte Carlo probabilistic approach in the Task 5 calculations, it was felt that the use of RESRAD 6.0 might provide for a more comparable calculation on the part of the RSAL Working Group.

As the Working Group has gained familiarity with the features of RESRAD 6.0, it has become obvious that the probabilistic feature, alone, will not enable the group to replicate the RAC approach or produce a computation of RSALs which can be compared with those calculated by RAC. This is because RAC essentially wrote new computer algorithms (sub-programs) for three of the most sensitive inputs into the RESRAD model used (version 5.82), and turned off the corresponding algorithms in RESRAD. These inputs are the Area of Contaminated Zone, Mass Loading, and Mean Annual Wind Speed. RAC cited limitations in the RESRAD algorithms as reasons for departing from RESRAD's basic computational approach. The alternate approach taken by RAC consisted of a mathematically complex process of empirical curve fitting of soil concentrations, "bootstrap" calculations of resuspension, use of alternate air transport modeling, and iterative "calibration" of the air model to actual air sampler results, as well as incorporation of a five year meteorological database array for the site. (See the final Task 5 Report.) While this alternate approach arguably addresses limitations in RESRAD (note that all computer models are limited by the approximations they use), it is not clear to the Working Group whether RAC's approach constitutes an improvement, or produces a more reliable RSAL value. Whatever the best RSAL approach may be, replication of RAC's approach is certainly outside the scope of the RSAL Working Group, since the group is not equipped to write, test and verify alternative software. Because the Working Group cannot replicate the RAC calculations, it is not possible to select values or distributions for these three key input parameters, based upon RAC's work, which would allow a direct comparison with RAC using RESRAD 6.0.

To fulfill the agreed upon work, the group proposes to model the resident rancher scenario, as described by RAC, using RESRAD 6.0 without modification, noting that the results should be compared with caution to the RAC work. Whenever possible, the input parameters for this scenario will be those used in the RAC Task 5 Report for the resident rancher (adult and child). For the three sensitive parameters cited above, alternative approximation methods, which are considerably simpler than those applied by RAC, but which are still conservative and complete, will be applied. These approximations, described below, have been agreed upon conceptually by

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a technical subgroup of the working group. They appear to be feasible, and straightforward, given the present site data:

> Area of the contaminated zone. The limitation of RESRAD which RAC attempted to address is that it models based upon a input defined area which is presumed to be uniformly contaminated. RAC attempted to model the contaminated zone, as precisely as possible by using isopleths which were fitted to soil contamination values taken from the RFETS soil database. The subgroup believes that it is possible to greatly simplify this approach if the contaminated zone is approximated as two zones - a smaller zone which is uniformly cleaned up to the RSAL value, and a second, larger zone, which contains all values of contamination ranging from the RSAL value down to background values. These zones would be modeled as concentric circles, with the smaller zone lying within the larger zone. The modeling approach would involve: 1.) Compute the annual dose, D_{res}, to maximally exposed residents due to the large zone (area not cleaned up) using a conservative value for the average contamination (greater than the actual average) and 2.) Derive the RSAL value for the area to be cleaned up, using an adjusted annual dose limit of [25 mrem - D_{res}] as the basis. This approach permits the use of RESRAD without modification, and still accounts conservatively for the impact of the large area of residual contamination.
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> Mass loading. RAC noted that versions of RESRAD, available at that time did not admit for the variability of this parameter due to wind speed and direction, and performed complex alternative computation to approximate the mass loading distribution, fitted to a Denver wind rose, and calibrated to local air sampling data. The working group believes that the variability of mass loading can be addressed within the context of RESRAD 6.0 since this parameter can be directly input as a distribution. The approach to developing this distribution, which appears feasible to the technical subgroup, will involve the use of past and recent site specific resuspension data developed or incorporated by MRI, Radian, and the Actinide Migration Panel, including the most recent work involving wind tunnel studies of burned and unburned areas of the site. The relationships between mass loading and wind velocity which these site specific studies provide can be used, in conjunction with site wind rose data (wind velocity and frequency), to construct site specific mass loading distribution curves (shape of the curve determined by frequency) for both the vegetated and denuded case. Although this approach is not comparable with the RAC approach, it is likely to be more conservative, since the dose reduction effect of varying wind direction with respect to the receptor is not incorporated (the computer treats the receptor as always downwind in RESRAD 6.0).
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> Average wind speed. RAC incorporated the variability of wind speed in their mass loading model. Likewise, the working group proposes to incorporate the variability of wind speed in the mass loading distribution, described above. A site specific value of average wind speed, based on local meteorological data will be used as the input to RESRAD 6.0 for this parameter.

The working group believes that these approximation methods are sound and will enable the group to proceed toward development of parameter distribution and modeling without undue

delay. It is to be noted that the values and distributions of the three parameters described above will be used for all of the scenarios modeled by the RSAL working group, since they represent site conditions which are common to all scenarios.

THE RURAL RESIDENT SCENARIO

As has been stated elsewhere, the working group believes that certain aspects of the resident rancher scenario modeled by RAC are not realistic, given the inherent features of the site, and is performing the modeling of this scenario for comparative purposes only. To address the site resident situation which the group believes is realistic, and will lead to the most restrictive RSALs for the case where institutional controls are absent, the group proposes to model a site specific version of the rural resident scenario, proposed in generic form by USEPA in its Technical Support Document for the Soil Cleanup Rule for Radioactively Contaminated Sites (40 CFR Part 196). This scenario, which will be modeled for both the adult and child cases, is similar in many ways to the RAC resident rancher scenario, with shallow groundwater and meat pathways turned off. There will also be some differences in site usage, breathing rates, and ingestion quantities - the rural resident may be thought of as a suburban worker dwelling on a 5-10 acre farmette, a practice which is not uncommon for the general area at this time. Although the head of the household works away from the site, the modeling will be done using adult and child residents who spend nearly 100% of time on site. The conservative features of this scenario over other EPA residential scenarios (eg. suburban resident) include high site occupancy, soil surface undisturbed by development (no credit taken for pavement, sod cover, etc., as in a typical subdivision), and larger quantities of home-grown vegetables ingested.

Scenario #4: Rural Resident

- Adapt to site specific conditions
- 2 - 10 acre farmette / ranchette
- Surface soil undeveloped
- Majority of time onsite
- Homegrown fruit/vegetables
- adult and child cases

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Anticipated Sensitive Pathways

- Ingestion of surface soil
- Inhalation of surface soil particulate
- Ingestion of homegrown plant material
- Incidental external exposure to gamma radiation

Rural Resident Summary

- Absence of institutional controls
- Most conservative of the realistic parameters
- Distributions for most sensitive parameters
- Deterministic values for slightly sensitive parameters

Scenario #5: Resident Rancher

- Described in RAC Task 5 report
- Will use all possible inputs identical to RAC's
- Muse use alternate approximations for:
  - area of contaminated zone
  - mass loading
  - average wind speed

Resident Rancher cont.

- Shallow groundwater pathway turned on
- adult and child cases
- results will not be directly comparable to RAC's

Anticipated Sensitive Pathways

- Ingestion of surface soil
- Inhalation of surface soil particulate
- Ingestion of homegrown plant material
- Ingestion of homegrown meat

Anticipated Pathways cont.

- Shallow groundwater pathway turned on
- Incidental external exposure to gamma radiation

Resident Rancher Summary

- Several aspects not deemed credible
- represents a more hypothetical extreme
- will be modeled as closely to RAC approach as possible
- For comparative purposes only

Task 3 Update

Scenarios

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Site Scenario List

- Office Worker Scenario
- Open Space User Scenario
- Wildlife Refuge Worker Scenario*
- Rural Residential
- Residential Rancher

Scenario #1: Office Worker (OW) Scenario Description

- The OW scenario is designated in RFCA
- OW(s) will be indoors most of the time
  - outside occasionally at lunch time
  - drive on and office site daily (M-F)
- OW(s) will not be in direct contact with soil

Anticipated Sensitive Pathways:

- Incidental ingestion of surface soil
- Inhalation of surface soil particulate
- External exposure to gamma radiation

Office Worker Summary

- The office worker Scenario is described by RFCA.
  - there are currently no plans for such use.
- Distributions will be used for the most sensitive parameters within a given sensitive pathway.
- It is not expected that this scenario will drive the Soil Action Levels at the site.