USING RISK-BASED CORRECTIVE ACTION (RBCA) TO ASSESS (THEORETICAL) CANCER DEATHS AVERTED COMPARED TO THE (REAL) COST OF ENVIRONMENTAL REMEDIATION

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ABSTRACT

In 1978, on the basis of existing health studies at the time, the Uranium Mill Tailings Remedial Action (UMTRA) Project legislation was proposed that would authorize remedial action at inactive uranium processing sites and vicinity properties. The cost of the program to the Federal Government was expected to be $180 million. With the completion of this project, approximately 1300 theoretical cancer deaths were prevented in the next 100 years at a cost of $1.45 billion, based on the Fiscal Year 1998 Federal UMTRA budget. The individual site costs ranged from $0.2 million up to $18 billion spent per theoretical cancer death averted over the next 100 years.

Resources required to sustain remediation activities such as this are subject to reduction over time, and are originally based on conservative assumptions that tend to overestimate risks to the general public. This evaluation used a process incorporating risk-based corrective action (RBCA); a three-tiered, decision-making process tailoring corrective action activities according to site-specific conditions and risks. If RBCA had been applied at the start of the UMTRA Project, and using a criterion of $\geq$1 excess cancer death prevented as justification to remediate the site, only 50% of the existing sites would have been remediated, yielding a cost savings of $303.6 million to the Federal Government and affected States, which share 10% of the cost. This cost savings equates to 21% of the overall project budget. In addition, only 22% of the vicinity properties had structural contamination contributing to elevated interior gamma exposure and radon levels. Focusing only on these particular properties could have saved an additional $269.3 million, yielding a total savings of $573 million; 40% of the overall project budget. As operational experience is acquired, including greater understanding of the radiological and non-radiological risks, decisions should be based on the RBCA process, rather than relying on conservative assumptions that tend to overestimate risks to the general public.

INTRODUCTION

Decades of processing uranium ore for use in the government’s nuclear weapons and energy programs resulted in the accumulation of contaminated mill tailings, a sand-like by-product of ore processing, at 24 sites located primarily in the Western United States (1). The uranium mill tailings were allowed to accumulate, often in unstabilized and unprotected conditions. About 5,314 vicinity properties identified to date used these tailings for constructing foundations and walls of private and public buildings, and under streets and utility corridors. In 1978, on the basis of existing health studies at the time, legislation was proposed that would authorize remedial action at these inactive sites. The cost of the program to the Federal Government was expected to be $180 million.

COMPARING THEORETICAL BENEFITS TO ACTUAL COST OF REMEDIATION

With the completion of this project, we have the opportunity to compare theoretical benefits (i.e., risk averted) to actual costs of remediation. Approximately 1300 theoretical cancer deaths were estimated to have been prevented in the next 100 years by the Uranium Mill Tailings Remedial Action (UMTRA) Project at a cost of $1.45 billion to the Federal Government. Table I summarizes the 1996 cost and cancer deaths prevented by the UMTRA Project based on the Fiscal Year 1998 Federal UMTRA budget. The most favorable cost benefits were associated with the high-risk sites. These included Salt Lake City, Grand Junction, and the vicinity properties, of which $0.2, $0.4, and $1.2 million were estimated to have been spent per cancer death averted over the next 100 years, respectively. The medium-, to low-risk sites were the least cost effective. For example, the Slick Rock site netted the least benefit for the cost with a projected $18 billion spent per theoretical cancer death averted. The lower cost benefit is attributable to its remote, rural location and sparse population resulting in very few persons being exposed. Only one actual fatality attributable to remedial action construction has been recorded in the history of the UMTRA Project. The industrial accident involved rock-grading equipment, and had nothing to do with radioactive materials.

Since resources required to sustain remediation activities are often subject to reduction over time, this subsequent evaluation using a process incorporating risk-based corrective action (RBCA) demonstrates how remediation programs should be reviewed and updated annually. RBCA is a consistent decision-making process for the assessment and response to a particular risk, based on the protection of human health and the environment (2).

THE RBCA PROCESS

Sites with mill tailings vary greatly in terms of complexity, site characteristics, and in the risks they may pose to human health and the environment. RBCA recognizes this diversity, and uses a three-tiered decision process that tailors corrective action activities according to site-specific conditions and risks. This decision process integrates risk and exposure assessment practices, as suggested by the U.S. Environmental Protection Agency, to ensure that the chosen action is protective of human health and the environment.

Tier 1 Evaluation (Very Conservative) - A risk-based analysis utilizing conservative exposure pathways and radionuclide transport factors for various <u>generic</u> property use categories (e.g., residential, commercial, and industrial uses).

The computer code used to perform the Tier 1 Evaluation is the RESidual RADioactive Material Guidelines (RESRAD) computer code (3). RESRAD was developed at Argonne National Laboratory for the U.S. Department of Energy to calculate site-specific residual radioactive material guidelines, as well as radiation dose and excess lifetime cancer risk to a chronically exposed on-site resident.

Nine environmental pathways are considered; direct exposure, inhalation of particulates and radon, and ingestion of plant foods, meat, milk, aquatic foods, water, and soil. Different exposure scenarios can be specified by adding or suppressing pathways, modifying usage, and occupancy parameters. Radiation doses, health risks, soil concentration guidelines, and media concentrations are calculated over user-specified intervals. The source is adjusted over time to account for radioactive decay and ingrowth, leaching, erosion, and mixing. For the Tier 1 Evaluation, conservative default values are provided for most of the parameters used by RESRAD.

Tier 2 Evaluation (Moderately Conservative) - A risk-based analysis utilizing the conservative exposure pathways and radionuclide transport factors used for the Tier 1 evaluation to calculate direct and indirect exposures at site-specific points of compliance.

Tier 3 Evaluation (Incorporating Site-Specific Conditions) - A risk-based analysis utilizing realistic site-specific information to calculate direct and indirect exposures at site-specific points of compliance.

The information is then evaluated against risk-based, site-specific corrective action target levels (e.g., 10^{-4} to 10^{-6}) for the radionuclide(s) of concern. After performing a Tier 3 Evaluation, if the exposure still exceeds the target levels at the points of compliance, a remedial action plan should be developed to reduce the potential for adverse impacts.

The advantages of the RBCA approach follow:

- Site assessment activities are focused on collecting information that is necessary to make risk-based corrective action decisions.
- Decisions are based on reducing the risk of adverse human or environmental impacts.
- Achieving compliance through remedial action is evaluated relative to site-specific standards applied at site-specific points of compliance.
- Higher quality, and in some cases, faster cleanups than are currently realized can be achieved by focusing on an acceptable degree of exposure and risk reduction.

However, in order to apply the RBCA process properly, the following pitfalls must be avoided:

- Restricting the RBCA process to a Tier 1 Evaluation only, and not allowing Tier 2 or Tier 3 Evaluations.
- Using conservative Tier 1 Evaluation exposure pathways and radionuclide transport factors to develop administratively mandated remediation standards rather than incorporating site-specific conditions.
- Using predictive modeling techniques that are not supported by available data or site conditions, including the use of unjustified or inappropriate exposure factors and toxicity parameters.
- Placing arbitrary time constraints on the corrective action process. For example, requiring that Tiers 1, 2, and 3 be completed within 30-day time periods that do not reflect the actual urgency and risks posed by the site.
- Applying technology-based cleanup requirements prior to evaluating corrective action target levels.
- Dictating that corrective action goals can only be achieved through source removal and treatment actions, thereby restricting the use of exposure reduction options, such as engineering and institutional controls.
- Using the RBCA process as a "fallback" only when active remediation is not feasible, instead of a process that is applicable during all phases of corrective action.
- Requiring continuous monitoring or remedial action at sites that have achieved the corrective action target levels.

NO FURTHER ACTION

When the RBCA corrective action target levels have been achieved at the points of compliance, then monitoring and site maintenance activities are no longer required to ensure that conditions persist. The only remaining activities, if any, are to ensure that institutional controls (i.e., restriction on use or access to a site or facility) remain in place.

APPLYING RBCA TO UMTRA

If RBCA had been applied at the start of the UMTRA Project, and using a criterion of $\geq$1 excess cancer deaths prevented as justification to remediate the site, only 50% of the existing sites would have been remediated, yielding a cost savings of $303.6 million to the Federal Government and affected States which share 10% of the cost. This cost savings equates to 21% of the overall project budget. In addition, only 22% of the vicinity properties had structural contamination contributing to elevated interior gamma exposure and radon levels. Focusing only on these particular properties could have saved an additional $269.3 million, yielding a total savings of $573 million; 40% of the overall project budget.

IMPACTS ON FUTURE REMEDIATION PROJECTS

Although larger communities will realize a greater "statistical" benefit by remediating a particular environmental risk, the number of theoretical cancer deaths averted in 100 years is still only a fraction of getting cancer in a lifetime. In the United States, men have a little less than 1 in 2 lifetime risk of developing cancer; for women the risk is a little more than 1 in 3 (4). Furthermore, the risk studies from exposure to low levels of ionizing radiation (i.e., radiological risk) are continually being studied and revised accordingly. Therefore, in accordance with current knowledge of radiation health risks, quantitative estimation of health risks should not be performed when an individual dose is below 5 rem in one year, or a lifetime dose is below 10 rem in addition to background radiation. Risk estimation in this dose range should be strictly qualitative, accentuating a range of hypothetical health outcomes with an emphasis on the likely possibility of zero adverse health effects. The current philosophy of radiation protection is based on the assumption that any radiation dose, no matter how small, may result in human health effects, such as cancer and hereditary genetic damage. There is substantial and convincing scientific evidence for health risks at higher doses. Below 10 rem, which includes environmental and occupational exposures, risks of health effects are either too small to be observed or are non-existent (5). This realistic approach of using current knowledge of radiation health risks will help distinguish between radiological risk and competing "everyday" risks that, in reality, are materially significant, and impact the population directly.

CONCLUSION

The allocation of limited resources (e.g., time, money, regulatory oversight) to any one site necessarily influences corrective action decisions at other sites. This has spurred the search for innovative approaches to corrective action decision making, which still ensures that human health and the environment are protected. The RBCA process is a consistent, streamlined decision process for selecting corrective actions at sites identified for remediation. Moreover, as operational experience is acquired, including greater understanding of the radiological and non-radiological risks associated with this and similar remedial action projects, decisions should be based on the RBCA process, rather than relying on conservative assumptions that tend to overestimate risks to the general public.

REFERENCES

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Table I. Evaluation of Cost and Cancer Deaths Prevented by the UMTRA Project Based on the FY98 Federal UMTRA Budget

Site	Excess Cancer Deaths Prevented by Remedial Action[a]	Predicted Nonradiological Fatalities[b]	Actual Nonradiological Fatalities	Total Deaths Prevented	Total Project Cost $Millions[c]	Cost/Death Prevented $Millions[d]
Grand Junction	589	0.35	1	588	256.3	0.44
Salt Lake City	313	0.14	0	313	75.0	0.24
Rifle	40	0.36	0	40	94.9	2.4
Durango	22	0.025	0	22	63.1	2.8
Canonsburg	15	0.0	0	15	35.8	2.4
Gunnison	6.5	0.052	0	6.5	63.2	9.7
Riverton	5.6	0.55	0	5.6	45.6	8.1
Falls City	2.3	0.040	0	2.3	56.7	25
Shiprock	2.0	0.0	0	2.0	22.9	11
Tuba City	1.9	0.070	0	1.9	34.9	18
Mexican Hat	1.3	0.029	0	1.3	53.2	41
Naturita[e]	0.91	0.072	0	0.91	59.8	66
Lakeview	0.27	0.022	0	0.27	32.6	120
Ambrosia Lake	0.086	0.20	0	0.086	39.0	450
Monument Valley	0.016	0.012	0	0.016	23.3	1,500
Lowman	0.013	0.0070	0	0.013	14.9	1,100
Green River	0.007	0.024	0	0.007	21.5	3,100
Slick Rock	0.003	0.085	0	0.003	53.1	18,000
Maybell	0.003	1.2	0	0.003	39.1	13,000
Spook	0.002	0.019	0	0.002	10.3	5,200
Belfield/Bowman[h]	–	–	–	–	10.0	–
SITE TOTALS	**1000**	**3.3**	**1**	**999**	**1,105.2**	**1.1**
VICINITY PROPERTIES[f]	**290**	**0.019**	**0**	**290**	**345.2[g]**	**1.2**
GRAND TOTALS	**1290**	**3.3**	**1**	**1289**	**1,450.4**	**1.1**

TABLE I. FOOTNOTES

a. Calculated by taking the total excess health effects estimated from continued exposure under conditions of no remedial action occurring over 100-year period of time minus the total excess health effects estimated during and after the proposed remedial action for 100-years, resulting in the net number of radiological health effects prevented by the remedial action.

b. Nonradiological fatalities are those fatalities associated with the transport of tailings and/or borrow materials and that may occur at the construction site. As of October 1996, there had been only one such fatality associated with remediation that occurred at the Grand Junction site.

c. The total project cost includes all costs associated with the UMTRA Project, which includes Technical Assistance Contractor (TAC) management, Remedial Action Contractor (RAC) management and construction, all subcontractor costs, surveillance and maintenance costs, but does not include DOE staff costs. Project costs are in escalated dollars derived from the FY 1998 federal budget submission. Vicinity property costs are shown separately.

d. These costs exceed the project cost when the average death per site prevented by the UMTRA Project is less than 1.0. The subtotal costs are derived from the total project cost divided by the total number of deaths.

e. Projected cancers averted for Naturita were not updated with the new risk coefficients because information presented in the Environmental Assessment (EA) was not separated into radon daughter/gamma components that could be easily modified.

f. Vicinity property evaluations of costs are projected for the duration of the UMTRA Project. Vicinity property evaluations of deaths prevented are evaluated based on the number of properties included in the UMTRA Project to date. The estimated cost/death for vicinity properties presented in Table 1 may exceed the actual cost/death due to the use of the highest indoor and outdoor gamma exposure rates in calculating the number of cancer deaths averted.

g. Estimated total cost for engineering and remedial action of vicinity properties at project completion (FY 1998 federal budget).

h. The state of North Dakota requested that the Belfield and Bowman sites not be remediated as part of the UMTRA project. Therefore, no cost-benefit analysis was made.