VOLUME 7 NO. 2 JANUARY 1999

Science for Democratic Action

AN IEER PUBLICATION

Cleaning Up the Cold War Mess

BY: ARJUN MAKHIJANI AND MARC FIORAVANTI

Information in this newsletter is based on IEER's 1997 report, Containing the Cold War Mess, *unless otherwise noted.*

The production of 70,000 nuclear weapons over more than fifty years in the United States[1] has created huge volumes of long-lived radioactive waste, decommissioning problems associated with thousands of facilities, and environmental concerns involving contaminated land and water. The Department of Energy (DOE) is responsible for managing some 36 million cubic meters of radioactive and hazardous wastes in a wide array of forms and storage configurations at 137 sites. DOE manages 5,000 excess (non-operational) buildings and facilities, and will be responsible for some 15,000 more as currently operating facilities are shut down.

ROBERT DEL TREDICI

Drums of transuranic waste slated for WIPP stacked inside a storage dome at Los Alamos National Laboratory in New Mexico (1994). The collective wisdom of the nuclear establishment has yet to produce a satisfactory solution to nuclear waste storage and management.

Weapons production and related activities have contaminated 79 million cubic meters of soil and almost 2 billion cubic meters of groundwater (enough to fill a lake 100 square kilometers in area and 20 meters deep). Additionally, DOE manages an estimated 820,000 metric tons of miscellaneous materials, including 585,000 metric tons of depleted uranium, mostly in the form of uranium hexafluoride.[2]

Since 1989, DOE has carried out an environmental management program explicitly aimed at addressing contamination associated with the nuclear weapons complex. The current annual budget of the program is approximately $6 billion. In 1996, DOE calculated the cost of clean-up over the next three-quarters of a century at $227 billion. That is a partial tally, leaving out currently operational sites, for instance. Estimates for the total cost have varied from about $100 billion, in the early years before the problem was well understood, to $1 trillion. To date, DOE has spent about $40 billion. While this is a great deal of money, these sums should be considered in the context of overall expenditures of nuclear weapons since 1940, estimated at about $5.5 trillion in 1996 constant dollars. (This includes Pentagon expenditures such as those on delivery systems).[3]

Why do clean-up?

Clean-up problems are so complicated and costly that there is a tendency in the nuclear establishment to simply bury the problem, literally and figuratively. There continue to be discussions about declaring severely contaminated sites "national sacrifice zones." Besides being unnecessary, this would be unjust to the communities that have already borne an enormous burden from nuclear weapons development. Sacrifice zones would also be dangerous in that abandoning the sites without cleaning them up would threaten precious water resources and pose security risks.

A number of other factors necessitate ongoing monitoring and expenditures of billions of dollars per year. For example, there are security issues associated with the large quantities of plutonium in waste and in shut-down facilities. The continuing dangers of fires and explosions, such as the one

SEE **COLD WAR MESS,** PAGE 2
ENDNOTES, PAGE 22

INSIDE

COLD WAR MESS

FROM PAGE 1

that occurred in the Hanford Plutonium Finishing Plant in May 1997, also need to be addressed. The question is not whether spending taxpayer dollars can be avoided altogether. It cannot. That is part of the cost and the legacy of the Cold War. The question is how the spending of it shall be carried out effectively to achieve health, environmental and security goals for this and future generations.

"Clean-up" of the nuclear weapons complex actually includes two separate but interconnected parts. Short- and medium-term *environmental remediation* efforts focus on reducing and, if possible, eliminating serious and urgent dangers. The dangers include risks of fires and explosions in high-level waste tanks and rapid migration of radionuclides through soil and groundwater. Remediation efforts are essential to protecting valuable land and water resources, such as the Columbia River and the Ogallala, Snake River Plain, and Tuscaloosa Aquifers.

Complementing these efforts is *long-term waste management* designed to take care of the wastes from past operations and from remediation of the complex. These two aspects of the work need to be coordinated so that short-term actions do not jeopardize long-term efforts.

Harmonizing short-term and long-term goals

There is some inherent tension between environmental remediation and waste management: the more thorough the local clean-up, the larger the volume of contaminated materials that will have to be managed as waste. Decommissioning of highly contaminated facilities, long-term protection of groundwater from reckless dumping practices of the past, and solidification of highly radioactive waste will result in substantial volumes of long-lived radioactive waste. (These processes do not create new radioactivity, but put existing radioactivity in new forms to be managed with the objective of risk reduction.)

Since there is no practical way to get rid of radioactivity,[4] it is necessary to reduce risk by treating contaminated areas and facilities, removing or extracting the radioactive contaminants in them, and then managing the resulting wastes carefully, isolating them as much as possible from the environment. Environmental remediation efforts must keep one eye on minimizing current risks and keep the other steadily fixed on long-term waste management. Unless the remediation actions taken are compatible with sound long-term waste management, they may simply lay the basis for future problems. Indeed, it is past irresponsible waste management and disposal practices dominated by short-term expediency that have created some of the most serious clean-up problems of today. The most important examples of this are the high-level waste in the tanks at Hanford, buried transuranic (TRU) wastes, and contaminated aquifers at many sites due to poor waste discharge and dumping practices.

DOE continues to operate without having internalized this simple principle. For instance, at the Fernald site in Ohio, DOE implemented a short-term solution to manage silos containing radium-contaminated waste which has greatly complicated efforts to retrieve waste from the silos to process them into a form more suitable for long-term manage-

SEE COLD WAR MESS, PAGE 3

SCIENCE FOR DEMOCRATIC ACTION

Science for Democratic Action is published four times a year by the Institute for Energy and Environmental Research:

6935 Laurel Avenue, Suite 204
Takoma Park, MD 20912, USA
Phone: (301) 270-5500
FAX: (301) 270-3029
E-mail: ieer@ieer.org
Web address: www.ieer.org

The Institute for Energy and Environmental Research (IEER) provides the public and policy-makers with thoughtful, clear, and sound scientific and technical studies on a wide range of issues. IEER's aim is to bring scientific excellence to public policy issues to promote the democratization of science and a healthier environment.

Thank You to Our Supporters

We gratefully acknowledge our funders whose generous support has made possible our project to provide technical assistance to grassroots groups working on nuclear weapons-related issues, and our global outreach project.

W. Alton Jones Foundation • John D. and Catherine T. MacArthur Foundation • Public Welfare Foundation • C.S. Fund • HKH Foundation • John Merck Fund • Ploughshares Fund • Unitarian Universalist Veatch Program at Shelter Rock • Town Creek Foundation • Beldon II Fund • Turner Foundation • New Land Foundation

Thanks also to the SDA readers who have become donors to IEER. Your support is deeply appreciated.

Credits for This Issue

Production and graphics: Pat Ortmeyer
Photos: Robert Del Tredici
Tank graphic p. 19: DOE

Science for Democratic Action is free to all readers.

Managing Editors: Pat Ortmeyer and Anita Seth

FIRE, CEMENT, AND PLUTONIUM-LACED SOLVENTS AT THE SAVANNAH RIVER SITE

About half-a-million gallons of plutonium-contaminated spent solvent consisting of kerosene and tributyl phosphate was generated as a result of reprocessing operations at the Savannah River Site. Of this, 370,000 gallons were burned in open, smoky fires during the 1950s and 1960s. In 1975, five years after the requirement for retrievable storage of transuranic (TRU) waste, the site reported that 150,000 gallons of spent solvent were kept in a couple of dozen tanks. The transuranic content, according to site figures, appeared to be on the order of 150 nanocuries per gram. The site now reports that about 40,000 gallons are stored in new tanks, but there is no clear account of the balance of 110,000 gallons. Some may have been burned in an incinerator during the late 1970s or early 1980s.

The radiation doses from the open burning of waste highly contaminated with plutonium need to be evaluated as part of the assessment of the health impact of the operation of the Savannah River Site.

Some of the tanks that were once used to store this solvent have been emptied by spraying water in the tanks and pumping out the liquids. Several tanks have been "closed" — that is, filled up with cement and left in place in the New Burial Ground at the site. The final radionuclide content of these tanks was not estimated before closure. DOE is now in the process of characterizing the residual spent solvent in twenty-two tanks in the Old Burial Ground, and planning for "closure" of these tanks as well.

Pouring cement into the tanks while there are still wastes containing plutonium in them is highly inappropriate. It will leave a festering problem that will be extremely difficult to deal with should the integrity of the tanks be compromised, as it almost certainly will be before the residual plutonium in them decays. The cementation of the tanks as a method of decommissioning is an example of how DOE's "solutions" of today are laying the foundations of the clean-up problems of tomorrow — in the same manner that past mismanagement created serious problems today.

COLD WAR MESS

FROM PAGE 2

ment (see Fernald case study, p. 9). The DOE is also reprocessing irradiated fuel and target rods that are deteriorating in spent fuel pools at the Savannah River Site in South Carolina with the objective of reducing the risks from these materials. Yet the resultant high-level liquid wastes pose even greater risks in some ways because they aggravate the problem of emptying the high-level waste tanks at SRS and also exacerbate the interim risks from those tanks.

Another example of the long-term problems that DOE is creating relates to the cementation of buried waste tanks containing some reprocessing wastes at Savannah River (see box, this page). DOE is planning similar problematic cementation at Hanford (see case study on p. 5)

Weapons production and related activities have contaminated 79 million cubic meters of soil and almost 2 billion cubic meters of ground-water.

The kinds of waste forms, the technologies and steps used to stabilize waste, and the location and types of waste repositories are all connected issues. DOE's failure to integrate them has in part been responsible for high costs and inadequate results.

IEER's clean-up report

IEER conducted an overview study of DOE's remediation and long-term waste management efforts and evaluated DOE's Environmental Management efforts in its October 1997 report, *Containing the Cold War Mess*. Part of the impetus for this report was the failure of the DOE to produce a programmatic environmental impact statement (PEIS) for environmental remediation despite a legal commitment to do so (see note #2 on p. 16) and the inadequacy of the $31 million Waste Management PEIS which skirted the major issues.[5] The DOE agreed to review IEER's report and issue a response in 30 days. The response was, in fact, issued after five months (see "The DOE-IEER Dialog on Clean-up," beginning on page 4).

In *Containing the Cold War Mess* we attempted to address the major issues of the environmental legacy of nuclear weapons production through case studies of three different problems, each important in its own way:

- **The Hanford waste tanks**, which are the most expensive and technically difficult single component of environmental remediation in the nuclear weapons complex;
- **Transuranic (TRU) waste** at five seriously-affected sites: Hanford, the Savannah River Site, Los Alamos National Laboratory, the Idaho National Engineering and Environmental Laboratory, and the Oak Ridge Reservation. TRU waste constitutes the most expensive part of the waste management program;

SEE **COLD WAR MESS**, PAGE 4

COLD WAR MESS
FROM PAGE 3

• **The Fernald, Ohio site**, which provides an example of a site where a new technology is being tried to deal with radium- and thorium-contaminated wastes.

These three case studies are presented in more detail beginning on page 5. IEER also examined overall technical and institutional issues cutting across the nuclear weapons complex. Below is a summary of some of IEER's findings of the problems in DOE's Environmental Management program and recommendations for its restructuring and improvement.

Findings

Despite about $40 billion in expenditures since 1989, DOE does not have a clear direction or plan for dealing with remediation and waste management problems. The program is plagued by poor management, huge cost overruns, repeated slippage of deadlines, and a constant parade of plans. (DOE's annual "Five-Year Plans" produced in the late 1980s and early 1990s were replaced by priority lists and planning documents such as "Risk Data Sheets" in the mid 1990s, which were replaced by the "Ten-Year Plan" in the late 1990s. The "Ten Year Plan" has been renamed several times and is now called "Accelerating Clean-up: Paths to Closure.") None of these plans has offered a comprehensive approach to environmental remediation and waste management, and the programs and strategies they recommend raise serious questions.

Nevertheless, an area in which DOE has achieved considerable success has been in characterizing the scope of the environmental problems around the nuclear weapons complex in some detail. At the start of the 1990s, little but the broad outlines were known. A number of efforts have been undertaken since that time to better characterize the problem. For instance, the Plutonium and Highly Enriched Uranium (HEU) Vulnerability Studies (published in 1994 and 1996 respectively) laid out where, how, and in what chemical form plutonium and HEU were stored, and outlined the potential dangers.[6] The plutonium study noted the presence of flammable gases in storage containers for plutonium at Rocky Flats and criticality risks with storage of HEU. Two Baseline Environmental Management Reports (BEMR), published in 1995 and 1996, outlined for the first time the vast scope and cost of the remediation problem on a site-by-site basis and listed the clean-up tasks. Unfortunately, the series was stopped and replaced by the far more limited and less useful "plans" mentioned above, characterized more by political expediency than technical substance.

Another successful DOE effort was the Technical Advisory Panel on the Hanford tanks which expanded the knowledge base from which solutions could be devised, resulting in the remediation of the most serious known risk of tank explosions – that in Tank 101-SY. DOE's *Linking Legacies* report is another important effort that provided an overview of the production of nuclear weapons and the environmental contamination and waste management problems that resulted from it.

Other Findings:
Poor Data Collection

One of the biggest obstacles to further progress on clean-up is the poor quality of DOE's data collection. One example is DOE's data on buried transuranic (TRU) wastes. DOE's plan for the management of TRU waste has been based on an assumption that the radioactivity of "buried" waste was much less than the radioactivity of that which was "retrievable" and of that which DOE intended

SEE **COLD WAR MESS**, PAGE 14

THE DOE - IEER DIALOG ON CLEAN-UP

In October 1997, IEER published *Containing the Cold War Mess: Restructuring the Environmental Management of the U.S. Nuclear Weapons Complex*, a detailed report on the Environmental Management (EM) program of the Department of Energy (DOE). Alvin Alm, DOE's Assistant Secretary for Environmental Management at the time, ordered a thorough review of the analysis, findings, and recommendations of the report. The review was to be finished within 30 days but ended up taking five months to complete and involved thirty DOE staff.

The seriousness with which DOE approached the review represented an important break from its past pattern, and in its reveiw the DOE addressed much of the substance of IEER's analysis. Under the direction of former Assistant Secretary Al Alm and Acting Assistant Secretary Jim Owendoff the EM staff approached the review seriously and cooperatively, and IEER staff worked with them in that same spirit. DOE's extraordinary review process was coordinated and led by Jim Werner and Matt Zenkowich in the Office of Strategic Planning and Analysis.

Upon completion of the review, DOE admitted to a number of problems and committed to undertake three very important efforts, wholly or partly in response to IEER's report:

1. DOE announced a review of aspects of its management of buried transuranic wastes. DOE did not, however, announce how it will involve the public nor set a deadline for its review. In March 1998, IEER suggested that DOE issue technical guidance for compiling transuranic waste data within 30 days and complete its review in 12 months. The DOE has informed IEER that it is producing a new set of data on buried TRU waste. DOE

CONTINUED ON PAGE 14

Case Study #1:
High-Level Waste Tanks at Hanford

The Hanford facility, built in the early 1940s in south central Washington state, was one of two centers of plutonium production for the US nuclear weapons program (the other was the Savannah River Site in South Carolina. Nine plutonium production reactors and five reprocessing plants that chemically separated plutonium from uranium and fission products were built at Hanford between 1943 and 1963. All reactors and reprocessing operations were shut by the late 1980s, though there have been periodic proposals to revive certain operations there, such as tritium production.

TABLE 1: LONG-LIVED RADIONUCLIDES IN HANFORD TANK WASTES

Radionuclide	Half-life (years)	Estimated Total Tank Inventory (curies)*
Carbon-14	5,730	5,300
Strontium-90	29	62,000,000
Technetium-99	213,000	40,000
Cesium-137	30	47,000,000
Uranium:		
U-235	704,000,000	20
U-238	4,460,000,000	460
Neptunium-237	2,140,000	141
Plutonium:		
Pu-238	88	860
Pu-239	24,110	31,000
Pu-240	6,537	8,000
Pu-241	14	50,000
Americium:		
Am-241	432	150,000
Am-243	7,370	19
Curium-244	18	1,600

*Corrected for decay to January 1996.
Source: *Containing the Cold War Mess*, p. 199.

Hanford's five reprocessing facilities resulted in massive quantities of high-level liquid waste containing fission products (such as technetium-99, cesium-137, and strontium-90) and residuals of plutonium, uranium, and other heavy radioactive elements. The scale and complexity of Hanford wastes has made it the most difficult remediation problem in the United States. Approximately 54 million gallons (206,000 cubic meters) of high-level waste containing roughly 200 million curies of radioactivity are stored in 177 tanks at Hanford. (149 of these are single-shelled tanks, 28 are newer double-shelled tanks.) This represents 60% of total high-level waste in the United States by volume (the Savannah River tanks contain the largest amount of radioactivity, with about two-thirds of the total).

About 67 of the single-shelled tanks at Hanford have leaked or are suspected to have leaked. The volumes and radioactivity contents of these leaks are still the subject of considerable uncertainty. Official data have been published from time to time, with estimates of both volume and radioactivity generally increasing as new information comes to light (see tables 1 and 2).

Contamination of the Vadose Zone

The soil column above the water table around the tanks and below them, known as the *vadose zone*, has been contaminated by these leaks. Other dumping has also contaminated the Hanford vadose zone. For instance, large volumes of radioactively contaminated liquids were discharged into the soil and into "cribs" (trenches) built for the purpose. The highly contaminated vadose zone poses a severe risk to the most important surface water resource in the northwest, the Columbia River, which runs through the Hanford reservation. A failure to remediate the vadose zone and to empty the tanks of their radioactive waste would present a continuing threat to the region and its people and economy that could have unforeseeable negative consequences. DOE is moving some of waste from single shell tanks into double shell tanks to reduce the risk of leaks.

Recent data show that contamination from leaking tanks appears to be worse than previously thought. In August 1998, DOE released a report that examined leaks

SEE **HANFORD,** PAGE 6
ENDNOTES, PAGE 19

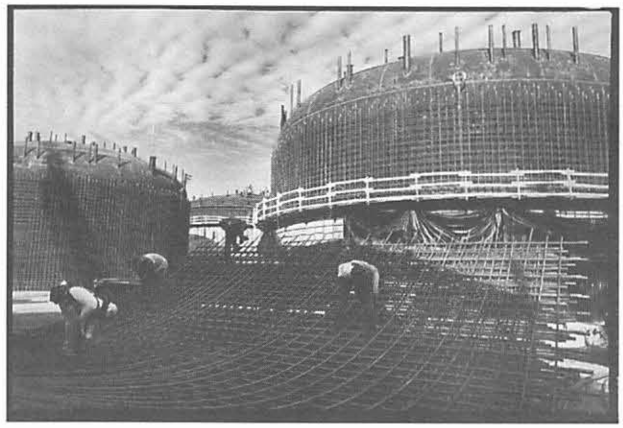
HANFORD

FROM PAGE 5

in the so-called "SX tank farm," concentrating on 5 tanks: 4 that have leaked and one that is believed not to have leaked.[1] The report estimates that 413,000 gallons of liquid contaminated with cesium-137 (a radionuclide with a half-life of about 30 years) have leaked from the four tanks, with a radioactivity level of 1 million curies (upper-bound estimate). The report gives a lower-bound estimate of about half this amount.

The report contains no analysis of the sensitivity of the results to variations in its assumptions about key parameters and notes that there is a great deal of uncertainty, but the new estimates of the volumes of waste that leaked are much higher than earlier ones. The radioactivity estimates are also higher. The previous estimate of the amount of cesium-137 in all the contaminated liquid that has leaked from *all* tanks was approximately 1 million curies. Table 2 shows various estimates of volumes of liquids that have leaked from these four tanks.

Efforts to establish a scientifically-sound approach to contamination of the vadose zone, begun recently by Undersecretary of Energy Ernest Moniz, must continue to receive high priority and attention. A thorough reconsideration of tank waste retrieval and tank decommissioning is also needed, since current plans appear to rely on groundwater models that have been invalidated by recent investigations and disclosure of data regarding radionuclide migration and leaks.



ROBERT DEL TREDICI

Construction of a one million gallon double-walled carbon-steel tank in the 200-Area Tank Farm at Hanford, 1984.

Tank Remediation

All of the leaking tanks at Hanford are "single-shell" tanks — i.e. tanks that do not have a second complete steel containment vessel enveloping the inner tank (see diagram, page 19). In total, the 149 single shell tanks (all beyond their design lives of 25 years) contain roughly 5,700,000 gallons of pumpable liquid. An important part of DOE's tank management involves pumping liquids from the single shell tanks into double shell tanks in order to prevent further leaks.

The process faces challenges, however. Liquids are present in the tanks as *supernatant* and *interstitial* liquid. Supernatant occurs on top of the sludge and saltcake (waste that has crystallized into chemical salts) in the tanks. Supernatant can be somewhat straightforwardly pumped from the tanks. But interstitial liquid occurs in the pore spaces of the saltcake and sludge and is more difficult to pump. In fact a considerable amount of liquid might remain in the pores even after extensive pumping. Therefore, it is difficult to ensure against leaks until the tanks are completely emptied.

SEE HANFORD, PAGE 18

TABLE 2:
ESTIMATES OF LEAKAGE FROM FOUR TANKS
(in gallons)

	SX-108	SX-109	SX-111	SX-112
Hanlon 1996 estimate	2,400 to 35,000	less than 10,000	500 to 2,000	30,000
Grand Junction 1996 estimate	35,000	up to 250,000	"no credible leak estimate"	30,000
Agnew and Corbin 1998 estimate	102,000 to 203,000	56,000 to 111,000	14,000 to 55,000	22,000 to 44,000

Sources: Adapted from: *Containing the Cold War Mess*, p. 184. B.M. Hanlon, *Waste Tank Summary Reports*, HNF (formerly WHC), EP-0182, (Richland, WA: US DOE Office of Environmental Restoration and Waste Management, 1996); US DOE, *Vadose Zone Characterization Project at the Hanford Tank Farms, SX Tank Farm Report*, DOE/ID/12584-268, GJPO-HAN-4, (Grand Junction, CO: Grand Junction Projects Office, September, 1996); Agnew and Corbin 1998, page 7 (see footnote #1 for full reference).

Case Study #2:

Transuranic Waste: TRU and Consequences

Until 1970, radioactive wastes heavily contaminated with plutonium and other transuranic radionuclides (elements with atomic numbers greater than that of uranium) were, for the most part, managed in the same way as "low-level" radioactive wastes and dumped into shallow land burial sites. Beginning in 1970, a new waste classification, transuranic (TRU) waste, was created. It was defined as waste containing greater than 10 nanocuries per gram of transuranic elements with half-lives greater than 20 years (relaxed in 1984, to 100 nanocuries per gram).[1] TRU wastes are a concern because of the long half-lives and health dangers of transuranic elements, such as plutonium-239, and have been deemed dangerous enough to be disposed of in a deep geologic repository.

> Data on the volume, mass, and radioactivity of buried transuranic waste and transuranic soil are inconsistent among DOE sites and poor overall.

To further complicate the picture, some sites in the DOE weapons complex had their own definitions of TRU waste prior to 1970 that did not match subsequent Atomic Energy Commission (AEC) or DOE definitions. Some other sites ignored the 1970 AEC rule and continued to bury or otherwise dispose of TRU wastes. For example, between 1966 and 1984, Oak Ridge TRU wastes were mixed with cement and pumped into deep rock formations (a practice called "hydrofracture"), which resulted in contamination of the groundwater. Some of the TRU wastes that were classified as "retrievably stored" were, in fact, improperly managed and have now been designated as "buried waste," as for instance at Oak Ridge and Savannah River. The confusion in regulations and practice and lack of enforcement has complicated clean-up because the various TRU waste categories are now mixed up in burial areas.

In addition, data on the volume, mass, and radioactivity of buried transuranic waste and transuranic soil are inconsistent among DOE sites and poor overall. DOE's data on radioactive waste were, until recently, compiled annually in its Integrated Data Base Reports.[2] However, the data on TRU waste vary inexplicably from year to year and are inconsistent with those reported in other documents (see page 12 for details). For instance at Los Alamos, there are two quite different estimates of the amount of plutonium in the waste — one of 610 kilograms published by DOE headquarters in its report, "Plutonium: The First 50 Years"[3] and the other of 1,375 kilograms published in various other sources.[4] The enormous difference of 765 kilograms – enough to make more than 150 nuclear weapons – has not been explained so far as we are aware.

The DOE has no standard method for collecting and recording TRU waste data, nor has it been able to provide any rationale for the discrepancies. IEER's report demonstrated that DOE TRU waste data were hopelessly flawed and inconsistent for all sites except the Idaho National Engineering and Environmental Laboratory where some effort had been made to develop fact-based data. In five months of effort, the DOE could not provide IEER with evidence of any technical guidance or quality assurance methods used by it or its contractors to ensure the integrity of the data.

The only study of actual records that has been done (conducted for buried TRU waste at the Idaho Lab)

SEE **TRU WASTE**, PAGE 8
ENDNOTES, PAGE 16

WIPP: NO TRU SOLUTION

In the late 1950s, the National Academy of Sciences made a recommendation that highly radioactive waste be disposed of in geologic formations, such as deep salt beds. In the 1960s various areas were explored, and an area near Carlsbad, New Mexico was tested in the 1970s. Congress authorized construction of the Waste Isolation Pilot Project (WIPP) for this site in 1979 and construction began in the 1980s.[1]

In the twenty years since WIPP was authorized, the Department of Energy (DOE) has been trying to open the facility for disposal of some of the transuranic (TRU) waste from its sites. But WIPP faces a number of serious criticisms about its technical suitability as a repository.[2] After years of delay, it has recently been licensed by the Environmental Protection Agency (EPA) to receive transuranic waste. However, it has not yet received a license to receive waste known as "mixed waste," which is a mixture of transuranic waste and chemicals regulated under the Resource Conservation and Recovery Act (RCRA), the US hazardous waste law.[3] The vast majority of waste to be placed in WIPP is considered mixed TRU waste.

In an effort to officially open WIPP, the DOE decided to place 36 drums of waste it considered to be non-mixed TRU waste into the repository.[4] The waste was debris waste, such as used gloves and glovebox parts, rags, plastics, and paper containing plutonium-238 from manufacture at Los Alamos National Laboratory (LANL) of radioisotope thermal electricity generators (RTGs) for

SEE **WIPP**, PAGE 8
ENDNOTES, PAGE 17

TRU WASTE

FROM PAGE 7

estimated that the transuranic radioactivity was nine to twelve times higher than previously estimated and contained three times as much mass of transuranic radionuclides[5] (see discussion in main article on page 14). Despite this startling finding, DOE did little or nothing to try to arrive at better estimates of buried TRU waste quantities at other sites, or to reassess its strategy for managing these wastes. It took the publication of the IEER report for the DOE even to acknowledge that there may be a problem worth examining.

Based on the data available, it seems that roughly two-thirds of the waste is buried in shallow pits and trenches (generally before the 1970 directive ended this practice). The other one-third is kept in "retrievable storage," mostly in covered, above-ground facilities.

DOE is putting most of its TRU waste management money into the area that is least urgent — sending retrievably stored waste to the Waste Isolation Pilot Plant (WIPP) in New Mexico (see box). Of all TRU waste, the retrievably stored wastes pose the least short- and medium-term risks, since they are generally monitored and stored in covered facilities, or are in the process of being moved to such facilities. Newly-generated TRU wastes are also being monitored and retrievably stored. WIPP cannot accommodate the wastes that make up far more of the problem: buried TRU waste and associated highly contaminated soil. This waste threatens many vital water resources, including the Snake River Plain Aquifer, the Columbia River, and the Tuscaloosa Aquifer (located beneath the Savannah River Site). Despite these risks, DOE has put a low priority on buried TRU waste, TRU contaminated soil, and the aquifers they are threatening.

The high priority given to the WIPP repository does not arise out of environmental considerations. Rather it is driven by political and associated legal commitments made during the Cold War, notably to the state of Idaho, that stored TRU waste would be moved to a repository. DOE's commitment to WIPP is in direct contradiction to its stated policy of giving high priority to projects for managing and eliminating "urgent risks."[6] At this stage the most important task, from the standpoint of safeguarding the environment and human health, is the protection of water resources from further contamination and the removal and stabilization of buried TRU waste and TRU soil.

DOE is putting most of its TRU waste management money into the area that is least urgent – sending retrievably stored waste to WIPP.

DOE's few attempts to deal with buried TRU waste have been inadequate and misguided. Rather than develop a comprehensive plan that would begin with careful characterization of the problem and thorough technology development, DOE has wasted most of the relatively small resources devoted to the buried TRU waste problem. It has been pursuing in-situ vitrification, an inappropriate and inadequate technology.[7] Its Pit 9 project at the Idaho

SEE TRU WASTE, PAGE 11

WIPP: NO TRU SOLUTION

WIPP, FROM PAGE 7

the space program. DOE claimed this waste was not hazardous based upon its knowledge of the process used in manufacturing the RTGs. However, IEER's review of DOE's "Acceptable Knowledge" report and its supporting documents found that DOE failed to show sufficient knowledge of waste in the drums to claim it was non-hazardous.

In addition to a number of lapses in the documentation of the waste, which called into question DOE's knowledge of the waste material, there was a serious gap in DOE's technical assessment of the waste. IEER's analysis showed that LANL had failed to properly take into account the chemical changes undergone by certain materials when they are irradiated. This phenomenon, known as *radiolysis* or *radiolytic decomposition*, occurs when materials such as plastics and rubber are irradiated, and results in the formation of a number of new chemical compounds. It also causes the enhanced release of chemicals already present in the waste material (see Dear Arjun, p. 21).

The presence of some of these chemicals in high enough concentrations could cause the waste to meet one or more of the four characteristics of hazardous waste as defined by RCRA (toxicity, corrosivity, ignitability, and reactivity). For example, the presence of hydrogen chloride can cause the waste to be considered corrosive. So while the waste may not have been hazardous when it was initially created, it may have become hazardous due to irradiation while being stored. IEER concluded that some of the waste from LANL's Pu-238 processing most likely met the RCRA hazardous waste definition, which WIPP is not yet licensed to store.

After reviewing the materials submitted by DOE (and those prepared by IEER), the New Mexico Environment Department (NMED), which has jurisdiction over determining compliance with RCRA, decided to require LANL to sample the waste being proposed for emplacement in WIPP order to confirm that it should be classified non-hazardous. While NMED

SEE WIPP, PAGE 17

Case Study #3:

Radium- and Thorium-Contaminated Waste at Fernald

The Fernald site, originally called the Feed Materials Production Center, is located approximately 20 miles northwest of Cincinnati, Ohio. Its main mission was to produce uranium metal for use in the US nuclear weapons program. From 1952 until 1989, nine plants on the site processed a wide variety of uranium-containing materials, such as ore concentrates and recycle materials, and produced large quantities of radioactive and toxic wastes. Wastes were dumped in pits or scrap piles or stored in drums or silos. Production at Fernald ended in July 1989. Cost estimates for total Environmental Management activities at the site have ranged from $3 billion to $5.4 billion, and activities could stretch to the year 2030.

The most dangerous emissions have historically been in the form of radon-222 from Silos 1 and 2, which are tanks that contain large quantities of waste containing radium-226 from the processing of uranium ore. Silo 3 also contains radium-bearing wastes though at lower concentrations. Official studies have noted that there is concern about the structural integrity of the silos and the threat of roof collapse. This and the threat of radon gas emissions makes the remediation of these silos crucial to protection of the health of the communities around Fernald and to limiting worker exposure. A structural failure of the silos and discharge of their contents into the soil could also threaten the groundwater of the region over the long-term.

ROBERT DEL TREDICI

The Feed Materials Production Center (Fernald Site). The silos are not visible, but are located off the lower left edge of the picture.

Actions taken so far have been, at best, temporary palliatives. At worst, they have been complete failures that have increased risks due to delays. For instance, in 1991 a layer of clay was added to the top of the material in the silos to try to reduce radon emissions. This succeeded temporarily, but the clay proved not to be an effective cap over the waste, and emissions are now back up. Furthermore, the clay will considerably complicate the job of actually emptying and decommissioning the tanks. We believe that a better approach would have been to install a tornado-resistant enclosure, estimated to cost $5 million and require 10 months to implement. This would have reduced short-term emissions without complicating long-term remediation. But adding a layer of clay was cheaper in the short-term.

During 1998, the DOE came up with yet another plan. Since the silos are deteriorating, it now wants to build a new set of tanks so that the wastes can be transferred to them. If successful, this would create new "temporary" storage that would eliminate the risk of short-term and medium-term large radon releases. However, the transfer of wastes could prove to be technically difficult, as it has in past attempts, due in part to the nature of the wastes. Thus, DOE is pursuing another untested approach on a large scale without having done sufficient preliminary work. Moreover, the problems with waste handling in the failed pilot plant project should have made the DOE more cautious about launching into a massive project on silo waste transfer without more technology testing. (See discussion under "Monumentalism" in main article, page 15.)

For long-term remediation the DOE chose, in a December 1994 Record of Decision, to "vitrify" the silo wastes (though by that time design of a pilot vitrification plant was already underway). DOE unfortunately uses the term "vitrification" in two quite different ways. The first refers to mixing a relatively small quantity of radioactive material into a large volume of molten glass

SEE FERNALD, PAGE 10

FERNALD
FROM PAGE 9

and making real glass logs laced with radioactive materials. The second is to take a large volume of radioactive waste, consisting principally of various kinds of soil, and convert the mix into a glass-like substance. In the former case, the glass-making is well-understood. Only the technologies to prepare and mix the radioactive materials with the molten glass need to be developed (and in some cases they already have been). In the latter case the composition of the "glass" cannot be controlled, and hence the "vitrification" technology itself needs to be developed. DOE's plans at Fernald involved the latter, much more uncertain, type of vitrification. (In this article we use the term in its latter meaning – conversion of radioactive soil into a glassy material.)

This project failed completely, largely as a result of serious technical mistakes by DOE and its contractor, Fluor Daniel Fernald.

Despite the fact that the waste in the silos was not fully characterized and a novel vitrification technology was being proposed, DOE and the contractor decided to "fast-track" the pilot plant project by proceeding with simultaneous design and construction. This led to significant problems. For example, the melter delivered by a subcontractor did not match the preliminary designs that Fluor Daniel Fernald had used in its construction of the rest of the pilot plant.

The technical failures at Fernald have been as bad as the managerial failures. Materials used in the melter, particularly molybdenum disilicide "bubbler tubes," were incompatible with the high-lead content of the waste. As a result, the melter was destroyed part-way through the first of two phases of pilot plant testing. This dramatic failure is of even greater concern because project personnel identified the exact issue that led to destruction of the melter during technical reviews, yet it was not resolved.

Despite the fact that the waste in the silos was not fully characterized and a novel vitrification technology was being proposed, DOE and the contractor decided to "fast-track" the pilot plant.

Cost and schedule increases

Contractor and DOE failures led to significant cost increases for the Vitrification Pilot Plant. In February 1994 the pilot plant effort was estimated to cost $15.8 million. By June 1996, the cost estimate for completion of all Pilot Plant testing was $66 million — a four-fold increase. Through November 1996, $50 million had been spent. In December 1996, during Phase I of testing (which only involved non-radioactive simulants of the waste in the silos), the accident that destroyed the melter rendered the pilot plant useless for future work.

Had the melter not failed, the $66 million estimate in June 1996 would surely have been exceeded because major modifications would have been necessary to prepare for tests involving actual radioactive waste from

SEE FERNALD, PAGE 11

ESTIMATED RADIONUCLIDE CONTENT OF SILOS 1, 2, and 3
principal radionuclides only

mean concentration, picocuries per gram

Radionuclide	Silo 1 (3,240 cubic meters)	Silo 2 (2,845 cubic meters)	Silo 3 (3,890 cubic meters)
Lead-210	165,000	145,000	2,620
Polonium-210	242,000	139,000	(not listed)
Radium-226	391,000	195,000	2,970
Thorium-230	60,000	48,400	51,200
Uranium-234	800	961	1,480
Uranium-238	642	912	1,500

Note: Volumes for Silos 1 and 2 do not include 357 and 314 cubic meters, respectively, of bentonite clay. Bentonite clay was not added to Silo 3.
Source: D. Paine (Silos Project Manager), *Operable Unit 4: Project History and Status Presentation*, Fernald, OH: Meeting of Independent Review Team, November 14 1996, pages 8 and 11. (Adapted from *Containing the Cold War Mess*, p. 224.)

FERNALD
FROM PAGE 10

the silos. The plant, as built, could not have handled radioactive materials without high levels of worker exposure.

As costs mounted during design and construction of the Pilot Plant, DOE and Fluor Daniel Fernald began to revise their estimates for the full-scale vitrification facility. In January 1996, cost estimates for the whole project had more than tripled from $92 million to over $300 million. In April 1997, Fluor Daniel Fernald estimated the total cost to range between $376 and $563 million (This estimate involved substitution of cementation for vitrification as the treatment method for Silo 3 waste.) Additionally, the estimated completion (including decontamination and decommissioning) had slipped by nine years — from 2002 to 2011.

Technical, managerial, and financial shortcomings early on in the Pilot Plant project led to attempts to abandon the vitrification treatment selected in the Record of Decision. Changes from vitrification to cementation for all or part of the waste have been proposed even though there seems to be no established, essential technical obstacle to proceeding with a vitrification program for wastes in all three silos. Vitrification, if successful, would likely provide for better waste isolation and smaller final waste volumes.

These changes to the remediation program are being pursued in large part due to supposed cost savings, yet DOE has not made a proper comparison of the alternatives, nor has it adequately explained why treatment cost estimates have changed drastically from those cited in the Record of Decision.

IEER believes that DOE should take the following steps to get its program for treatment of the radium- and thorium-contaminated wastes contained in the Fernald silos on the proper track:

1. The entire remediation program for the silos needs to be put on a sound financial and technical footing. Given prior egregious cost misestimation and escalation and the fact that the project now is estimated to involve hundreds of millions of dollars, a thorough independent review of both the accounting and engineering aspects needs to be carried out before any cost increases are granted.
2. The waste in all three silos should be more thoroughly characterized. Development of vitrification techniques for the waste in Silos 1 and 2 should proceed along a focused, targeted effort in a one- to two-year time frame.
3. DOE should not rush into alternative treatments, such as cementation for Silo 3, given DOE's own evaluation of problems and difficulties with such technologies. Vitrification should still be given top priority.
4. A modular approach to vitrification, which would allow for operating flexibility in order to treat a potentially heterogeneous waste feed, is advisable.
5. DOE should more carefully consider building a tornado-proof roof over the existing silos and constructing a single new tank to establish the feasibility of waste transfer as an alternative to its current plan of building a new set of tanks for holding wastes.

TRU WASTE
FROM PAGE 8

National Environmental and Engineering Laboratory was an ill-advised experiment in "privatization" that led to huge cost increases, technical failure, disputes, and delays instead of actual progress on reducing the risks posed by buried waste.

Justification for leaving TRU waste in shallow land burial rests on an assumption that transuranic elements are relatively immobile in the environment. Based on some laboratory data and computer models that did not reflect field data, DOE predicted that it would take hundreds of thousands of years for the plutonium to travel distances of a few tens of meters. However, rapid migration of transuranic elements has been documented at several sites. A 1995 study at Oak Ridge found "significant and rapid"[8] transport of curium-244, a transuranic element. A 1998 study at Oak Ridge indicates that contaminants show signs of rapid transportation "with little retardation."[9] At the Idaho Lab, americium-241, another transuranic element, has been detected in the Snake River Plain Aquifer 580 feet below the burial areas. Measurements in wells at the Nevada Test Site have provided evidence that plutonium can and does bind to small ("colloidal") particles that may then travel "a significant distance through fractured volcanic rock."[10] Measurements of the soil beneath the high-level waste tanks at the Hanford site show that plutonium has migrated a "surprisingly far distance" and has been measured as deep as 100 feet at elevated concentrations.

In light of our findings on DOE's management of TRU waste, IEER makes the following recommendations:

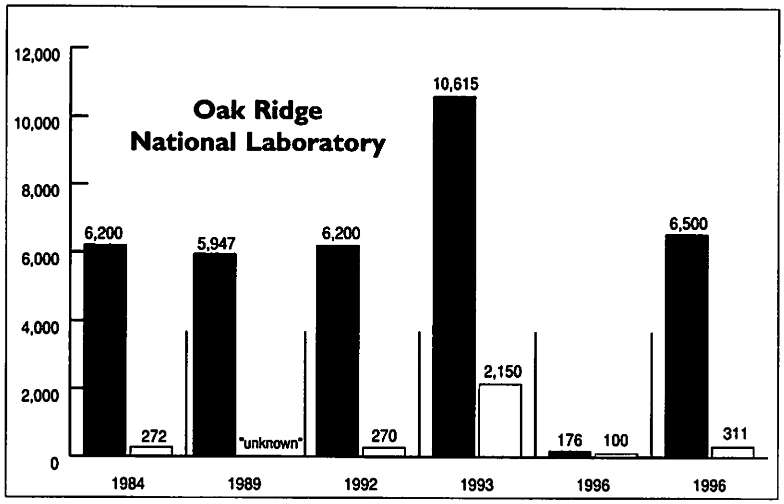
SEE TRU WASTE, PAGE 16

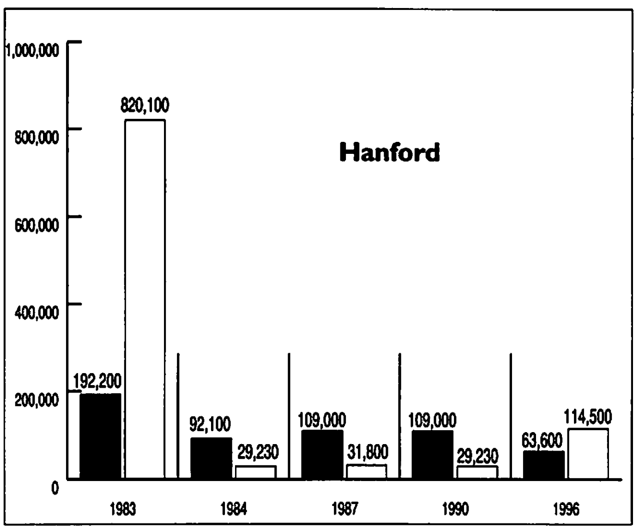
FOLLOW THE BOUNCING DATA:
DOE's Ever-Changing Estimates of Buried TRU Waste

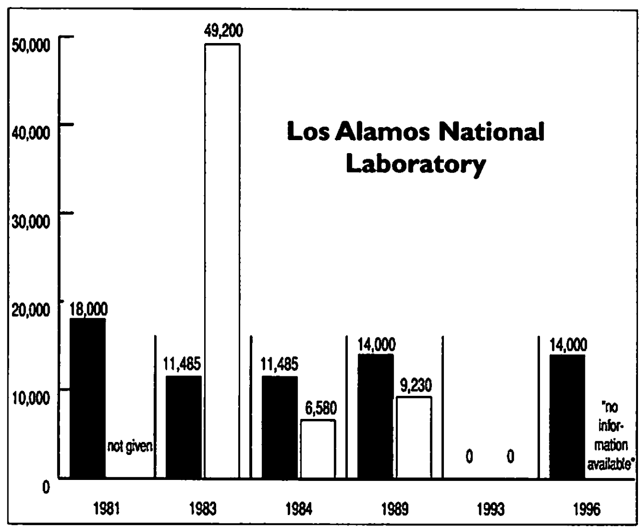
Our review of DOE's data on buried transuranic waste revealed that at many sites, the values given for the volume, radioactivity, and mass of buried transuranic waste often vary from year to year in ways that do not always seem to have reasonable explanations. In general, these changes do not reflect new waste being buried or old buried waste being dug up, but appear to be the result of: 1) re-categorization of waste containing between 10 and 100 nanocuries per gram from TRU waste to "low-level" waste; 2) realization that some "retrievably stored" waste is, in fact, not readily retrievable; 3) re-examination of old records; and 4) mistakes.

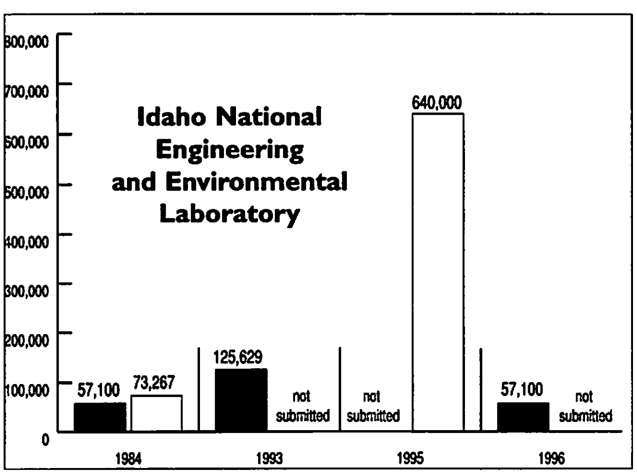
(Source for all charts: *Containing the Cold War Mess*, Chapter 2.)

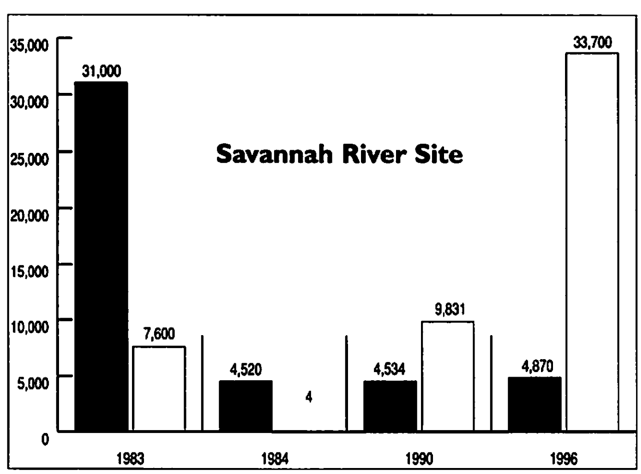
For all charts:
■ = volume in cubic meters; □ = TRU radioactivity in curies











Commercial and Military Nuclear Waste

The data on significant portions of nuclear waste are uncertain or unavailable. There are no reliable overall data on uranium mining waste, though fragmentary data indicate that the amounts are comparable to those of mill tailings in weight or volume. The radioactivity of reject ores and mine wastes per unit weight is generally considerably lower than that of mill tailings.

The uranium mining and milling wastes due to commercial nuclear power generation in the United States are far higher than those indicated in the table. That is because most uranium used in US nuclear power plants is imported (80 to 90 percent in recent years). The environmental impact of US nuclear power plants therefore extends considerably beyond its borders. Canada, Australia, and the countries of the former Soviet Union are the main suppliers to the United States.

Transuranic wastes are generated mainly in plutonium separation (reprocessing) as well as processing and fabrication of separated plutonium into nuclear weapons or commercial products. The transuranic wastes in the DOE are mainly from nuclear weapons production. However, some fraction of DOE high-level waste is due to the separation of plutonium-238 for commercial purposes (mostly NASA radioisotope thermal electricity generators). There are no data available for transuranic waste generated during the operation of the commercial reprocessing plant at West Valley, New York (1966-72).

Official data on TRU waste generated by nuclear weapons production are unreliable and internally contradictory. The DOE database shows that buried TRU waste has a total radioactivity greater than 0.14 million curies. However, the only technically reasonably survey of buried TRU wastes concluded that there are between 640,000 and 900,000 curies of radioactivity in TRU waste buried at Idaho alone. Hence the DOE's figure of greater than 0.14 million curies of radioactivity for buried TRU waste is utterly misleading. We have added a figure of 0.6 million curies for Idaho buried waste to the DOE figure of 2.6 million curies for retrievably stored TRU wastes to come up with the estimate of greater than 3 million curies (rounded to one significant digit).

NUCLEAR WASTE, 1996

	Mining[a]	Milling	Low-level	TRU	High-level	Spent Fuel
Weight/volume:						
nuclear weapons	~100 million MT	100 million MT	3 million m^3	>200,000 m^3	345,000 m^3	2,483 MT
commercial	~130 million[b] MT	130 million[b] MT	1.8 million m^3	not available	2,000 m^3	34,300 MT
Radioactivity (curies):						
nuclear weapons	10,000[c]	100,000	>12.1 million	>3 million[d]	880 million	not available
commercial	10,000[c]	~100,000	>5.1 million	not available	23.6 million	~30,000 million

Sources:

Military figures: Stephen I. Schwartz, ed., *Atomic Audit*, (Washington: Brookings Institution Press, 1998), p. 375, Table 6-1.

Other data taken or estimated from *Integrated Data Base: US Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-006 Rev. 12 and Rev. 13, Table 0.3; and *Containing the Cold War Mess*.

Notes:

- Figures are rounded to the number of significant places implicit in each case.
- The symbol ">" means "greater than".
- MT = metric tons; m^3 = cubic meters

a. Weight of mining waste assumed to be roughly equal to the weight of mill tailings.
b. Commercial mining and milling wastes are far more than indicated in the table. See text.
c. Mining waste specific activity assumed to be one-tenth that of milling waste.
d. For TRU waste, radioactivity figure combines the estimate of TRU radioactivty at the Idaho site plus the DOE estimate of retrievably stored waste.

COLD WAR MESS

FROM PAGE 4

to generate over the next 30 years. However, the only comprehensive analysis of historical records relating to buried transuranic waste that we found was performed for the Idaho Laboratory and completed in 1995.[7] This study estimated that there was between 640,000 and 900,000 curies of buried TRU waste at the Idaho Lab, compared to the previous estimate of 73,300 curies.[8] Therefore, buried TRU waste at this site alone was within a factor of two of the total alpha-emitting radioactivity in all stored TRU waste, estimated by the DOE to be 1,100,000 curies. And buried waste poses a far more serous immediate hazard since it is threatening vital groundwater resources with contamination.

Data on TRU waste from other sites varies wildly from year to year without scientifically plausible explanations (see page 12). In its five-month review of *Containing the Cold War Mess* DOE did not come up with a single technical document to explain how TRU waste data were, in fact, generated. We do not know of any technical guidance issued by DOE to the sites around the weapons complex to guide data collection. Since the publication of *Containing the Cold War Mess*, the DOE has embarked on another effort to collect TRU waste data, but there is still no sound technical guidance to ensure the quality of the information. Whether the result will be any more meaningful than past data compilations remains to be seen.

The situation with TRU waste is emblematic of a larger problem. So far as we have been able to determine, DOE has not made any significant quality control efforts to provide consistent, correct data to the public. We have found many serious inconsistencies in the data published by DOE. For example, there is a disparity between the waste volumes estimated in the Stockpile Stewardship and Management Programmatic EIS and those used in the Waste Management Programmatic EIS.

Misplaced Priorities

DOE's determination to hold on to Cold War levels of spending for military purposes has created a situation where its priorities for "clean-up" do not correspond systematically to urgent problems. In some cases DOE adopts unsound but politically expedient approaches to problems that will persist for thousands of years. One of the most important examples is the focus of TRU waste management efforts on the Waste Isolation Pilot Plant (WIPP) rather than on addressing the more dangerous problem of buried wastes (see box on WIPP, beginning on page 7).

Furthermore, DOE has shown a persistent devotion to maintaining and increasing nuclear weapons production capabilities at the expense of health and the environment. A number of Cold War technologies are being perpetuated through the Environmental Management program. For example, the re-start of the F and H reprocessing canyons at the Savannah River Site in 1996 has more to do with maintaining reprocessing capability than environmental management. Though it is allegedly to deal with leaking and corroding spent fuel rods, reprocessing generates more separated plutonium and high-level liquid waste. These two materials pose among the greatest risks within the DOE complex. The conversion of a reprocessing scheme (called pyroprocessing) for a new type of breeder reactor called the Integral Fast Reactor into a waste management technology is another example of the same tendency.

Monumentalism

DOE continues to rush into large projects without

SEE **COLD WAR MESS**, PAGE 15

DOE-IEER DIALOG, continued

DOE-IEER, FROM PAGE 4

headquarters has called attention to the data quality problems detailed in *Containing the Cold War Mess*, and asked that these problems be remedied. But it has as yet issued no detailed guidelines that would ensure the technical integrity of this data. Currently, buried TRU waste data except those for the Idaho Lab site are utterly unreliable. Further, DOE continues to promote WIPP as the solution to the problem of transuranic waste (see transuranic waste case study, p. 7). As far as we can determine, no fundamental review of the management of TRU waste has been undertaken.

2. DOE is making a greater effort to create a plan for vadose zone remediation at Hanford. Recently-published efforts, such as an in-depth study of leaks from the SX tank farm (see Hanford case study, page 5), indicate that the problem is far worse than it was understood to be in 1996, when DOE completed the Environmental Impact Statement for remediation of high-level waste in the tanks.
3. DOE agreed to take steps to put in place independent review of all major projects.

DOE made a major break from the past by addressing external criticism in a constructive spirit and in making some specific commitments as a result. However, we note that more than one year after the publication of *Containing the Cold War Mess*, DOE's follow-up leaves a great deal to be desired. First, DOE failed to address many

SEE **DOE-IEER**, PAGE 15

COLD WAR MESS

FROM PAGE 14

proper scientific and engineering work. We have called this seemingly endemic tendency "monumentalism."

A good example is the plan to vitrify radium- and thorium-contaminated wastes from three large silos at the Fernald site near Cincinnati. The waste was not well characterized and the treatment technology was not well tested. Yet, DOE and its contractor, Fluor Daniel Fernald, proceeded with simultaneous design and construction of a pilot plant. When the key piece of equipment, the melter, was delivered, some of the parts did not match with what had been built at the site. Furthermore, in December 1996, the melter was destroyed part-way through the first of two phases of pilot plant testing, a failure that is of even greater concern because project personnel identified the potential problem during technical reviews; yet it was not resolved (see Fernald case study, page 9).

Another example is the failure of the in-tank precipitation process for treating and concentrating 90 percent of the high-level radioactive waste volume at the Savannah River site. After $550 million and 14 years of development, the DOE abandoned this project in 1997 as a failure. The process chosen generated large amounts of flammable and toxic benzene that gave rise to new severe risks. The DOE and its main contractors ignored repeated warnings from inside as well as outside observers that it was proceeding far too fast and on too large a scale. After almost two years of study, the DOE still wants to proceed with essentially the same technology using smaller tanks and lower temperatures, at an additional cost of $1 billion.

Privatization

In response to a contracting system that has not yielded the desired performance, DOE is trying an approach known as "privatization." Under privatization, the technical risk for the project is supposed to shift to the contractor, who operates under a fixed-price contract. Supposedly, the contractor would only be paid upon successful implementation of the project — when the "end product" is delivered.

DOE claims that this approach to contracting will drive down costs through competition and also bring in more industrial expertise. But it is grossly unsuited for one-of-a-kind problems posed by projects such as the Hanford waste tanks or the Idaho National Laboratory's Pit 9. DOE finds it difficult to hold contractors accountable for project mismanagement and poor technical decisions. It has often allowed huge cost increases without adequate, detailed, engineering reviews of their basis, as for instance in the Fernald vitrification project.

DOE has chosen to experiment with this new approach to contracting on the largest and most complicated problem in the Environmental Management program. From the start, results at Hanford have not been promising.

SEE **COLD WAR MESS**, PAGE 17

DOE - IEER DIALOG, continued

DOE-IEER, FROM PAGE 14

serious issues raised in the report despite five months of review time. Second, DOE's progress on fulfilling the commitments it did make has been unsatisfactory.

Among the crucial issues that DOE failed address are:

- **The fundamental problems with DOE's TRU waste management strategy:** The total amount of buried TRU waste and soil is far greater and more environmentally threatening in the short- and medium-term than the retrievably-stored waste slated to be disposed of in the WIPP repository.
- **A number of issues relating to waste classification and management:** These include IEER's recommendation that all Hanford waste in the high-level waste tanks be handled as high-level waste, instead of a large volume being planned for on-site disposal as "low-level" waste. IEER presented estimates of the cost of managing Hanford high-level waste in this way. DOE did not respond. DOE did not consider IEER's recommendation that it explore calcining as an interim step for Hanford tank waste, apparently because no contractor suggested it in its menu of options. Instead, DOE continues to insist that calcining be considered as a final step, and then dismisses the idea. In addressing calcining in this way, DOE raises a straw man -- there is no technical literature that suggests that calcining by itself could result a final waste form suitable for repository disposal. Even though DOE failed to review IEER's cost estimates, it clings to the belief that direct production of a final waste form would be more cost-effective. It also failed to estimate the cost or risk of the possibility of failure of its approach, which gambles everything on large-scale application of technologies for final waste forms that have never been tried on waste as difficult and complex as that in the Hanford tanks. These are very serious lapses of internal technical and managerial judgment in relation to DOE's most important clean-up task.
- **Recommendation regarding the repository programs:** IEER recommended that the politically expedient Yucca Mountain and WIPP repository programs be suspended and that in their place a scientifically sound program for long-term high-level waste management be created. This would include geologic repository research, sub-seabed disposal research, and research on engineered materials analogous to natural materials that could contain radioactivity for millions of years. DOE disregarded

SEE **DOE-IEER**, PAGE 19

TRU WASTE

FROM PAGE 11

1. DOE should work with Congress and the affected states to stop the WIPP program and reorient the TRU waste management program to address buried waste and TRU-contaminated soil. Monitoring of retrievably-stored waste should be continued. TRU waste and high-level waste management should be merged into a single program for wastes designated for repository disposal. The Yucca Mountain repository program for high-level wastes should also be cancelled, so that the scientific work on how to isolate both transuranic and high-level wastes from the human environment can be put on a sound scientific footing.
2. DOE should immediately create a program of estimating the volume and activity of buried TRU waste along the lines of the Idaho Lab's effort. The overall effort could perhaps be modeled on the plutonium and uranium vulnerability studies (see main article, page 4).
3. DOE should abandon the strict distinction between the current TRU waste classification (100 nanocuries per gram) and waste with somewhat lower TRU concentrations (10 to 100 nanocuries per gram) and proceed to treat all waste associated with TRU burial areas as TRU waste, unless there is a technically and economically defensible rationale to do otherwise.
4. DOE should examine the feasibility of excavating all buried TRU waste and associated soil and storing it retrievably along with TRU waste that is already classified as retrievably stored. Due to the existing soil and groundwater contamination caused by buried TRU waste, as well as the long half-lives of transuranic radionuclides, institutional controls and caps are especially inappropriate solutions. It is impossible to maintain institutional controls for periods that might approach even a single half-life of plutonium-239 (over 24,000 years) and caps merely cover up the contamination without ensuring its isolation from the groundwater.
5. DOE should pursue a more technically-sound effort to develop safe retrieval technologies for TRU waste. Particular attention should be given to serious hazards that could affect worker safety and health, including explosives and highly toxic materials that may be buried at some sites.

1 The Nuclear Regulatory Commission definition puts the half-life minimum at five years. For anomalies in official definitions, see "The Curious Case of Curium" in *Science for Democratic Action* Vol. 6 No. 1, p. 12.

2 In December 1998, the DOE settled a 10-year lawsuit with 39 public interest groups over DOE's failure to conduct a PEIS for environmental remediation. Among other outcomes, the agreement requires DOE to create a regularly-updated public database on nuclear wastes stored and generated at DOE sites from all department activities. The data is to include waste types, volume, radioactivity, and transportation plans. Also as part of the settlement, plaintiff groups agreed not to bring legal action against DOE based on its failure to conduct a PEIS for environmental restoration and waste management.

3 US DOE, *Plutonium: The First 50 Years: United States Plutonium Production, Acquisition, and Utilization from 1944 to 1994*, (Washington: US DOE, February, 1996), p. 82.

4 DOE Memorandum to Jenny Craig, EM-24, Office of Environmental Management, from Richard J. Guimond, Admiral, Assistant Surgeon General, USPHS, Principal Deputy Assistant Secretary for Environmental Management, and Everet H. Beckner, Principal Deputy Assistant Secretary for Defense Programs, January 30, 1996, Attachment B.

5 Lockheed Martin Idaho Technologies Company, *A Comprehensive Inventory of Radiological and Nonradiological Contaminants in Waste Buried in the Subsurface Disposal Area of the INEL RWMC During the Years 1952-1983*, INEL-95/0310, Rev. 1, (Idaho Falls, ID: Idaho National Engineering Laboratory, August 1995).

6 The Environmental Management program states it as follows "Goal 1: Eliminate and manage urgent risks." US DOE, *Environmental Management 1996: Progress and Plans of the Environmental Management Program*, DOE/EM-0317, (Washington: DOE Office of Environmental Management, November, 1996). See also US DOE, *Accelerating Cleanup: Focus on 2006, Discussion Draft*, DOE/EM-0327, (DOE Office of Environmental Management, June, 1997), p. 2-2.

7 In-situ vitrification involves placing electrodes into the ground in a waste pit surrounded by materials (graphite and glass frit) that act as a "starter path" for an electrical current. The current travels along the starter path material to the adjacent contaminated soil in the pit, causing it to melt. Radionuclides in the soil are either incorporated into the molten soil or are burned off — gases are collected with a hood placed over the area. It can destroy organic toxic material in the soil and immobilize radionuclides. But the glass is frequently of poor quality, and cracks in the matrix could cause rapid leaching of contaminants.

8 R.B. Clapp and J. A. Watts, eds., *Fourth Annual Environmental Restoration Monitoring and Assessment Report (FY 1995)*, DOE/OR/01-1413&D1, (Oak Ridge, TN: Environmental Sciences Division, Oak Ridge National Laboratory, ESD Publication 4463, issued September, 1995), p. 4-20.

9 John F. McCarthy, William E. Sanford, and Paige L. Stafford, "Lanthanide Field Tracers Demonstrate Enhanced Transport of Transuranic Radionuclides by Natural Organic Matter," *Environmental Science and Technology*, web edition (http://acsinfo.acs.org), ASAP article, Nov. 11 1998.

10 A.B. Kersting, et al, "Migration of Plutonium in Groundwater at the Nevada Test Site," in David K. Smith et al, *Hydrologic Resources Management Program and Underground Test Area Operable Unit: FY1997 Progress Report*, UCRL-ID-130792, (Livermore, CA: Technical Information Department, Lawrence Livermore National Laboratory, May, 1998), pp. 76-92.

ERRATA

from SDA Vol. 6 No. 4 / Vol. 7 No. 1 double issue on disarmament

Page 20:

- The row labeled "CTBT Status" in the table "The Nuclear Numbers" should read that Britain has ratified the CTBT, while China has signed it.
- Footnote reference 1 should be added to "India" in the first row of the table, and the note should read: "China and India are the only nuclear weapons states with a no-first-use policy."
- The 160 operational British weapons listed in column 4 of the table are Trident II SLBMs, and should have appeared in the row labeled "missiles."

Page 36:

- The entry for May 11 and 13, 1998 should read that India conducted 5 nuclear tests.

COLD WAR MESS

FROM PAGE 15

For example, only two contractors bid on two available contracts, but as the process wore on, just one was left in the running – British Nuclear Fuels Limited (BNFL). Despite DOE's earlier insistence that three to five bidders were needed to make the initiative a success, it still went ahead with the "privatization." Since the publication of *Containing the Cold War Mess*, DOE has continued down this mistaken path with a $6.9 billion "privitized" contract with BNFL that places more of the liability on the DOE (and hence the taxpayers). This is a highly risky and inappropriate contracting arrangement for this unique and difficult project. It risks repeating on a larger scale the problems that have already occurred in Idaho with the Pit 9 project to retrieve and treat some of the buried transuranic wastes there.

Lack of Clean-up Standards

After having agreed to cooperate with the EPA in developing national residual radioactivity standards and regulations to govern decommissioning, DOE apparently asked EPA in 1996 to stop work on the standards, and EPA agreed. DOE's rationale that site-by-site guidelines would be more appropriate is highly misleading. National standards would provide rules that limit risk to present and future generations from remediation and waste disposal activities. They need not dictate how to assess factors contributing to exposure to radiation specific to each site.

DOE is proceeding in an *ad hoc* way that all but guarantees large discrepancies in protection between sites. For instance, the levels of residual plutonium suggested for the Rocky Flats site "buffer zone" (651 picocuries of plutonium-239/240 per gram of soil) was almost 40 times greater than the plutonium soil levels DOE agreed to for Rongelap and Johnston Atolls in the Pacific, where atmospheric nuclear tests were conducted in the 1950s. This was so controversial that DOE could not implement it, and has now commissioned (via a local panel) the Risk Assessment Corporation to do a $470,000 study.[9]

Lack of a framework for clean-up and waste management

Even after tens of billions of dollars of expenditures and large piles of environmental impact statements costing vast sums of money, the DOE does not have a technically sound, coherent framework for clean-up and waste management. Such a framework would include:

- A set of stringent clean-up standards that protect public health, and safeguards from any residual radioactivity for future generations;
- A waste classification system that corresponds to the hazard and longevity of the radioactive waste and a management system that isolates the wastes from the

SEE **COLD WAR MESS**, PAGE 20

WIPP: NO TRU SOLUTION

WIPP, FROM PAGE 8

has approved LANL's Confirmatory Sampling and Analysis Plan and the results of the analysis, IEER believes the sampling was insufficient to determine whether or not the waste is actually hazardous. Among other problems, DOE did not conduct the necessary tests to determine whether the concentrations of benzene, acetone, vinyl chloride or hydrogen chloride, four compounds IEER identified as being of potential concern, would be above the levels which would render the waste hazardous under RCRA. Given the highly varied nature of the waste, the difficulty in getting representative samples, and the strong probability that some of the waste meets RCRA's hazardous waste criteria, a more prudent approach would be to assume all the drums in question are hazardous.

This issue extends well beyond the original 36 drums of debris waste. Even with a RCRA permit, WIPP will not be able to accept waste which is corrosive, ignitable, or reactive because the WIPP Waste Acceptance Criteria exclude these categories of waste. It is unknown at this time how much TRU waste is ineligible for WIPP because it has become corrosive, ignitable, or reactive during storage. This further calls into question WIPP's suitability as a repository for mixed transuranic waste. And even if these issues are resolved and WIPP opens, it will not address the vast quantities of buried TRU waste and TRU soil in the complex, which pose far greater environmental dangers than does retrievably stored TRU waste. The first priority should be reducing the risks from buried TRU waste and TRU-contaminated soil.

DOE's rush to open WIPP holds many parallels to its repository program for high-level waste at Yucca Mountain. Both programs are technically unsound and should be abandoned. It is far better to admit now that these programs are fundamentally flawed than to put wastes into them in a rushed manner that is driven mainly by political timetables.

1 "WIPP Fact Sheet," US DOE Carlsbad Area Office National Transuranic Waste Program website, www.wipp.carlsbad.nm.us/fctsheet/wippback.htm.

2 See IEER's 1992 report, *High-Level Dollars, Low-Level Sense* and *Containing the Cold War Mess*. Also see SDA Vol. 6 No. 1 page 13. All available from IEER. Portions are also available on our website, www.ieer.org.

3 Waste that is radioactive is regulated under the Atomic Energy Act. Hazardous waste is regulated by RCRA. Waste is considered "hazardous" if it contains chemical compounds regulated under RCRA or if it meets one of the four RCRA characteristics of hazardous waste: toxicity, corrosivity, ignitability, and reactivity. Hazardous waste which contains radioactive constituents is called "mixed waste," which, because it is a type of hazardous waste, is regulated by RCRA.

4 The original 36 drums of waste were repackaged and split into a new total of 116 drums in order to meet transportation requirements for the waste. However, for simplicity we refer to the original 36 drums throughout this article.

HANFORD

FROM PAGE 6

The DOE has adopted the misleading practice of declaring a tank "interim stabilized" even if it still contains up to 50,000 gallons of interstitial liquid. Further, the DOE has no chemical or radiological criteria for declaring the tanks to be "interim stabilized." Since these tanks also contain flammable and/or explosive materials, and since the risk of fires depends on the amount of water present in the tanks, the pumping of liquids out of the single shell tanks (which include both water as well as other liquids) changes the risks both in single shell and double shell tanks. Hence, a declaration that a tank is "interim stabilized" should involve careful consideration of chemical and radiological criteria.

Although removing the liquids from single shell tanks is desirable in order to prevent further leaks, it also creates new concerns such as increasing the temperature in the tanks being emptied and changing the chemistry of the double shell tanks into which the liquids are being pumped. There is also a concern that the process of pumping out liquids may initiate new corrosion in the single shell tanks. As liquids are pumped, new parts of the inner wall of the tank are exposed at the point where the liquid and air meet (the "liquid-air interface"). Electrochemical phenomena that are not yet well understood could cause rapid corrosion at this interface.

Long-term management of tank wastes

In addition to the short-term goal of preventing leaks, it will be necessary in the long term to remove the waste from the tanks and put it into a form that will pose the lowest threat to the environment. DOE's current plan is to remove 99% of the waste volume from the tanks (and possibly more); separate the retrieved waste into high- and low-level waste streams; vitrify (turn into glass) both waste streams, disposing of the high-level waste in a geologic repository and the low-level waste on site. This plan has a number of problems, including that it will greatly increase the volume of highly radioactive waste dumped on the site.

Another problem is that the vitrification program is proceeding without sufficient technical preparation and without a proper back-up plan in case of failure. The DOE awarded a $6.9 billion "privatized" contract to British Nuclear Fuels, Limited (BNFL, a British government owned corporation) to vitrify waste in about 10 percent of the volume of Hanford tank wastes. The contract raises serious questions. First, the technology proposed by BNFL has not been adequately tested on Hanford's unique waste types. Second, construction of the vitrification plant would proceed when overall design work on the facility is less than 50% complete. If the technology fails, US taxpayers will pick up BNFL's costs.

The contract with BNFL also raises safety questions. Safety documents submitted by BNFL for the Hanford contract were described by DOE regulators as "poorly done."[2] In addition, BNFL's record in its home country, where it is covered by the British Official Secrets Act, leaves much to be desired. The DOE has not used the leverage of contracts with BNFL's US subsidiary to raise the issue of making the records of BNFL's British operations public. We believe making these records public is relevant to assessing how it will perform in its US operations.

Because this plan would involve disposal of the vitrified "low-level" waste at Hanford, DOE envisions that waste going to a deep repository would be reduced. DOE has failed to account for the cost of increased local disposal at appropriate open market equivalent prices. Moreover, the so-called "low-level" waste designated for on-site disposal would, in other countries such as Britain or France, be classified as "intermediate level waste" and be designated for deep geologic disposal.

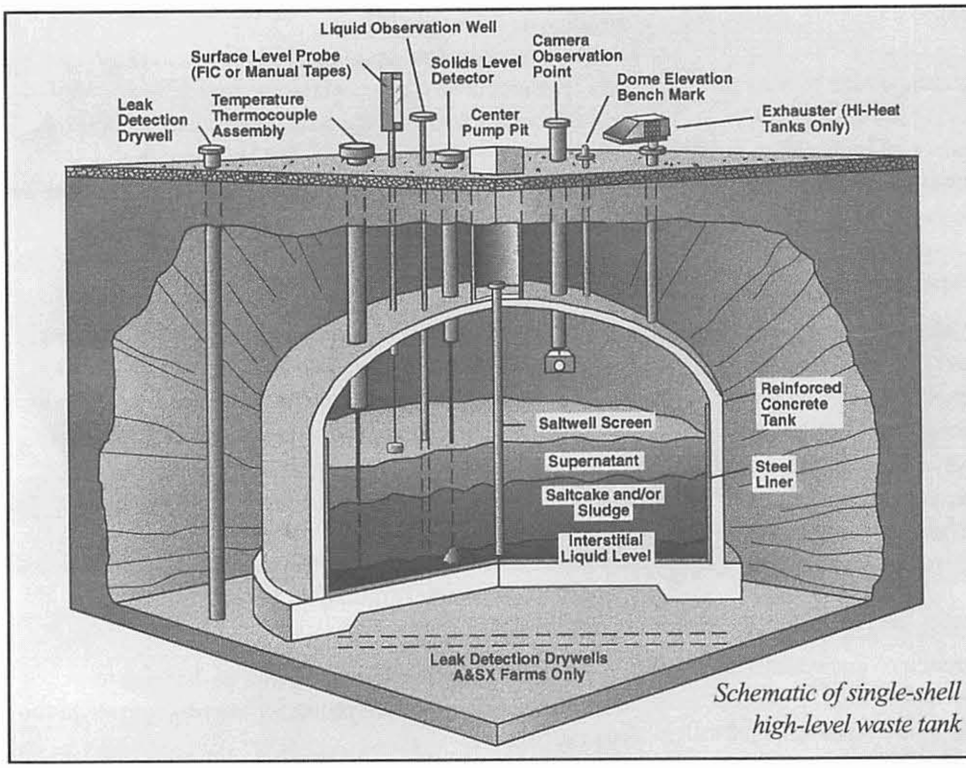
Finally, DOE does not appear to be planning for the decommissioning of the tanks themselves. Rather, the plan appears to call for pouring cement into the tanks after they have been pumped out, even though that process may leave up to one percent of the volume of the highly radioactive waste in the tanks. The radioactivity in this waste could, in many tanks, present a serious long-term environmental hazard. If the waste leaks from the tanks, cementation of the tanks will have created a huge new problem that could greatly complicate any future attempts to remediate the vadose zone.

Of all Cold War wastes in the United States, those at Hanford are the most varied and the problems they pose are the most intractable. According to recent estimates, removal and treatment of Hanford tank wastes will cost about $15 billion. Even this huge amount overlooks several costs, such as those required to decommission the tanks themselves, deal with the contaminated soil around the tanks due to direct discharges and leaks, and remediate the contaminated groundwater. It also does not account for the cost for possible vitrification technology failures, discussed above.

Recommendations

The Hanford tank program needs to be thoroughly revamped. It should shift from the present arbitrary goals to ones that are better suited to environmental protection, and to short- and long-term waste management and disposal. For example, for the purposes of *interim* waste stabilization, DOE should examine

SEE **HANFORD**, PAGE 19



Schematic of single-shell high-level waste tank

HANFORD

FROM PAGE 18

calcining, an approach to solidification of waste that would involve heating the wastes and turning them into a powder form. Calcining would result in a relatively stable waste form and greatly reduced waste volumes and is therefore likely to be more compatible with either vitrification or immobilization in ceramics. Calcine can be stored without the same kind of serious short- and medium-term risks to the environment associated with the current form of tank waste. Despite these potential advantages, the DOE and its contractors have not carefully examined the option of using calcining as an interim method. Rather, they have dismissed it by noting that calcining would not produce a waste form suitable for repository disposal, a fact not in dispute.

Other IEER recommendations are that the DOE examine the following elements more carefully than it has done so far:[3]

- Adopt a goal to process all high-level waste tank contents for management as high-level waste;
- Revamp groundwater models to reflect actual data on vadose zone contamination;
- Initiate two parallel programs for solidification of high-level waste: 1) develop methods for calcining high-level waste while researching ceramic and glass immobilization for the calcine, and 2) pursue pretreatment and specific glass-making approaches that would not require calcining.

Additional IEER recommendations for waste treatment at Hanford address determining the extent of existing contamination in light of decommissioning and decontamination plans (see report).

1 Steven F. Agnew and Robert A. Corbin, *Analysis of SX Farm Leak Histories – Historical Leak Model*, Chemical Science and Technology Division, Los Alamos National Laboratory, LA-UR-96-3537, August 1998.

2 Ms. Gary L. Jones, US General Accounting Office, Testimony Before the Subcommittee on Oversight and Investigations, Committee on Commerce, House of Representatives, *Nuclear Waste – Schedule, Cost, and Management Issues at DOE's Hanford Tank Waste Project*, GAO/T-RCED-99-21; (Washington: US GAO, October 8, 1998).

3 A more complete and detailed set of recommendations can be found in our report.

DOE - IEER DIALOG, continued

DOE-IEER,

FROM PAGE 15

this recommendation for overall restructuring.

DOE has expressed a desire to continue to work with IEER to help it improve its Environmental Management program. IEER will continue to provide DOE with its views as part of this process and remains committed to pursuing a constructive dialog with DOE. To date, the only major programmatic change that has begun to occur in DOE, partly as a result of IEER's work, is the higher priority now being given to the problem of the contamination of the vadose zone at Hanford. This project is essential to the protection of the Columbia River, which flows through the site. We appreciate and recognize that this is a very big, positive change in a crucial program. However, proceeding with a $6.9 billion "privatized" contract for Hanford tank waste remediation without major independent review (see main article), risks considerable delays, cost overruns, technical and legal disputes, and failure.

COLD WAR MESS

FROM PAGE 17

environment for time periods comparable to the duration of the hazard;[10]

- Interim measures for stabilization of high-risk materials and wastes in order to protect vital resources, such as aquifers and surface water bodies from further contamination while long-term measures are being researched, designed, and implemented.

The DOE has none of these elements in place and it is not even headed in the right direction in most cases. DOE has sacrificed short-term safety by rushing into major projects and combining long-term and interim steps. For instance its waste classification system, like that of the Nuclear Regulatory Commission, is a hodge-podge of regulations that defines waste more according to its origin than according to management requirements, longevity, and hazard.

For DOE, "completion of clean-up" will entail an inconsistent and piecemeal approach to environmental remediation and will likely leave "legacy wastes" such as the large volumes of buried transuranic waste at Hanford and the Savannah River Site in shallow land burial. "Completion" is a misleading term that implies many problems will be resolved. In fact, the approach DOE is taking is reminiscent of the short-sighted, expedient approaches that were promoted in the past as waste management "solutions."

Conclusions and Recommendations

IEER's conclusion is that overall, the Department of Energy's environmental management plan is faced with problems that are so fundamental that only a thorough restructuring can cure them. Under the current approach, not only are huge sums of money being wasted, but major programs are failing without lessons being properly learned. Cold War technologies that create more dangerous waste, like reprocessing, are being pursued in the name of Environmental Management. Short-sighted and ill-designed remediation programs are on the course to becoming even larger environmental problems in the future. Even much basic data is of appallingly poor quality, with numbers jumping around from one year to the next and one report to the next without explanation, coordination, quality control, or a scientific review process.

We have come to these dismal conclusions about DOE's programs despite having observed that there are many competent professionals in the DOE system (including its contractors). There is also widespread and deep support in the country for a clean environment, and the communities that are near DOE facilities are no exception. These elements can be a part of the foundation of a sound environmental management program. But they are not enough. Institutional and technical changes will also be needed, as we discuss below.

A restructured program must begin with a thorough reassessment of environmental remediation and waste management programs taken together. The starting point for examination of the options for dealing with the radioactive legacy of nuclear weapons production is that we cannot "clean it up" in the conventional sense of the phrase. Rather, the objective is reduction of risk, which has three aspects:

1. Take urgent action to reduce the risk of environmental or health disasters (such as leaks from or explosions in high-level waste tanks), and further spread of irremediable contamination (such as contamination of sole source aquifers).
2. Contain radioactive waste for periods comparable to the times during which they will remain dangerous.
3. Address both radioactive and non-radioactive waste and clean-up problems and cancer as well as non-cancer health risks.

Our other general recommendations deriving from these three risk reduction principles are summarized in the box on page 24.

In addition, DOE should reverse its decision regarding national clean-up standards and should cooperate with EPA in the setting of stringent standards. Such standards would strengthen accountability to the public on the part of both DOE and its contractors. We suggest that a single framework for environmental remediation and waste management would consist of the following technical elements, among others, when sites are released for unrestricted use:

- a set of remediation standards that apply nationally (but allow for local communities to set stricter standards) and that include protection for health of future generations and the environment;
- the "as low as reasonably achievable" (ALARA) guide for release of sites for unrestricted use should be remediation to background levels, if reasonable, or else to keep doses to under 2 millirem per year (the British ALARA guideline);[11]
- a remediation standard setting a maximum dose of 10 millirem to a future maximally exposed individual (typically a subsistence farmer) for as long as the threat persists, with specific provisions for protection of groundwater as per Clean Water Act regulations;
- systematic consideration of non-cancer risks and synergisms between risks from radioactive and non-radioactive toxic materials, with more stringent limits for some pollutants, if required for health protection.

The same dose and risk guidelines and rules should be followed when sites are released for restricted uses. The

SEE COLD WAR MESS, PAGE 22

Dear Arjun

Dear Arjun,

What is radiolysis and what does it have to do with nuclear waste?

-Wired in Winnipeg

Dear Wired,

For everyone but the nuclear establishment, radiolysis refers to a highly effective hair-removal technique that involves sitting next to a very loud radio and having body hair simply blown off your body. It was popularized by dancers at Radio City Music Hall in the 1950s.

In the nuclear establishment, where hair is relatively scarce anyway, radiolysis refers to something else: a process by which radioactivity breaks down and hence changes chemical compounds.

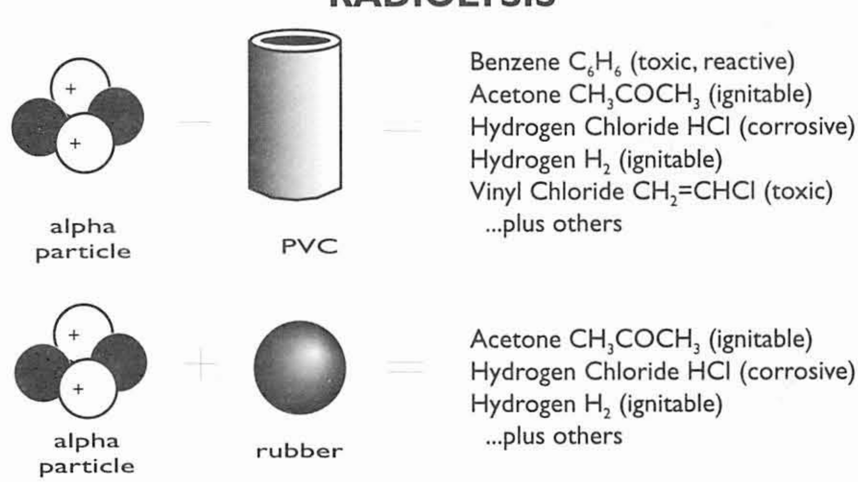
Radiolysis is a principal cause of certain kinds of waste management problems, notably in relation to liquid radioactive wastes and wastes containing mixtures of radioactive materials and non-radioactive chemicals. Chemicals present in the waste break down over time due to the action of radiation unless they are in very stable forms. The breakdown products in turn create new chemical reactions with each other and with pre-existing chemicals. These processes make estimation of the chemical make-up of the waste very difficult. They also frequently result in the generation of hydrogen gas due to the radiolysis of water and of organic compounds, as well as of other toxic and flammable chemicals. Such radiolytic decomposition is one of the main sources of risk of fires and/or explosions in some of the high-level waste tanks at Hanford and Savannah River Site. Build-up of dangerous chemicals due to radiolysis has also affected plutonium storage at Rocky Flats, as well as TRU waste at various sites. One of the problems has been the breakdown of plastics into flammable and toxic gases by radiolysis. Radiolysis can actually render waste more hazardous over time, or it can create hazardous waste from what was originally non-hazardous waste. Furthermore, depending on the half-life of the radionuclide (and decay products), this process can continue for a very long time.

The chemical changes undergone by vinyl-chloride and polyvinyl chloride (PVC), the material used to make items like plastic containers, tubing, and car dashboards (as well as TRU waste packaging) provide an example of radiolysis that results from the production of a wide variety of chemicals. When irradiated by alpha particles, these PVC materials release gases containing molecules such as benzene, acetone, and hydrogen chloride (HCl). Such radiolysis can change the status of waste from initially non-hazardous to hazardous under the Resource Conservation and Recovery Act (RCRA), the United States hazardous waste law (see box on WIPP, beginning on page 7). Wastes can be classified as "hazardous" under RCRA either because of the specific process or chemicals used to make them or because they meet one of the four defined characteristics of "hazardous waste:" toxicity, ignitability, corrosivity, and reactivity.

If RCRA-regulated radiolysis products are created in sufficient concentrations to meet any of the four characteristics, it would render the waste hazardous under federal law. This would mean that the management and disposal of the waste would require a RCRA permit. The RCRA permit would be in addition to other permits and waste packaging requirements relating to the radioactivity of the waste.

Ghost written by Hisham Zerriffi

RADIOLYSIS



Alpha irradiation of PVC plastic and rubber materials produces a number of compounds which have the potential to convert initially non-RCRA waste into RCRA waste.

It pays to increase your jargon power with Dr. Egghead

1. TRU waste:

a) Trash that has accumulated beyond the planet Uranus

b) Movie title rejected by the producers of "True Grit"

c) Best-selling product of the multinational corporation, "Trash R Us"

d) Acronym for *transuranic waste*, a category of radioactive waste containing more than 100 nanocuries per gram of alpha-emitting transuranic radionuclides with half-lives of more than 20 years.

2. vadose zone:

a) Where Darth Vader goes to get spaced out

b) A highly contaminated area inside the headquarters of the Very Active Department Of Security & Energy

c) The area between the endzone and the zero yard line where refs can't tell if a touchdown was made or not

d) The layer of soil above the water table, the contamination of which can threaten groundwater resources and any surface water resources affected by groundwater outcrops.

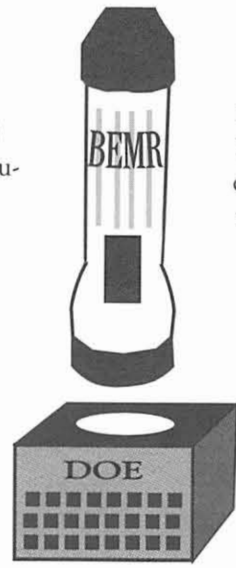
3. radiolytic products:

a) A new division of Sony corporation that produces electronic radios

b) A brand name for a line of radios with lots of lights and buttons

c) Premiums offered by National Public Radio during fundraising week

d) Products of chemical decomposition resulting from the action of radiation on chemicals. (Hydrogen gas resulting from the decomposition of water is an example.)



4. BEMR:

a).A device to project a beam of light into the Department of Energy to see if anyone is home

b) Someone who is always smiling broadly

c) Coveted homemaker's award for individuals making the best use of Sunbeam countertop appliances

d) Acronym for *Baseline Environmental Management Report*. The DOE published two editions of this report, which represented its first attempts to make a comprehensive assessment of clean-up requirements and costs. The production and updating of this useful document was ended in 1996.

5. saltcake:

a) A hearty staple food of the Vikings

b) Official dessert of the Indian independence movement

c) A sweet French pastry whose spelling got confused during transliteration

d) Chemicals that crystallize out of concentrated liquid radioactive waste to form piles of salt. Saltcake is one of the waste forms that has accumulated in high-level waste tanks at Hanford and Savannah River Site.

answers: 1) d; 2) d; 3) d; 4) d; 5) d.

COLD WAR MESS

FROM PAGE 20

main difference between restricted and unrestricted uses should stem from the fact that under restricted use, dose can be limited by institutional and technical means not available in the unrestricted case.

1 This includes weapons produced and then dismantled. At its peak in the mid-1960s, the US arsenal was about 32,000 warheads.

2 US DOE Office of Environmental Management, *Linking Legacies*, DOE/EM-0319, (Washington: Environmental Management Information Center, January, 1997), p. 105, figure 6-1.

3 Stephen I. Schwartz, ed., *Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons Since 1940*, (Washington: Brookings Institution Press, 1998), p. 4. See also *Science for Democratic Action* (SDA) V6N4 /V7N1 (double issue), p. 21. The $5.5 trillion does not include $300 billion estimated by the authors of *Atomic Audit* for future clean-up and waste management costs (excluding any new weapons production activities).

4 Some have advocated transmutation of long-lived radionuclides into short-lived ones. This essentially involves building more nuclear power plants (not necessarily of the type that is common today) as well as complex facilities to separate radionuclides. Such facilities create new problems, new wastes, and huge costs. They also raise proliferation issues. For a commentary on the National Research Council study on transmutation as a waste management technique, see SDA Vol. 6 No. 1, p. 4.

5 The PEIS cost much more that $31 million, but the DOE claimed that part of the cost was attributable to supporting work that would have been needed anyway.

6 These studies were initiated, funded, and conducted by DOE's Office of Environment, Safety, and Health, not the Environmental Management program. The EM program has never conducted such a review of hazards internally.

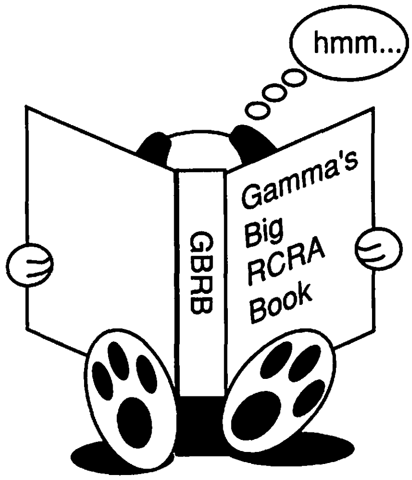
7 Lockheed Martin Idaho Technologies Company, *A Comprehensive Inventory of Radiological and Nonradiological Contaminants in Waste Buried in the Subsurface Disposal Area of the INEL RWMC During the Years 1952-1983*, INEL-95/0310, Rev. 1, (Idaho Falls, ID: Idaho National Engineering Laboratory, August 1995).

8 See *Containing the Cold War Mess*, p. 84. Note that the radioactivity of alpha-emitters is only a portion of the total radioactivity in TRU waste. More than half of the radioactivity in stored waste and an unknown portion in buried waste is from fission products and other radionuclides

SEE **COLD WAR MESS,** PAGE 24

Sharpen your technical skills with Dr. Egghead's
Atomic Puzzler

Gamma at the Lab



Dr. Egghead's trusty dog Gamma was snooping around Los Alamos National Laboratory and came across some plastic waste contaminated with plutonium-238. Gamma wants to figure out if the waste might meet the toxicity criterion for benzene under the Resource Conservation and Recovery Act (RCRA). He weighs the plastic material and finds that it weighs 2 kg. An assay of the material reveals it contains 0.4 grams of Pu-238. After a little sniffing around, Gamma digs up the following information:

- There are 6.4×10^{11} disintegrations per second in one gram of Pu-238.
- Each disintegration is the emission of an alpha particle with ~5.6 MeV of energy.
- There are 6.2 molecules of benzene produced for each MeV deposited into the plastic material.
- Each Benzene molecule weighs 1.29×10^{-19} milligrams.

Can you help Gamma figure out the maximum amount of benzene that could be produced due to radiolysis of the plastic? Gamma has decided to break the question down into pieces:

1. How many disintegrations per second are there in the 0.4 grams of Pu-238?

____

2. How many disintegrations occur over the whole year?

____

3. What is the total alpha particle energy emitted over the course of the year (in MeV)?

____

4. If all the alpha particle energy is deposited into the plastic, how many benzene molecules are created over the course of the year?

____

5. What is the total weight of the benzene produced in the plastic?

____

6. What is the concentration of the benzene in the plastic waste? (Express your answer in milligrams/kilogram.)

____

While you have been doing your calculations Gamma has been looking up the benzene concentration limit under the toxicity characteristic of the Resource Conservation and Recovery Act. According to RCRA, waste is considered hazardeous if the leachate from one kg exceeds 10 milligrams of benzene. If all of the benzene produced were to remain part of the waste and end up in the leachate, would the plastic be considered hazardous under RCRA?

____

Send us your answers via fax (301-270-3029), e-mail (ieer@ieer.org), or regular mail (IEER 6935 Laurel Ave., Suite 204, Takoma Park, MD 20912), postmarked by March 15, 1998. IEER will award 25 prizes of $10 each to people who send in a solution to the puzzle (by the deadline), right or wrong. There is one $25 prize for a correct entry, to be drawn at random if more than one correct answer is submitted. International readers submitting answers will receive a copy of *Dangerous Thermonuclear Quest* in lieu of a cash prize, due to exhange rates.

RECOMMENDATIONS ON CLEAN-UP AND WASTE MANAGEMENT

1. Create a new, rational, environmentally-protective system of radioactive waste classification according to longevity and specific activity, so that comparable hazards are managed comparably.
2. Coordinate waste management and environmental remediation and make reducing short-term risks compatible with minimizing long-term risks.
3. Put an institutional structure into place that is both scientifically and financially accountable and that demonstrably has as its top priority the protection of health and environment, rather than weapons production or perpetuation of Cold War technologies.
4. Suspend the politically expedient Yucca Mountain and WIPP repository programs and put in place a scientifically sound program of long-term high-level waste management.
5. Provide funds and technical support to communities that have residual contamination so that they can monitor the environment and keep themselves informed.
6. Create a rigorous, open, and truly independent procedure for evaluating successes and failures.
7. Manage non-radioactive toxic components of waste in ways that do not seriously compromise management of radioactive components.
8. Make risk reduction for off-site residents and for workers compatible with minimization of risk for future generations.
9. If sound remediation technologies are not available, take interim measures (such as restricting access to sites), make investments in research and development, and create rules that would allow for a future progressive return of sites and resources to general use, if appropriate.
10. Make public all information that was created at taxpayer expense relating to health and the environment, including that produced and/or held by contractors and sub-contractors, and create an explicit public right to this information.
11. Impose stringent financial accountability on the contractors and institute engineering-based methods to review project budgets and large budget increases.
12. Create national clean-up standards and allow state and local governments and Indian tribes to apply stricter clean-up standards.

COLD WAR MESS, FROM PAGE 22

that are not transuranic alpha emitters.

9 DOE provided a $470,000 pass-through grant to the Rocky Flats Radionuclide Soil Action Level Oversight Panel, an independent body which selected Risk Assessment Corporation (RAC) to conduct the study. RAC will assess the calculation of Rocky Flats soil action levels. (Note: RAC was formerly called Radiological Assessment Corporation.)

10 To a certain extent, longevity and hazard in the sense of radioactivity per unit weight are inversely related. Radionuclides with long half-lives have a lower activity per unit weight and vice-versa. However, for a broad class of radionuclides, the half-lives are such that small quantities of the material are highly dangerous and the half-life of the materials very long. Plutonium-239 and radium-226 are examples of such radionuclides, with half-lives of 24,100 years and 1,600 years respectively.

11 "Background" levels in this context mean radioactivity from natural sources plus that from fallout from nuclear testing. However, it should not include radioactive contamination caused by activities conducted on that site.

Science for Democratic Action is free to all readers. IEER is able to provide this newsletter and other resources due in part to the generous contributions of our supporters. If you would like to contribute, simply make your check out to IEER and mail to the address below. Donations are fully tax deductible. IEER is a 501(c)3 non-profit organization.

The Institute for Energy and Environmental Research
6935 Laurel Avenue, Suite 204
Takoma Park, MD 20912

Address correction requested

NON-PROFIT
US POSTAGE
PAID
MERRIFIELD, VA
PERMIT #1112

Printed on recycled paper.

IEER