CALLED THE "STACKER RETRIEVER ROOM," technicians adjust the remote manipulator that gives the room its name. It is used to move the containers of weapons-grade plutonium in and out of the room.

CLEANING UP *the* Cold War Legacy

During WWII and the Cold War, the best engineering and research minds in the United States, with the political and financial support of Congress, created a magnificent machine designed to protect America's security—the Nuclear Weapons Complex. But it was totally focused on the nuclear weapons production mission. It ignored what would happen when the U.S. won the Cold War. As a result, a legacy was created—thousands of tons of the deadliest substances known to the human race, with a half-life of 22,000 years.

Little did I know when I began my career that it would end in a full circle. My first assignment was as XO for an Honest John Battery in Korea—complete with nuclear warheads. Nearly 34 years later, when I retired from government service, it was as the manager of the Rocky Flats Environmental Technology Site, the manufacturing facility for the plutonium-based triggers of America's nuclear arsenal. My career circle included all aspects of the nuclear weapons business—a business that is virtually shut down in America and now wrought with controversy.

In 1945, America used two atomic bombs to end WWII, establishing itself as the most powerful military force on Earth.

This incredible new technology accomplished that and much more—most profound of which was the initiation of a global arms race of massive proportions. It also spun off many peaceful and beneficial applications, ranging from nuclear electric energy to nuclear medicine.

The Manhattan Project is now famous for its unprecedented level of effort, bringing together the greatest minds in the world and producing results with an unparalleled efficiency—building a workable nuclear bomb from scratch in 3 years. Whole cities, complete with infrastructure, were built in this time. For example, at Savannah River Site in Aiken, SC, five nuclear power plants and two chemical processing plants (canyons) were designed and built in less than 5 years for under $3 billion. By contrast, to build a single nuclear power plant today would take between 8–15 years and more than $1 billion.

by
MARK N. SILVERMAN '61
and RAY D. HOESE

Not so well-known is the similar level of effort that came afterward, on a global scale, costing more than $300 billion—as the U.S. and Soviet union each built more than 30,000 nuclear warheads. For the United States, it was a source of great pride that has now turned to prejudice, and, in some corners, shame as we attempt to deal with the "Cold War Legacy" of waste by-products.

America's euphoria over winning WWII came to an abrupt end in August 1949 when the Soviet Union detonated its first nuclear weapon. Just a few months later, North Korea invaded South Korea—the Allies took this as a warning that the spread of communism and its military might was a global threat. The Cold War nuclear arms race was on.

Nobel Prize–winning theoretical physicist Niels Bohr had argued in 1939 that building an atomic bomb "can never be done unless you turn the entire United States into one huge factory." As America began building the facilities required to develop and build these extremely complex weapons, we found Bohr was correct. As the Manhattan Project took wing, 12 mostly remote sites were identified as the engines that would drive America's nuclear weapons machine.

A remote and wind-blown mesa 16 miles northwest of Denver was chosen to produce one of the more significant components of America's nuclear weapons—the trigger, also called a pit or hockey puck for its size and shape. Sites all over the country were designated to produce the other components.

The story of Rocky Flats reflects the story of the Cold War itself—from the buildup of nuclear arms through the demise of the Soviet Union, including the contamination and hazardous waste left behind.

Rocky Flats was late coming on the scene. Los Alamos and the Nevada Test Site had been on-line for years. The uranium processing plants at Oak Ridge, TN, were begun in 1942. Sites in Idaho, California, Missouri, Washington, South Carolina, and Texas already had been built.

The Rocky Flats announcement came in March 1951, a time when Communism was on the move. There was a front-page story in the *Denver Post*—"There's Good News Today—A-Bomb Plant Comes to Denver," it read. According to the article, "The plant will work with radioactive materials but will not complete the process that goes into A-bomb manufacturing." This was the standard for nuclear weapons production. Components and processes were divided up throughout the country. The site near Denver was chosen, in part, for its then-remote location and proximity to the University of Colorado—a resource for technical expertise. Ironically, Boulder later became the center for anti-nuclear and anti-war activists.

"There's Good News Today—A-Bomb Plant Comes to Denver"

For the most part, the plant was welcomed by the local communities because it would provide an economic boost to the rural area. Boulder's (then) mayor called the plant a "wonderful thing for Boulder. It may bring some problems, but they are far out-weighed by the advantages." A local store clerk said, "Anything that can be done for the defense effort, should be done . . ." And the *Denver Post* called the plant "a source of satisfaction to all residents who have an abiding faith in Colorado's destiny and future greatness."

For many reasons—the economic gains and a greater trust in government at the time—the local community paid little attention to the veil of secrecy that surrounded the plant and its operations. Rocky Flats was working with the mysterious and fascinating substance plutonium—a dynamic metal that is fissile, toxic, radioactive, gives off heat, easily changes volume and density with temperature, and, left in the right atmosphere, can burn spontaneously. It also absorbs water and rusts. These characteristics made processing and manufacturing the metal a very complex, difficult, and dangerous job.

Rocky Flats received the plutonium metal from other sites and shaped it into triggers—the heart of a nuclear weapon. It also included non-nuclear production activities, such as metal working and fabrication and stainless steel and beryllium component manufacturing. At one point, Rocky Flats machined depleted uranium for the armor-plating on the M1A1 Abrams Tank.

In the push to win the Cold War, thousands of tons of waste began to accumulate, especially in the late 1980s—not just at Rocky Flats, but at many Department of Energy (DOE) facilities. (See Table 1.)

[It should be noted that the U.S. atomic weapons program was originally controlled by the Atomic Energy Commission, which became the Energy Research and Development Administration, which, in 1977, became the Department of Energy.]

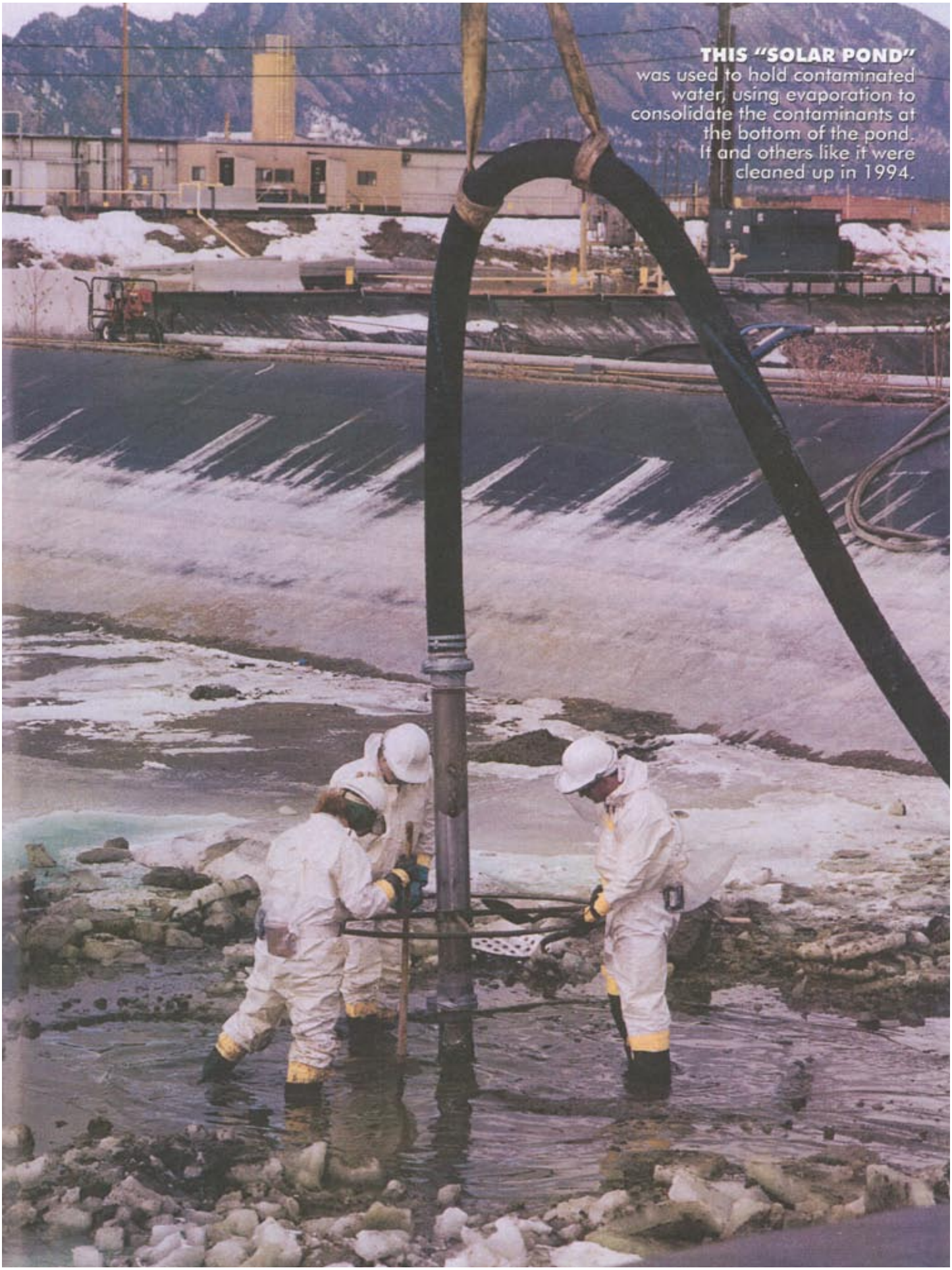
Every site in the DOE complex is contaminated to some extent, not only in buildings, but also in soil, air, groundwater, and surface water at some sites. At the Hanford site in Washington, tritium has been detected in groundwater, and high-level waste has leaked from storage tanks. At Oak Ridge, an estimated 1,000 tons of mercury have been released into the environment. At Fernald, OH, several hundred tons of uranium dust were dispersed into the air and drinking-water wells were contaminated.

The larger-than-football-field-size buildings used for reprocessing spent fuel at the Hanford Site and the Savannah River Site are so contaminated with radioactive material that decontamination must be done by remote control. Some of the rooms at Rocky Flats are called "infinity rooms," because the levels of contamination are too high to be measured.

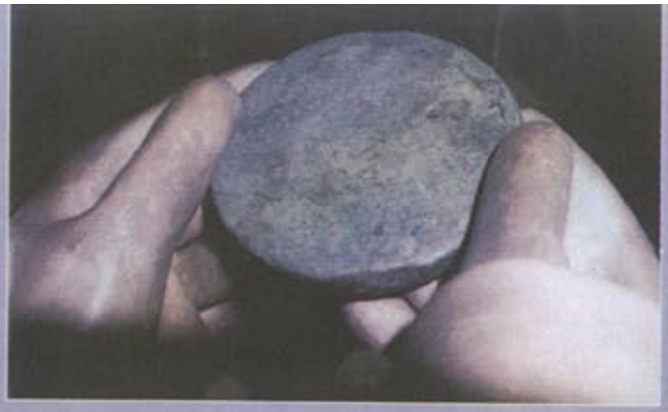
Now that the Cold War has ended, DOE's primary mission at most sites has shifted from building bombs to cleanup, and the veil of secrecy has been lifted. This shift has meant extreme growing pains for the last 5 years, since 1992, when President Bush curtailed the production of nuclear weapons.

DOE is committed to making progress—"moving dirt more than paper"—and investing in technology that leads to more effective and efficient cleanup.

Though aggressive action sounds attractive, cleanup and decontamination are not so simple. The many different substances (radioactive and hazardous) and the many different regulations (federal, state, local) often slow progress to a standstill. And during the processes of cleaning up contaminated soil, water, or buildings, workers also will generate huge amounts of new waste and discover new hazards that were not common during the production mission.



THIS "SOLAR POND" was used to hold contaminated water, using evaporation to consolidate the contaminants at the bottom of the pond. It and others like it were cleaned up in 1994.



THIS HOCKEY PUCK SIZE "BUTTON" of plutonium is the refined metal used as the core of the nuclear trigger. It was the main product of the Rocky Flats Plant.

Furthermore, nobody wants this waste—neither the communities surrounding the sites where it is now located, nor the communities adjacent to the sites where it could be stored for the long term.

The greatest immediate threat at Rocky Flats and other DOE sites is to the workers handling unstable nuclear materials. The most unstable form is plutonium and uranium liquids—plutonium or uranium dissolved into acid solutions. These are the materials that can most easily "go critical," which means sustain a nuclear chain reaction giving off deadly amounts of radiation. In normal manufacturing, the metal-working process calls for plutonium and uranium to be dissolved into acid solutions, then precipitated out in a solid form. When Rocky Flats' production was suddenly shut down in 1989, 30,000 liters of liquid solutions were left in place.

Only in 1994 did the Site break through the bureaucratic barriers and start to stabilize the liquid plutonium and Highly Enriched Uranium. With time, these solutions become more dense and changed chemically, raising the potential for a criticality. A simple change in geometry, such as pouring a liter of liquid plutonium into another container, could cause a criticality. Rocky Flats recently shipped tons of its uranium liquids to another, less metropolitan site—a major milestone in reducing risks to the workers and surrounding communities.

The most significant environmental contamination at Rocky Flats was discovered in 1964. More than 4,700 drums containing metal cleaning solvents contaminated with plutonium and uranium were stored at the southeastern edge of the plant. Some of the drums corroded and leaked contaminants into the soil. The drums were all removed by 1968, but winds and rain had spread contaminated soil toward the east, only a few miles from the city of Arvada and into Standley Lake, the drinking water reservoir for five cities near Rocky Flats.

The area was covered with gravel and capped with an asphalt pad in 1969 to prevent any more spreading of the contaminated soil. This area, the "903 Pad," remains one of the top priority cleanup sites at Rocky Flats.

The first major incident involving the release of airborne radioactive material at Rocky Flats occurred in 1957, with a fire in building 771, a plutonium processing facility. Design features of the building and equipment contributed to the severity of the fire—prompting modification of equipment throughout the country's nuclear weapons complex.

A still-larger fire occurred at Rocky Flats on Mother's Day, 1969. That May 11, when most employees were off-duty, a piece of scrap plutonium spontaneously ignited in building 776—another plutonium processing building. The fire was the costliest industrial accident in America at that time—estimates place the damage at more than $48 million. Several employees who helped extinguish the blaze inhaled large doses of plutonium.

There was airborne contamination from the fire as well as some ground contamination from the fire-fighting efforts and ensuing clean-up activities. The Colorado Board of Health later determined that no radiation went beyond the boundaries of the site at the time; however, it has since made it off the site through the creeks that run north and south of the site and into two drinking-water reservoirs just to the east of the site: Standley Lake and the Great Northwestern Reservoir.

Fortunately, plutonium is extremely heavy and settled to the very bottom of the silt strata in these lakes. Nonetheless, it poses a potential threat that must be monitored and eventually neutralized. In 1996, a $30 million diversion reservoir was built between Rocky Flats and Standley Lake, the drinking water sup-

TABLE 1. Wastes Volumes* Across the DOE Complex (in cubic meters)

Site	High-Level	Transuranic	Low-Level	Low-Level Mixed	Total (site)
Livermore, CA	245	606	459	1,310	
Nevada Test Site, Mercury, NV	620	270	908	1,798	
Oak Ridge Nat'l Labs	1,798	3,538	3,035	8,371	
Miamisburg, OH	263	8,860	114	9,237	
Paducah, KY	5,400	5,387	10,787		
Y-12, Oak Ridge, TN	825	13,515	14,440		
WVDP, West Valley, NY	2,200	427	14,274	120	17,031
Los Alamos, NM	11,257	6,602	17,859		
Rocky Flats, CO	1,196	6,500	16,700	24,396	
Fernald, OH	27,000	2,151	29,151		
Portsmouth, OH	25,000	11,184	36,184		
K-25, Oak Ridge, TN	14,586	38,966	53,552		
INEL, ID	11,000	34,731	14,080	25,442	85,253
Savannah River, SC	126,300	15,113	1,655	7,342	150,410
Hanford, WA	238,900	9,594	51	6,427	254,972
Others	2,301	26,706	29,007		
Total All Sites & Sources	378,400	75,298	125,890	162,988	742,576

* Volumes fluctuate as wastes are continuously being generated, processed, and disposed, giving this chart a wide margin of error.

ply for Westminster, Arvada, Northglenn, Broomfield, and Thornton, CO.

The 1969 fire led to many studies on plutonium combustibility and resulted in upgraded safety and fire systems at Rocky Flats and other sites across the country. This included the requirement that plutonium work take place in an oxygen-free atmosphere.

During the 1970s, local citizens grew increasingly skeptical and vocal about the safety at Rocky Flats and the potential environmental impact of its activities. Well-organized demonstrations were regular events throughout the 1970s and early 1980s—keeping pace with increased environmental awareness across the country. At one point, thousands of protesters linked arms in a human chain that completely surrounded the 600-acre site.

The 1980s brought a greater focus on environmental issues; most of the current federal and state environmental laws and regulations for managing waste were defined during this decade.

This environmental sensitivity, combined with a complex political scenario, led to the most pivotal event in Rocky Flats' history. On 6 Jun 1989, agents from the FBI and Environmental Protection Agency raided the site, seeking evidence to support alleged criminal environmental violations. The raid was the first time federal agents had ever "raided" another federal facility.

Although the major claims were never substantiated, Rockwell International (the operating contractor at the time) agreed to a plea bargain—admitting to some environmental crimes, paying $18.5 million in fines.

In November 1989, Rocky Flats was added to the list of highly polluted sites destined for cleanup under the federal Superfund program. In December, plutonium operations were "temporarily" curtailed to make safety and environmental compliance improvements. Because the curtailment was expected to last just a few weeks, the special nuclear materials were left in tanks and pipes—which was only appropriate for short-term storage. Then came the most pivotal event of 1989, the fall of the Berlin Wall . . . marking the end of the Cold War.

Meanwhile, Rocky Flats' temporary moratorium of plutonium operations stretched from weeks to years . . . ironically making the site more dangerous than ever. With the Cold War over and nuclear weapons production "politically incorrect," it was almost impossible for the plant to do the safe thing—resume plutonium processing to stabilize the materials and make them safe for storage.

Why? Because the result of this processing was weapons-grade plutonium—and that was unacceptable in the then-political and social climate. Three Mile Island, Chernobyl, and other nuclear mishaps left little possibility in the U.S. of new construction of commercial nuclear power plants in the foreseeable future. Ironically, the environmental impacts, especially of global warming, are significantly less from nuclear-powered plants than from coal-fired power plants.

On 6 Jun 1989, agents from the FBI and Environmental Protection Agency raided the site.

Plans for resuming weapons production at Rocky Flats were refined, stalled, revised, refined again . . . and finally scrapped in January 1992, when President Bush announced the curtailment of the W88 weapons program—Rocky Flats' only remaining production work. Environmental restoration, waste management, and building decommissioning became the site's new missions.

Though the new direction for the DOE had been clearly set by the end of the Cold War, obstacles came into play just as clearly. In 1989, there was a near-universal decline in off-site waste storage options—primarily from the Governor of Idaho's refusal to accept onto DOE's Idaho National Engineering Laboratory any more transuranic waste from Rocky Flats.

A facility in New Mexico called the Waste Isolation Pilot Project, or WIPP, was scheduled to begin taking shipments of transuranic waste in 1989. A series of technical, regulatory, legal, and political setbacks, however, have delayed WIPP's opening again and again. It is currently targeted to open in 1998.

The Nevada Test Site also stopped accepting Rocky Flats' radioactive waste shipments in 1990. As off-site waste storage options diminished, there was a buildup of radioactive waste stored on-site. This is a problem throughout the DOE weapons complex as sensitivity to environmental issues increases, reducing storage options throughout the nation.

From 1992 to 1995 were years of extensive analysis as Rocky Flats worked to figure out how to proceed. The Rocky Flats path became bogged down because of a number of political, regulatory, and technical issues. The result—very little actual clean up was accomplished, but more than $3 billion was spent doing little more than paper studies required by the federal and state regulatory agencies.

This period was exacerbated by DOE's maintenance and operating (M&O) contractor system where one company was hired to run a given site. In this system, the operator was basically paid to show up—the fee was directly proportional to the gross number of employees. In a production mode, with real incentivized deadlines, this system worked well. But after 1989 at Rocky Flats, there was no production, no clear mission, no real deadlines, and regulatory and political turf battles only confused matters.

As a solution, Congress increased Rocky Flats' budget, and the M&O contractor added more personnel and still nothing got done—except for interminable studies required by the regulators. The result was a 1992 budget of $800 million, almost 8,000 employees, and analysis, reports, and debates being most of the work product. For comparison, at the height of production, the 1989 budget was less than $500 million with approximately 4,000 employees. This trend crested in 1994 when Rocky Flats' budget reached almost $900 million.

The solution to this problem has been a tangled effort at contract reform aimed at replacing the single contractors with teams of "world's best-in-class" companies paid for performance. In 1995, Rocky Flats hired a new contractor to run the site under the first-ever performance-based contract for DOE.

Simply put, if no work gets done, no fee is paid. The Kaiser-Hill Limited Liability Company, a joint venture be-

(continued on p. 52)

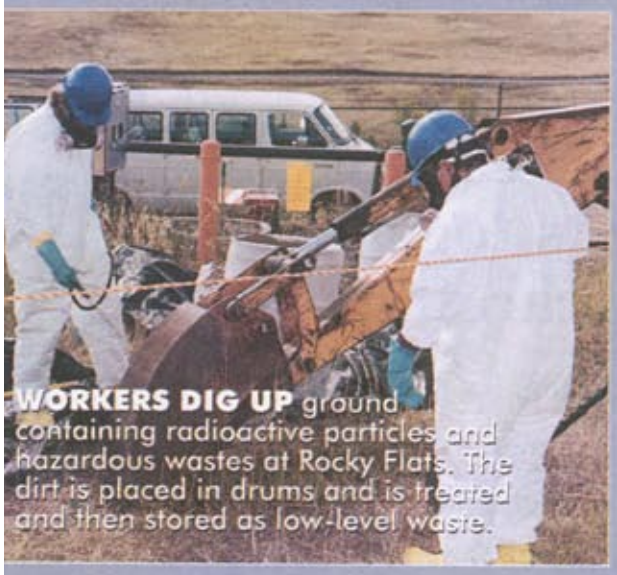
CLEANING UP the Cold War Legacy

(continued from p. 23)

tween ICF Kaiser and CH2M Hill Company, was hired in July 1995 as the "performance-based integrating contractor." This means Kaiser-Hill supervises and integrates a team of expert companies to oversee the numerous, varied, and complex tasks at the site. The team now includes Westinghouse, British Nuclear Fuels Limited, Morrison-Knudsen, Rust Engineering, Dyncorp, and Wackenhut Security.

This first for DOE has become the model as old contracts expire and the DOE struggles to find ways to actually clean up these sites in a period of declining budgets.

MARK SILVERMAN hosts a contingent of the Russian Nuclear Federation as they inspect Rocky Flats under the terms of non-proliferation agreements with Russia and the International Atomic Energy Agency.



WORKERS DIG UP ground containing radioactive particles and hazardous wastes at Rocky Flats. The dirt is placed in drums and is treated and then stored as low-level waste.

FORMER SECRETARY OF ENERGY HAZEL O'LEARY has her shoes scanned for radioactive particles before leaving a nuclear building she has just toured with Mark Silverman.

The changes of the early 1990s were not only in Rocky Flats' mission, but also in the post–Cold War philosophy of the DOE. This is most evident in the Department's "Openness Initiative" begun in 1993. Millions of pages of documents were declassified, and barriers, physical and otherwise, were brought down. Projects, including secret testing of radioactivity on people, were brought to light. This openness helped to usher in a new era of community involvement and trust—including more access to nonclassified areas and public participation in site decisions. Nearly every week, some group is visiting Rocky Flats—getting a firsthand look at some of the work and technology developments.

In 1994, and again in 1996, a Russian technical team visited Rocky Flats in the first-ever exchange program to observe American procedures, equipment, and storage of special nuclear materials. Part of the visit included a look inside the plutonium storage vaults. These unprecedented visits epitomized the new direction of Rocky Flats and DOE.

Rocky Flats now leads the nation in the movement to clean up and close down America's unneeded nuclear weapons plants. This very complicated process involves dealing with a variety of different categories of wastes and materials. At Rocky Flats this includes approximately 5,000 cubic meters of low-level radioactive waste and 18,000 cubic meters of low-level mixed (radioactive and hazardous) waste; 1,200 cubic meters of transuranic waste; and approximately 30,000 liters of plutonium and uranium solutions (see Table 1).

The plutonium and uranium liquids are highly unstable and must be processed to a stable, solid form and configured for long-term storage. Reducing these highest risks is now the focus of the site's budgeting and planning. The money to maintain and monitor these materials can be used to clean up the site once the risks are reduced. Some buildings, because of extensive radiological and security monitoring systems, cost more than $40 million a year each just to keep open.

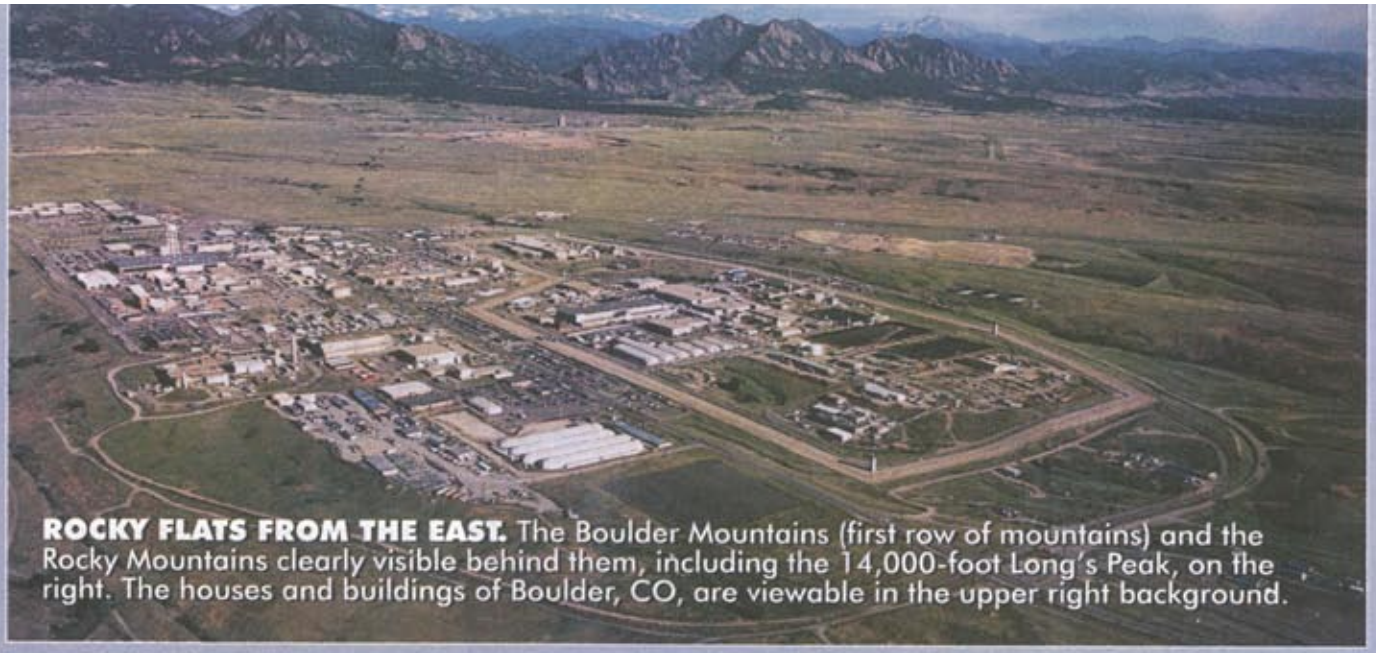
Reducing these maintenance and storage costs is known as "reducing the mortgage." The highly radioactive plutonium and uranium forms are very expensive to store because they have to be monitored and guarded. The more practical and safer alternative is to ship them to a site with a continuing mission—where there is now, or will be, a robust storage facility, such as Aiken, SC; Hanford, WA; Oak Ridge, TN; or Idaho Falls, ID. Rocky Flats' transuranic waste is slated for shipment to the WIPP facility in New Mexico when it opens. Until then, transuranic waste must be stored on-site—with costly maintenance and monitoring expending funds that could be used for risk reduction and environmental cleanup.

How to store the huge amounts of low-level and low-level mixed wastes on site is another issue. The preferred option is to ship it off-site—but this is complicated by political and budget issues. It is cheaper to store it on-site, but some in the local communities object to this, fearing the government may leave it there forever, creating "nuclear ghost towns," or that it may leech into the ground and water while it is there. Others, however, now object to moving the wastes. They want the site cleaned up to background levels, which will add decades and scores of billions of taxpayers' dollars to the cleanup effort.

Rocky Flats was in an isolated and remote part of Colorado when it was built in the 1950s, but residential populations have moved closer and closer. Today, more than two million people live within a 50-mile radius of the site. This proximity is unique in the United States and makes the cleanup and closure of Rocky Flats an urgent goal of DOE.

The long-term vision and mission of Rocky Flats is to achieve a closure of the site that is environmentally and fiscally responsible and sensitive to the concerns and needs of the local community. If only it were that simple.

America's nuclear arms buildup was a huge and very successful effort. It is



ROCKY FLATS FROM THE EAST. The Boulder Mountains (first row of mountains) and the Rocky Mountains clearly visible behind them, including the 14,000-foot Long's Peak, on the right. The houses and buildings of Boulder, CO, are viewable in the upper right background.

likely that this same scale of effort—dedication, political and financial—will have to be applied to clean up the Cold War's legacy of contamination. The cost has been estimated to be more than $250 billion and could take from 20–80 years. Yet the trend is going in the opposite direction. Time is passing. The Cold War is fading from our national memory. The alternative to cleanup is the creation of dozens of nuclear ghost towns that will dot the United States, as in Russia, untouchable for 40,000 years and still posing risks to those who live near and around them.

This nuclear-nonproliferation mentality also has had a sobering side effect. Rather than slowly down-sizing America's nuclear weapons "machine," it would be more accurate to say an ax has been taken to it. Facilities have been dismantled or left to deteriorate and, most significantly, people with irreplaceable and unduplicatable skills have been laid-off or retired. If for some reason America needed to produce nuclear weapons in Cold War volumes again, it would almost be starting from scratch.

Tritium, a key element in hydrogen bombs, has a half-life of 12½ years and America currently has no tritium production on-line.

In a recent report titled "Erosion by Design," the House National Security Committee says that with the dismantling of America's nuclear weapons complex and no nuclear testing, America cannot maintain a competent nuclear deterrent in a world that, despite test-ban treaties and other non-nuclear agreements, remains a very dangerous place.

In all fairness, it must be noted that we have enough nuclear weapons in our arsenal to last a few decades, but tritium's half-life of 12½ years requires that it be replenished in existing weapons on a regular basis to provide the desired yield. In the meantime, tritium is being recycled from dismantled weapons.

The issues—complex, political, and expensive—cannot be adequately covered in an article of this length.

DOE has a daunting task on its hands. Because of an unflattering history of bureaucracy and mismanagement, disbanding DOE is and has been seriously discussed in more than one Congressional committee. This would change nothing of the enormous scope of the cleanup of chemical and nuclear contamination necessary for closing the books on the Cold War.

The most important factor now is to proceed carefully, with forethought of how today's actions will affect the future. The lack of that planning is what got us here in the first place—an error we cannot afford to repeat.

Little did I know when I graduated in 1961 that the skills I would most need in the post–Cold War era involved negotiations and building political coalitions. The most daunting task I inherited in 1993 was to overcome the distrust, anger, and hostility between Rocky Flats and its stakeholders including the regulators, citizens, news media, and elected officials at all levels. In order for Rocky Flats to get on with the task of reducing the risk and cleaning up the site, I would have to forge an alliance of environmentalists, peace activists, elected officials, and regulators. This coalition was essential to our reaching a regulatory enforceable cleanup agreement with the State of Colorado and the Environmental Protection Agency.

Regaining a level of trust with the news media also was a key ingredient, as they were crucial to creating an environment in which a dialogue could proceed.

Perhaps this is the biggest lesson we need to learn and implement. As we continue to ensure our nation's security, as we live up to our motto of "Duty, Honor, Country," we need to develop and employ different skills than just those needed on the battlefields for which West Point so ably trains us. Now there are many different battlefields. We must have the public's trust and confidence, we must communicate with them frequently, openly, and honestly. We must never forget that our mission is to serve our nation, which we cannot do so unless we have the public's support. We will only get and keep their support if we have earned their trust and confidence. ■

ABOUT THE AUTHORS

Mark N. Silverman retired on 1 Jun 96 after nearly 34 years of Army and federal government service. In June 1995, he was awarded the President's Rank of Distinguished Executive Service for his leadership in cleaning up Rocky Flats.

Ray D. Hoese is a communications specialist at Rocky Flats.