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Intentional Releases: Lifting the Veil of Secrecy

IN February 1986, officials at the Department of Energy responded to requests from activists by releasing 19,000 pages of documents on the early operations of the world's first plutonium factory, at Hanford, Washington. Combing through these documents, reporters and citizens found references to an event cryptically named the "Green Run," in which radioactive material was deliberately released into the air at Hanford in December 1949.[1]

In the aftermath of the public discovery of the Green Run, Senator John Glenn asked the General Accounting Office, the investigative arm of Congress, to find out if there were other instances in which radioactivity had been intentionally released into the environment without informing the surrounding community. In 1993, the GAO reported twelve more instances of such secret intentional releases.[2]

Following additonal research by the DOD and DOE, the number of secret intentional releases has expanded to several hundred, conducted between 1944 and the 1960s. At the Army's Dugway Proving Ground in Utah, dozens of intentional releases were conducted in an effort to develop radiological weapons, some in tests of prototype cluster bombs, others using different means of dispersal; at Bayo Canyon in New Mexico, on the AEC's Los Alamos site, researchers detonated nearly 250 devices, which contained radiolanthanum (RaLa) as a source of radiation to measure the degree of compression and symmetry of the implosion used to trigger the atomic bomb. Other intentional releases were not classified, although not all were made known to the public in advance. At AEC sites in Nevada and Idaho, radioactive materials were released in tests of the safety of bombs, nuclear reactors, and proposed nuclear rockets and airplanes; in still other cases, small quantities of radioactive material were released in and around AEC facilities and in the Alaskan wilderness to determine the pathways such material follows in the environment.[3] Public witnesses from several of these communities told the Committee that they remain deeply disturbed by these releases, wondering whether there is still more information about the secret releases in their communities that they do not know and how much will, at this late date, be impossible to reconstruct.

INTENTIONAL RELEASES AND THE CHARTER THIRTEEN

The Advisory Committee is authorized by its charter to examine "experiments involving intentional environmental releases of radiation that (A) were designed to test human health effects of ionizing radiation; or (B) were designed to test the extent of human exposure to ionizing radiation." The charter also called for the Committee to "provide advice, information, and recommendations" on the following thirteen experiments and similar experiments identified by the Interagency Working Group:

(1) the experiment into the atmospheric diffusion of radioactive gases and test of detectability, commonly referred to as "the Green Run test," by the former Atomic Energy Commission (AEC) and the Air Force at the Hanford Reservation in Richland, Washington;

(2) two radiation warfare field experiments conducted at the AEC's Oak Ridge office in 1948 involving gamma radiation released from non-bomb point sources or at near ground level;

(3) six tests conducted during 1949-1952 of radiation warfare ballistic dispersal devices containing radioactive agents at the U.S. Army's Dugway, Utah, site; [and]

(4) four atmospheric radiation-tracking tests in 1950 at Los Alamos, New Mexico. . . .

Tests of nuclear weapons, intentional environmental releases of radiation in amounts greatly in excess of any of the releases identified above, were not included in the charter. As discussed in chapter 10, the Committee did seek to investigate human subject research conducted in connection with these tests.

This chapter reports on what we found as we sought to retrieve what we could about the releases identified in our charter, determine the nature and number of further intentional releases, identify the ethical standards by which these activities can be evaluated, and determine what lessons can be learned from the past.

Because of the secrecy surrounding these releases—as opposed to atmospheric nuclear weapons tests, which were impossible to hide—many of them took place with no public awareness or understanding. The intentional releases were conducted primarily at sites such as Hanford, Los Alamos, and Oak Ridge, in which defense and atomic energy facilities were located, but they were largely unknown to those who lived in surrounding areas.

There is no evidence in any of these cases that radioactive material was released for the purpose of studying its effects on human communities. As we discuss later in the chapter, the public often was exposed to far greater risk from the routine course of operations of the facilities than from the intentional releases themselves.

That the possible health effects from the Green Run and other intentional releases are so slight that they cannot be distinguished from other sources of disease is small comfort to "downwinders" who were put at risk without their knowledge. The Committee heard from many of them and learned that the longer-term costs of secrecy extend well beyond any physical injury that may have been incurred. These costs include, first, the anxiety and sense of personal violation experienced by those who have discovered that they have intentionally and secretly been put at risk, however small, by a government they trusted. But they also include the consequences for that government, and its people, of the attendant distrust of government that has been created. And finally, they also now include the citizen and taxpayer resources that must be expended in efforts to reconstruct long-buried experiences, and determine, as best as can currently be done, the precise measures of the risks involved.

The chapter is divided into two parts. The first and lengthier section reconstructs the history of the three kinds of releases that were in our charter—the Green Run, radiological warfare tests, and the RaLa tests—and includes a discussion of some types of intentional releases that were not expressly identified in the charter. This section concludes with a review of what is known today about the likely risks of all the releases we consider, as well as a review of the science of dose reconstruction by which this knowledge is obtained. In the second part of the chapter, we focus on the ethical and policy issues raised by intentional releases. We examine the rules that currently govern intentional releases in an effort to learn whether secret environmental releases like the Green Run could take place today and, if so, whether, in light of lessons learned from the past, current procedures and protections are adequate.

WHAT WE NOW KNOW

The Green Run

While the other intentional releases addressed in the Committee's charter were part of the effort to develop the U.S. nuclear arsenal, the Green Run was conducted to develop intelligence techniques to understand the threat posed by the Soviet Union. In 1947 General Dwight D. Eisenhower assigned the Air Force the mission of long-range detection of Soviet nuclear tests.[4] Based on observations from Operation Fitzwilliam, the intelligence component of the 1948 Sandstone nuclear test series, the Air Force determined aerial sampling of radioactive debris to be the best method of detecting atomic releases.[5] An interim aerial sampling network was in place in early September 1949 that detected radioactive debris from the first Soviet nuclear test.[6]

Around the same time, Jack Healy of Hanford's Health Instrument (HI) Divisions noticed anomalous radioactivity readings from an air filter on nearby Rattlesnake Mountain. The HI Divisions were responsible for radiological safety, and Healy had set up this filter to test how radioactive contamination varied with altitude. The rapid decay of his radioactive samples led Healy to conclude that they had come from a recent nuclear test.[7] Soon after news of Healy's observation reached Washington, D.C., Air Force specialists arrived and took Healy's samples and data for analysis. It is not clear whether Healy's observation came in time to support President Harry Truman's announcement on September 23 that the Soviet Union had exploded its first atomic bomb,[8] but it did confirm that radioactivity from a nuclear test could be detected on the other side of the globe.

Now that the Soviet Union knew how to make atomic weapons, the United States needed to know how many weapons and how much of the critical raw material plutonium the Soviets possessed. Like nuclear testing, plutonium pro-

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HANFORD: THE WORLD'S FIRST PLUTONIUM FACTORY

In 1942 General Leslie Groves selected the Hanford site overlooking the Columbia River in southeast Washington state for the Manhattan Project's plutonium factory. The river would provide a large, reliable supply of fresh water for cooling the plutonium-production reactors, and Hanford's relative isolation from major population centers would make it easier to construct and operate the facility without attracting unwanted attention. The nearby towns of Richland, Kennewick, and Pasco soon became boom towns whose economies depended on Hanford.

At Hanford, neutrons converted uranium 238 in the production reactor's nuclear fuel into plutonium 239. Chemical separation plants then separated this plutonium from the fission products and residual uranium in the irradiated fuel elements. The first separation plants, the T and P plants, used acid to dissolve these fuel elements, but this was superseded by the more efficient Redox and Purex processes in the 1950s.

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duction released radioactive gases that sensitive instruments could detect, though not at such great distances.[9] To identify Soviet production facilities and estimate their rate of plutonium production, the Air Force now needed to test ways to monitor these gases.[10]

In late 1948 and early 1949, Air Force and Oak Ridge personnel conducted a series of twenty air-sampling flights at Oak Ridge and three at Hanford.[11] The results were disappointing: instruments detected airborne releases of radioactive material at ranges of up to fifteen miles in the hills and valleys near Oak Ridge, but no farther than two miles from Hanford, because of measures taken to reduce radioactive emissions there. At an October 25, 1949, meeting at Hanford, representatives of the Air Force, the Atomic Energy Commission, and General Electric (the postwar contractor for the Hanford site) agreed to a plan to release enough radioactive material from Hanford[12] to provide a larger radioactive source for intelligence-related experiments.[13]

This intentional release took place in the early morning of December 3, 1949, but information about it remained classified until 1986. Two periodic reports of the HI Divisions described a plutonium production run using "green" fuel elements.[14] The story of this "Green Run" has emerged piecemeal since then. The most complete account comes in a 1950 report coauthored by Jack Healy (referred to as the Green Run report), which was declassified in stages in response to requests from the public under the Freedom of Information Act and inquiries by the Advisory Committee.[15]

Although cooling times of 90 to 100 days were common by 1949, the fuel elements used in the Green Run were dissolved after being cooled for only 16 days. This short cooling time meant that much more radioactive iodine 131 and xenon 133 were released directly into the atmosphere, rather than decaying while the fuel elements cooled. Furthermore, pollution control devices called scrubbers normally used to remove an estimated 90 percent of the radioiodine[16] from the effluent gas were not operated.[17]

When these "green" fuel elements were processed, roughly 8,000 curies of iodine131[18] flowed from the tall smokestack at Hanford's T plant. This stack was built in the early years of Hanford's operation when large quantities of radioactive gases were routinely released in the rush to produce plutonium. Although the Green Run represents roughly 1 percent of the total radioiodine release from Hanford during the peak release years 1945–1947, it was almost certainly larger than any other one-day release, even during World War II.[19]

One clear purpose of the Green Run was to test a variety of techniques for monitoring environmental contamination caused by an operating plutonium-production plant. A small army of workers, including many from Hanford's HI Divisions, took readings of radioactivity on vegetation, in animals, and in water and tested techniques for sampling radioactive iodine and xenon in the air.[20] The Air Force operated an airplane carrying a variety of monitoring devices—the same aircraft used in earlier aerial surveys at Oak Ridge and Hanford—and set up a special air sampling station in Spokane, Washington.[21]

Those operating the equipment encountered numerous technical problems, including a lost weather balloon and failed air pumps. The greatest problem, however, was the general contamination of monitoring and laboratory equipment. The contamination created a high background signal that made it difficult to distinguish radioactivity on the equipment from radioactivity in the environment. The main cause of this contamination was the weather at the time, which led to much higher ground contamination near the stack than expected.[22]

The plans for the Green Run included very specific meteorological requirements. These requirements were designed to facilitate monitoring of the radioactive plume by aircraft, but they were similar to the normal operational requirements, which were designed to limit local contamination:

- A temperature inversion,[23] to keep the effluents aloft, but at a low altitude;
- No rain, fog, or low clouds to impede aircraft operations;
- Light to moderate wind speeds (less than fifteen miles an hour);

- Wind from the west or southwest, so the plane would not have to fly over rough terrain;[24] and
- Strong dilution of the plume before any possible contact with the ground.[25]

Jack Healy reports that he made the decision to go ahead with the Green Run on the evening of December 2, 1949, even though the weather did not turn out as expected. Some have suggested that the Air Force pressed to go ahead with the release in spite of marginal weather conditions, but Healy recalls no such pressure.[26] The plume from the release stagnated in the local area for several days before a storm front dispersed it toward the north-northeast. As a consequence, local deposition of radioactive contaminants was much higher than anticipated.[27] The Green Run report concludes:

> Under the worst possible meteorological conditions for such a test, the airborne instruments detected the radioactive gases at a distance better than 100 miles from the stack. Under favorable conditions, it was estimated that with the same concentrations this distance could have been increased by up to a factor of ten.[28]

Despite the contamination of equipment, the monitoring provided a record of the extensive short-term environmental contamination that resulted from the Green Run. Measurements of radioactivity on vegetation produced readings that, while temporary, were as much as 400 times the then-"permissible permanent concentration" on vegetation thought to cause injury to livestock.[29] The current level at which Washington state officials intervene to prevent possible injury to people through the food supply is not much higher than the then-permissible permanent concentration.[30] Animal thyroid specimens showed contamination levels up to "about 80 times the maximum permissible limit of permanently maintained radioiodine concentration."[31]

In spite of this contamination, the public health effects of the Green Run, discussed later in this chapter, were quite limited. However, in 1949, at the time the Green Run was conducted, the most important environmental pathways for human exposure to radioiodine were unknown. (Understanding developed shortly thereafter that environmental radioiodine enters the human body from eating meat and drinking milk from animals that grazed on contaminated pastures.)[32] Thus, the effects of exposure through these pathways could not have been planned for, and it is fortunate that the risks were not higher.

The Control of Risks to the Public from Plutonium Production at Hanford

From the first years of Hanford's operation, its health physicists were aware of the problems of contamination of the site by radioactive wastes, and it quickly became clear that radioiodine posed the greatest immediate hazard.[33] Most fission products would remain in the dissolved fuel, but iodine gas would bubble out of the solution, up through Hanford's tall stacks into the atmosphere and down onto the surrounding countryside. Other radioactive wastes could be stored and dealt with later, and other radioactive gases were chemically inert and would quickly dissipate.

Over the years, Hanford health physicists adopted three main approaches to the iodine problem:

- Choosing meteorological conditions for releases that would prevent air with high iodine concentrations from contaminating the ground near Hanford;
- Letting the irradiated fuel elements cool for extended periods before separating the plutonium, so that most of the iodine 131, which has an eight-day half-life, could decay; and
- Beginning in 1948, using scrubbers or filters to remove iodine from the exhaust emissions.

During World War II, producing plutonium for bombs was an urgent priority and knowledge of both the environmental hazards from iodine and the ways to prevent it were limited. Over the period 1944–1947, Hanford released nearly 685,000 curies of radioiodine into the atmosphere, about eighty times what was released in the Green Run.[34] After the war, an improving understanding of how iodine could contaminate the food supply,[35] evolving techniques to remove iodine from the plants' emissions, and policy decisions to limit the risks to the nearby population led to a marked reduction in iodine emissions.

When the AEC began operation in 1947, it promptly moved to review safety practices at Hanford and other operating facilities, which had operated largely autonomously until then. The advisory panel established for this purpose concluded that "the degree of risk justified in wartime is no longer appropriate."[36] To address the radioiodine problem at Hanford and related problems, the AEC established a Stack Gas Working Group, which met for the first time in mid-1948 to study air pollution from AEC production facilities. The chair of this group noted that the AEC "desires the removal from gaseous effluents of all [radioactive] material insofar as is humanly and economically feasible" and that because of uncertainties in risk estimates "no limit short of zero should be considered satisfactory for the present."[37] By 1949, daily emissions of radioiodine had fallen by a factor of 1,000 from their wartime highs.

The Green Run clearly did not conform to the practices designed to ensure public safety at Hanford in 1949 or even during the rush to produce plutonium for the first atomic bombs. In his monthly report for December 1949, Herbert Parker, Hanford's manager, concluded that the Green Run had posed a "negligible" risk to personnel, but "[t]he resultant activity came close enough to significant levels, and its distribution differed enough from simple meteorological predictions that the H.I. Divisions would resist a proposed repetition of the tests."[38] This suggests that Parker, at least, considered the risks of such releases potentially excessive even for a one-time event, particularly given the degree of uncertainty.

Parker's recognition of the uncertainties surrounding environmental risks from Hanford's radioiodine emissions was appropriate. At the time, it was not known that drinking milk from cows that graze on contaminated pastures is the main source of exposure, especially for children. Jack Healy recently suggested that if Parker had known of the milk pathway, he would have objected strongly to the Green Run.[39] The question remains as to the consideration that was given by the Green Run's planners to the possibility that they might not fully understand the risks that might be imposed on nearby communities.

Benefits of the Green Run

The Advisory Committee attempted to assess of the national security benefits that were expected and actually resulted from the Green Run. A planning memorandum before the Green Run notes, "the possibility of the detection of stack effluents is of great importance to the intelligence requirements of the country."[40] How important the detection of stack effluents was to the security of the nation in 1949 is not something the Advisory Committee was in a position to judge. We did attempt to ascertain, however, the purpose of the Green Run and the extent to which this purpose was served.

The Green Run report focuses primarily on ground-based monitoring of radioactive contamination in the environment, which provided a test for techniques that could be used on the ground in the Soviet Union. The report also describes efforts to track the radioactive plume by aircraft, but their significance is unclear. Aerial monitoring turned out to be the most effective method for detecting atmospheric nuclear tests, and perhaps it was expected to be equally effective for monitoring Soviet plutonium production. Plutonium production releases relatively little radioactivity into the atmosphere, however—too little to detect outside Soviet air space, and flying inside Soviet air space would have been risky. Alternatively, aerial radiation tracking may have been designed to test techniques for use in monitoring nuclear weapons tests. Finally, the Green Run report compares the pattern of the plume's dispersion with theoretical models, but this appears to be an attempt to estimate the pattern of contamination rather than to test the already well-established theory regarding atmospheric diffusion of gases developed in the 1930s.

It is difficult to ascertain how useful the Green Run actually was. The classified histories of the Air Force's atomic intelligence activities contain no references to the Green Run. These histories jump from events that directly preceded the Green Run—the Oak Ridge and Hanford aerial monitoring tests—to later ones, without any mention of the Green Run.[41] Perhaps most telling, a 1952 AEC report entitled "Technical Methods in Atomic Energy Intelligence" does mention the Green Run in the text, but only in a list of occasions on which a particular type of instrument was used. In describing ways of detecting plutonium-production facilities, the report relies on routine reports of environmental surveys from Hanford's routine operations.[42]

Secrecy and Public Risk

The Advisory Committee accepts that there may be conditions under which national security can justify secrecy in intentional releases like the Green Run, even as we recognize that secrecy can increase the risk to the exposed population.

In discussing this question it is important to explain that when we use the term *secret* we can be referring to secrecy regarding the very fact that a risk has been posed, secrecy regarding the purpose behind the risk, or secrecy regarding the means (for example, the science or technology) by which the risk was imposed. These distinctions are important because even if we agree that the undertaking of an activity is required for national security reasons, it does not follow that secrecy should govern all aspects of the activity. Thus, as an obvious example, atomic bomb tests were quintessential national security activities: information on the design of the bomb was secret, as was information on many of the specific purposes of the tests; however, in many (but not all) cases the public was given notice that a hazardous activity was being undertaken. Similarly, in the cases of other environmental releases, it may be that national security requires secrecy for some aspects of the release but does not necessarily preclude public disclosure sufficient to give basic notification of the existence of potential risk. The Committee is not equipped to say whether this was so in the case of the Green Run. However, in the case of radiological warfare, as we will discuss later, there was contemporary argument that some public disclosure was not inconsistent with national security.

If a release is conducted publicly, affected communities have an opportunity to comment and perhaps influence the conduct of the release in ways that serve their interests. Downwinders can be warned, giving them the options of staying indoors with their windows closed, wearing protective clothing, altering their eating habits, or evacuating the area. If the release is conducted in secret, foreign adversaries are less likely to be alerted, but downwinders will be deprived of their options. Of course, evacuation may not be warranted, and other precautions may not be needed, or they may be of limited value. But, as we have learned during the course of our work, secrecy, even where initially merited, has its long-term price.

At Hanford, as we have noted, the Green Run represented only a fraction of the risks (including nonradiation as well as radiation hazard) to which local communities may have been exposed in secret. The delayed legacy of these risks, in uncertainty and distrust, as witnesses from the Hanford community told the Committee, is only becoming apparent as the secret history of early Hanford operations has been made public.

During World War II, officials at Du Pont, the contractor for Hanford at that time, proposed a practice evacuation to prepare for a possible emergency. General Groves turned them down, saying that "any practice evacuation of the Hanford Camp would cause a complete breakdown in the security of the project."[43] As noted in the Introduction, at the onset of the Manhattan Project concern for the effects of Hanford operations on the surrounding environment, including the salmon in the Columbia River, led to a secret program of research on the environmental effects of Hanford's operations.[44]

Secrecy remained the rule at Hanford after the war. In 1946, as recalled years later by an early biologist at Hanford who wrote to radiation researcher and historian Newell Stannard, Hanford researchers resorted to deception simply to collect information about possible iodine contamination in livestock, by having employees pretend to be agricultural inspectors while surreptitiously monitoring iodine levels in animal thyroids. The biologist wrote: "Though the Environmental Study Group at Hanford had been sampling air, soil, water, and vegetation in a wide area surrounding the Hanford site for several years previous to 1946, it was agreed that sampling from farm animals for uptake of fission product plant wastes would be a much more sensitive problem. At the time, the revelation of a regional I-131 problem would have had a tremendous public relations impact and furthermore the presence of other radionuclides . . . was of possible National Defense significance."

He explained that he was called at home and told to report to work at the director's office in downtown Richland. There:

> I was introduced to two security agents of the Manhattan Engineer District . . . who were to be my escorts and contact men during the day. They proved to be the best straight faced "liars" I had ever known. I was no longer "Karl Herde of DuPont" but through the day would be known and introduced as Dr. George Herd of the Department of Agriculture. I was to simulate an animal husbandry specialist who had the responsibility of testing a new portable instrument based on an unproven theory that by external readings on the surface of the farm, the "health and vigor" of animals could be evaluated. I was advised not to be alarmed if at times during the conversations with farmers that they appeared critical or skeptical. I was to be very reserved and answer questions as briefly and vaguely as seemed acceptable. They agreed to carry a clipboard . . . I was to concentrate on the high readings (thyroids, of course) and furnish those for recording when not being observed.
>
> That day we visited several diversified farms under irrigation from the Yakima River between Toppenish and Benton City. . . Smooth talk and flattery enabled us to gain one hundred percent cooperation. . . .
>
> I was successful in placing the probe of the instrument over the thyroid at times when the owner's attention was focused on the next animal or some concocted distraction.[45]

In 1948, the AEC prepared a public relations pamphlet entitled *Handling Radioactive Wastes in the Atomic Energy Program.* The Department of Defense objected to the description of Hanford's operations, arguing that any description of the methods used to reduce contamination might be used by the Soviet Union to avoid detection of its plants.[46] The AEC decided at its October 7, 1949, meeting to release the pamphlet, which contained no specific numbers, in order to "dispel and allay possible latent hysteria."[47]

With a major expansion of Hanford's operations under way in 1954, questions arose over whether to publish information about contamination of the Columbia River. Parker warned that it might be necessary to close portions of the river to public fishing, but he and others noted that this could have a substantial public relations impact.[48] At the same time, there was concern that information on river contamination could make it possible to ascertain Hanford's plutonium output.[49] For this combination of public relations and security reasons, Hanford did not release any quantitative information or public warning on contamination of fish in the Columbia River until many years later.

It is difficult to argue with the need for secrecy about the purposes of the Green Run. Making information on U.S. atomic intelligence methods openly available could have led the Soviet Union to develop countermeasures to these methods. The issue remains important today in responding to the potential proliferation of nuclear weapons capabilities around the world.

But the results of the long delay in informing the public about the activities of which the Green Run was only a part are now evident in public anger and distrust toward the government. At the Advisory Committee's public meeting in Spokane on November 21, 1994, Lynne Stembridge, executive director of the Hanford Education Action League, argued that

> Information regarding that radiation release was kept secret for almost 40 years. There was no warning. There was no informed consent. Citizens down wind were never advised of measures that could have been taken to safeguard the health of themselves or their children.
>
> Although the Green Run was not as direct as handing a patient orange juice laced with radioactivity, or giving someone an injection, the Green Run was every bit as intentional, every bit as experimental, every bit as unethical and immoral as the medical experiments which have made headlines over the last year.[50]

Among the most damaging dimensions of the legacy of distrust created by the secrecy that surrounded the routine and intentional releases at Hanford is the government's loss of credibility as a source of information about risk. Now, when the government is attempting to find out what damage these releases actually did and share that information with the people affected, these people question why they should believe what the government says.[51] Federally funded scientists at the Fred Hutchinson Cancer Research Center in Seattle, Washington, are now studying those exposed as children to all of Hanford's iodine emissions—the many routine emissions as well as the Green Run—to see whether any health effects are detectable.[52] Whatever this study concludes, many residents are convinced that they have already seen the effects. Tom Bailie, who grew up and still lives on a farm near Hanford, spoke to the Advisory Committee's meeting in Spokane in November 1994. He pointed on a large map to what he called a "death mile," where "100 percent of those families that drank the water, drank the milk, ate the food, have one common denominator that binds us together, and that is thyroid problems, handicapped children or cancer."[53] It is doubtful that the results of any study supported with federal funds, no matter how impeccably conducted, would be believable to people like Mr. Bailie. Assuming that the Hutchinson Cancer Research Center study is so conducted, and assuming the study finds that at least some outcomes of concern to the community are not attributable to the Hanford emissions, government secrecy will have deprived Mr. Bailie and people like him of an important source of reassurance and peace of mind.

The Green Run, and the far greater number of environmental releases resulting from Hanford's routine operations, raises challenging questions about the balance between openness and secrecy in settings where citizens may be exposed to environmental hazards. Citizens may reasonably ask whether releases have been determined to be necessary in light of alternatives, whether actions have been taken to minimize risk and provide for any harm that might occur, whether disclosure will be made at the earliest possible date, and whether records will be created and preserved so that citizens can account for any health and safety consequences at the time of disclosure. As we will see, these questions were posed with regard to other environmental releases, and they remain with us today.

Radiological Warfare

The first proposed military application of atomic energy was not nuclear weaponry but radiological warfare (RW)—the use of radioactive materials to cause radiological injury. A May 1941 report by the National Academy of Sciences listed the first option as the "production of violently radioactive materials . . . carried by airplanes to be scattered as bombs over enemy territory."[54] It was not until later that year that a calculation by British physicists demonstrated the feasibility of nuclear weapons, and attention quickly turned to their development.

Military interest in both offensive and defensive aspects of radiological warfare continued throughout World War II. In the spring of 1943, when it was still unclear whether the atomic bomb could be built in time, radiological weapons became a possible fallback. Manhattan Project scientific director J. Robert Oppenheimer discussed with physicist Enrico Fermi the possibility of using fission products, particularly strontium, to poison the German food supply. Oppenheimer later wrote to Fermi that he thought it impractical unless "we can poison food sufficient to kill a half a million men." This proposal for offensive use of radiological weapons appears to have been dropped because of its impracticality.[55] At the same time, military officials developed contingency plans for responding to the possible use of radiological weapons by Germany against invading Allied troops.

The peacetime experience of Operation Crossroads in 1946, particularly the contamination of the Navy flotilla from the underwater nuclear test shot labeled Baker, revived interest in radiological warfare. Some, including Berkeley's Dr. Joseph Hamilton, concluded that radiological poisons could be used as strategic weapons against cities and their food supplies.[56] Once absorbed into the body, radioactive materials would cause slow, progressive injuries. Others proposed that RW could be a more humane form of warfare. Using radioactive material to contaminate the ground would render it temporarily unhabitable, but it would not be necessary to kill or injure people.[57]

Although many discussions of radiological warfare took place in classified military circles,[58] the basic notion of radiological warfare was not secret and was a subject of public speculation. But the government's program in radiological warfare remained largely secret, except in its broadest outlines. The postwar interest in radiological warfare spawned competing programs on radiological warfare both in the AEC and in various parts of the Department of Defense.[59] To meld these into a coherent program, the AEC and DOD established a joint study panel in May 1948, chaired by the chemist W. A. Noyes from the University of Rochester and including civilian experts and DOD and AEC officials.

At its first meeting that month, the Noyes panel recommended work in three areas: (1) biological research on the effects of radiation and radioactive materials, to be carried out mainly at the Army Chemical Corps's Toxicity Laboratory, located at the University of Chicago;[60] (2) studies on the production of radioactive materials for use in radiological warfare, carried out mainly by the AEC; and (3) military studies of possible RW munitions, also carried out mainly by the Chemical Corps.

The latter program was the focus of the Advisory Committee's attention because it involved the intentional release of radioactive materials during several dozen tests of prototype radiological weapons at the Chemical Corps's Dugway Proving Ground in the Utah desert. The offensive radiological warfare program field-testing program coincided with the Korean War years. The Noyes panel issued its final report after its sixth meeting, in November 1950,[61] and was revived briefly in 1952 to assess the status of the RW research program.[62]

The first two field tests were conducted at Oak Ridge. These involved sealed sources of radioactive material that were placed in a field in order to measure the resulting radiation levels. These measurements may have helped predict the effectiveness of radiological weapons. The sources were then returned to the laboratory and left no residual contamination in the environment.[63]

Most of the radiological warfare field tests were carried out by the Chemical Corps at the Dugway Proving Ground, using radioactive tantalum produced at Oak Ridge.[64] From 1949 to 1952, the Chemical Corps conducted sixty-five field tests at Dugway, intentionally releasing onto the ground roughly 13,000 curies of tantalum in the form of dust, small particles, and pellets. These were prototype tests, releasing much smaller quantities of radioactive material than the millions of curies per square mile that an operational radiological weapon would need to render territory temporarily uninhabitable.[65] Furthermore, the field-test programs used tantalum primarily because it could be produced at existing facilities. An operational radiological warfare program required materials that could be produced in greater quantities than tantalum, but this would have meant constructing special production facilities.[66]

In May 1949, the Chemical Corps established a panel of outside experts to provide advice on the safety of its field-testing program. Chaired by Dr. Joseph Hamilton, a strong advocate of the RW research program,[67] the panel was chartered to consider radiological hazards to the civilian population, including hazards to "the water supply, food, crops, animal population, etc." Occupational safety was left to the Chemical Corps.[68]

Under Hamilton's leadership, this panel raised a number of safety concerns but in the end appears to have been satisfied with the safety of the test program. Several months before the first panel meeting, Hamilton himself had objected to the use of the relatively long-lived isotope tantalum 182 (half-life, 117 days) as the radiological warfare agent in these field tests. He proposed using gold 198 instead (half-life, 2.7 days) to eliminate any lingering radiation hazard to the general population.[69]

At its first meeting, on August 2, 1949, the RW test safety panel provisionally accepted the proposed testing program of the Chemical Corps, subject to a radiological safety review of the results of the first two tests. Hamilton's potential opposition clearly was of consequence, and his agreement to proceed was cause for relief.[70]

Other members of the test safety panel, including Karl Morgan, head of health physics at Oak Ridge, raised concerns about the possible hazard posed by radioactive dust at an arid site like Dugway,[71] both on- and off-site. Morgan proposed the use of airborne monitoring equipment developed at Oak Ridge in tests that preceded the Green Run.[72] The use of such aircraft and other monitoring equipment evolved and expanded as the Dugway field tests continued over the next few years. Panel members approved the continuation of the program based in part on the results of these radiological surveys, which showed that contamination of the area was limited in size.[73]

In 1952 the Chemical Corps proposed a significant expansion of the radiological warfare program, with a large test of 100,000 curies planned for 1953 and still larger tests proposed for later. The test safety panel once again raised concerns over the radioactive dust hazard. Hamilton noted that there were several "hot spots"—areas of unusually high radiation—at Dugway and that trucks at one of the target areas were kicking up significant quantities of radioactive dust.[74] A Chemical Corps study in early 1953 concluded that the hazard was relatively slight.[75]

Hamilton favored going ahead with the 1953 tests and was greatly disappointed when they were canceled, and with them the entire radiological warfare test program.[76] The reasons for this cancellation are not entirely clear, but two factors are evident. The next phase of the program would have required the construction of expensive new production facilities, which collided with military budget cuts at the end of the Korean War. Furthermore, by 1953, only the Chemical Corps maintained a strong interest in the radiological warfare program, making it vulnerable to questions about whether it satisfied any unique military need.[77] The radiological warfare program did not end completely, but its focus narrowed to defensive measures, including shielding and decontamination,[78] with atmospheric nuclear tests providing the main opportunity for study.[79]

The radiological warfare test safety panel was an early example of the use of an expert panel to evaluate possible risks of planned government activities. Ideally, such a panel should not be chaired by a proponent of the program in question, although those with such knowledge of, and interest in, the program are of obvious value to a safety effort. Hamilton's evident enthusiasm for radiological warfare research raises questions about his impartiality as head of the panel,[80] but the panel as a whole appears to have dealt with serious public health issues in a responsible manner.

Secrecy in the Radiological Warfare Program

The U.S. radiological weapons-testing program appears to have remained formally secret until 1974 and remained largely unknown to the public until the GAO's report in 1993.[81] There was a recurring tension at the time between those who wanted to release information to allay unwarranted public fears about radiation hazards and those who thought that publicity would create unwarranted attention and public apprehension that could interfere with the successful prosecution of the program. If there was a concern that public knowledge of the general outlines of the program would undermine national security, none of the available documents state this argument explicitly, except through their classification markings.

In May 1948, at its first meeting, the Noyes panel recommended that the entire program be classified Secret, Restricted Data;[82] the Chemical Corps's RW program was classified at this level.[83] At its second meeting, in August, the Noyes panel revised this recommendation to conclude that "[t]he existence of an RW Program should be considered as unclassified information."[84] The Noyes panel was responding to the recommendation by the AEC's ACBM "that the Advisory Committee on Biology and Medicine urge that the broad subject of Radiological Warfare be declassified" on the grounds that "the subject appears in nearly every Sunday supplement in a distorted manner" and that "better work could be done from the scientific and medical standpoint" if the program were declassified.[85]

In February 1949, Defense Secretary James Forrestal, responding to requests for greater public disclosure of U.S. nuclear activities, appointed Harvard University President James Conant to chair a confidential ad hoc committee to make recommendations on "the information which should be released to the public concerning the capabilities of, and defense against, the atomic bomb and weapons of biological, chemical, and radiological warfare."[86] This high-level committee's work ended in October 1949 in deadlock, without making any strong recommendations. Its report to President Truman was quickly forgotten and, if anything, provided the basis for continuing the existing pattern of secrecy.[87]

Among the listed rationales provided by the majority of committee members who opposed the release of further information on the capabilities of atomic weapons was the absence of "public demand" for the information. (The positions taken "by certain well-known and probably well meaning pressure groups," they suggested, "do not spring from any general public sentiment in this regard and should, therefore be ignored.") James Hershberg, in his biography of Harvard University President James Conant, who chaired "The Fishing Party" (as the committee was code-named), has observed:

> Notably missing from this list is any indication that they were worried that the Soviet Union might derive military benefit from the release of data under consideration. . . . The observation [of the majority] that the "public would seem to be more concerned lest their officials release too much classified information, rather than too little" may have been accurate, but would the attitude have been the same if it were known the government was hiding the information not from Moscow but from its own people because it did not trust them? How else to explain the fear that "even a carefully reasoned statement . . . might have a very disturbing effect on the general public and could be misinterpreted by pressure groups in support of any extreme position they were currently advocating"?[88]

In May 1949, while Conant's panel deliberated and the Chemical Corps was preparing for the initial Dugway field tests, the Defense Department's Research and Development Board (RDB) addressed the question of releasing information on radiological warfare. The RDB's Committee on Atomic Energy recommended against a public release of information. Soon after, a joint meeting of the Military Liaison Committee and the General Advisory Council considered, but rejected a drafted letter to the President, also recommending a press release on the RW program. Later that year, on advice from Joseph Hamilton, the Chemical Corps prepared a release regarding munitions tests at Dugway. The Chemical Corps's proposal for a release was discussed with AEC and DOD officials, who rejected it, saying such a release was "not desirable."[89]

At roughly the same time, Defense Secretary Louis Johnson briefed President Truman on the radiological warfare program. The briefing memorandum prepared for Truman said that the planned tests posed a "negligible risk," but argued that "should the general public learn prematurely of the tests, it is conceivable that an adverse public reaction might result because of the lack of a true understanding of radiological hazards." It also noted that "a group of highly competent and nationally recognized authorities is being assembled to review all radiological aspects of the tests before operations are initiated at the test site."[90]

The reference in the briefing memorandum was to the radiological warfare test safety panel, which was being selected at that time. In August, at the first meeting of this panel, Albert R. Olpin, president of the University of Utah, noted the risk that uranium prospectors might stumble onto the site.[91] Citing Olpin's concern, Joseph Hamilton noted,

> While the hazards to health for both man and animals can be considered relatively slight, the adverse effects of having public attention drawn to such a situation would be most deleterious to the program. In particular, Dr. Olpin brought up the interesting point that most of Utah is being very carefully combed by a large number of prospectors armed with geiger counters. Needless to say, it is imperative that such individuals be denied the opportunity to survey any region containing a perceptible amount of radioactivity arising from the various radioactive munitions that are to be employed.[92]

Soon after this meeting, Hamilton also proposed a public release of information, perhaps reasoning that a program that was announced, but played down,[93] would attract less attention than one that was discovered accidentally. Hamilton's proposal was refused.[94] Echoing

Hamilton's concerns, the Chemical Corps proposed once more that the tests be made public, again citing the risk of discovery by uranium prospectors.[95] Robert LeBaron, chairman of the DOD's Military Liaison Committee to the AEC, turned down this request, claiming the need for review by the Armed Forces Policy Council.[96]

The official silence about the prospects for radiological warfare prompted some public speculation about the government's activities, including a report appearing in the *Bulletin of the Atomic Scientists*, a journal created following the war to give a policy voice in print to many of the physicists who had worked on the bomb. The journal had some following in the general public as well as the scientific community. The report mirrored much of the analysis of the Noyes panel and concluded that RW had significant military potential.[97]

In September 1949, the AEC's Declassification Branch recommended that certain general information, civil defense problems, and medical aspects of RW be declassified. Details regarding specific agents and methods of delivery, however, should remain secret.[98] These suggestions appear to have been adopted shortly thereafter, as AEC and DOD reports at the end of 1949 and into the early 1950s discuss some aspects of the RW program in very broad terms.[99] The closest thing to an official announcement of the field-test program appears to have come in a report for the first half of 1951.[100] This report briefly noted that "research and development activities in chemical, biological, and radiological warfare were accelerated," and that "Dugway Proving Ground . . . was reactivated, and major field-test programs in offensive and defensive toxicological warfare were started," but provided no details. The 1994 summary of declassification policy by the Department of Energy notes that offensive radiological warfare was declassified in 1951 by the AEC, although the Defense Department appears to have kept this aspect of the program classified until much later.[101]

The secrecy that surrounded the radiological warfare field-test program raises two related questions. The first question is whether concerns over public reaction are a legitimate basis for security classification. Officials at various levels cited fears of "public anxiety," "undue public apprehension," and even "public hysteria" to justify keeping even the most general information secret.

The documents reviewed by the Advisory Committee do not record the actual decisions at various stages to keep the field-testing program secret; they refer only to such decisions being made by others. It may be that those decisions reflected other reasons for secrecy. Or it may be that public reaction was considered a national security issue. This can be a legitimate argument, when the program in question is considered vital to the nation's security. However, the nation has a vital interest in open public participation in representative government, and making exceptions to the rule of openness requires a high standard of national need.

The second question is the same as the one raised for the Green Run: Can potentially important public health information about secret activities be made available to the public without compromising secrecy about the details and purposes of the activity? As described later in this chapter, this remains a live issue today.

The RaLa Tests: Two Decades of Experimentation

From 1944 to 1961, the Los Alamos Scientific Laboratory used lanthanum 140 (also known as radiolanthanum or RaLa) in 244 identified tests of atomic bomb components.[102] These tests were critical to the development of the plutonium bomb, which required a highly symmetrical inward detonation of high explosive—known as implosion—to compress the plutonium fuel and allow a critical chain reaction. The RaLa method (see "What Were the RaLa Tests?") was the only technique available for measuring whether the implosion was symmetrical enough and continued to be used for testing bomb designs until the early 1960s, when technical advances allowed the use of alternative techniques.[103]

WHAT WERE THE RALA TESTS?

Implosion devices use carefully timed detonations of carefully shaped high-explosive charges to generate a spherically symmetrical inward-directed shock wave. This shock wave in turn compresses the nuclear fuel of an atomic bomb—usually plutonium—causing it to "go critical" and undergo a nuclear chain reaction.[a]

In the RaLa tests, the plutonium core was replaced by a surrogate heavy metal with an inner core of lanthanum. Lanthanum 140 has a half-life of forty hours, emitting a high-energy gamma ray in its decay. Some of these gamma rays were absorbed as they passed through the outer components of the implosion device, the degree of absorption depending on how compressed those components were. Radiation measurement devices placed in various directions outside the device would indicate the overall compression and whether that compression was symmetrical or instead varied with direction. The lanthanum sources typically ranged from a few hundred to a few thousand curies, the average being slightly more than 1,000 curies, and were dispersed in the cloud resulting from the detonation.

In 1950 the Air Force flew a B-17 aircraft carrying an atmospheric conductivity apparatus in four radiation-tracking experiments at Los Alamos. These four experiments were identified subsequently by the General Accounting Office[104] and appear in the Advisory Committee's charter.[105] A historical analysis undertaken by the Los Alamos Human Studies Project Team in 1994 identified three of these experiments, in which the environmental release of radiation was incidental to the experiment, as part of the series of 244 intentional releases mentioned above; the presence of the tracking aircraft is all that distinguishes the three in the Advisory Committee's charter from the other 241.[106]

The Los Alamos Scientific Laboratory was established in 1943 as the atomic bomb design center for the Manhattan Project on a mesa overlooking the Rio Grande valley, about forty miles northwest of Santa Fe, New Mexico. The RaLa tests were conducted in Bayo Canyon, roughly three miles east of the town of Los Alamos, which grew up next to the lab. Although radioactive clouds from the RaLa tests occasionally blew back toward the town, the prevailing winds usually blew those clouds over sparsely populated regions to the north and east. Aside from a small construction trailer park and a pumice quarry within three miles, the next nearest population center was the San Ildefonso pueblo, roughly eight miles downwind of the test site in the Rio Grande valley. Several Pueblo Indian and Spanish-speaking communities lie within twelve miles of Los Alamos.

Risks to the Public

Concerns over risks to the public arose at the beginning of the RaLa program. In the early years, Los Alamos planners and health physicists worried that the detonations could cause some contamination in areas outside the test site, such as the construction trailer park and nearby hiking trails.[107]

As the RaLa program continued, several patterns of public safety practices developed. Initially, the principal way to protect people was to keep them out of the immediate test areas, but in later years it became the practice to test only when the weather was favorable, and later still to survey surrounding roads to detect whether contamination had reached hazardous levels.

Perhaps because early atmospheric monitoring had produced only negative results and be-

a. Lillian Hoddenson et al., *Critical Assembly: A Technical History of Los Alamos during the Oppenheimer Years, 1943–1945* (New York: Cambridge University Press, 1993), 268–271.

cause surveys in Los Alamos had indicated only minimal levels of contamination,[108] ground contamination was not believed to be a significant problem at first. Environmental surveys after RaLa tests indicated significant contamination at some locations within three miles of the release, but not at greater distances.

This observation, and the opening of a pumice quarry within three miles of Bayo Canyon, led to intensive studies of fallout from the RaLa tests in 1949 and 1950. These studies led Los Alamos to conclude that "any area which is two miles or more from the firing point may be regarded as a non-hazardous area."[109] As a result of these studies, Los Alamos restricted RaLa testing to take place only when the winds were blowing away from the town and laboratory of Los Alamos.[110] Systematic weather forecasting, therefore, began only in 1949, after more than 120 tests had been carried out, and maintaining the capability to forecast wind conditions for these tests remained an important requirement over the years.[111]

The meteorological constraints presumably reduced the radiation exposures in Los Alamos itself; exposures in more distant communities, while probably more frequent, remained lower than Los Alamos. At the Advisory Committee's public meeting in Santa Fe on January 20, 1995, however, Los Alamos activist Tyler Mercier commented that most of the "shots were fired when the wind was blowing to the northeast. At this point in time, that's where most of the population of this region lived. I mean, half of it is Spanish and half of it Native American." Mercier concluded that there "appears to be a callous disregard for the well-being and lives of the Spanish and Native Americans in our community."[112]

The RaLa tests were suspended from July 1950 to March 1952. Routine radiological survey procedures were put into place when testing resumed. Surveyors would drive along roads in three sectors monitoring radiation hazards. Readings were typically below 1 mrad per hour (1 mR/hr), but reached levels of up to 15 mR/hr at nearby locations and up to 3 mR/hr at distances of several miles. Readings in excess of 6 mR/hr required further action, including possible road closure. If the surveyors detected significant levels, they would continue monitoring in the next canyon downwind. On at least one occasion, ground contamination at relatively large distances from Los Alamos led monitors to extend their survey to a nearby town (Espanola), where they detected no radioactivity.[113]

The RaLa tests were understood from the beginning to be hazardous, but they were also critical to the design of nuclear weapons. Los Alamos officials took significant steps to understand and limit those risks. On at least two occasions—in late 1946 and from 1950 to 1952—they suspended testing amid questions about the continuing need and decided to continue testing.[114] When the RaLa tests finally ended in 1961, an alternative means of obtaining needed information had become available.

Risks to Workers

From the beginning, the RaLa tests also raised concerns over hazards to workers, particularly the chemists, in spite of elaborate measures adopted to limit these chemists' radiation exposures.[115] Lanthanum 140, with a half-life of forty hours, is itself the decay product of barium 140, which was separated from spent reactor fuel at Oak Ridge or Idaho National Engineering Laboratory in later years[116] and transported in heavily shielded containers to Los Alamos. There, chemists would periodically separate out the highly radioactive lanthanum for use in the implosion tests.

Soon after testing began on September 21, 1944, the RaLa program posed a puzzle for radiation safety. On October 16, Louis Hempelmann, director of the Health Division at Los Alamos, wrote to Manhattan Project medical director Stafford Warren about blood changes observed in the chemists working on the most recent RaLa test:[117]

> [I]t looks now as though I was too excited about the blood changes, but at that time it seemed to me to be such a clear cut case of cause and effect that I thought the measurements of dosage must have been incorrect. Now I feel reasonably certain of the dosage. . . . It was a case where risk was taken knowingly and willingly because it seemed necessary for the project. . . . It is my feeling that it should be the decision of the Director whether or not risks of this type should be taken. . . .[118]

In August 1946 Hempelmann termed the exposures of personnel in the Chemical Group "excessive" and recommended that no more "RaLa shots" be attempted until "replacements are obtained for each member in this team."[119] The tests were suspended temporarily "because of over-exposure of personnel to radiation."[120] Los Alamos was faced with the alternative of increasing its staff (so that individual exposures could be reduced) or shutting work down until safety measures were installed.

RaLa testing resumed in December 1946, after a review to determine whether it was still necessary,[121] but no documents are available to determine whether safety procedures or staffing were changed. What did change was that researchers began a formal study of the relationship between the radiation exposures and blood counts of the Bayo Canyon chemists. The chemists' depressed white blood counts (lymphopenia), presumably the same changes noted two years earlier, posed a puzzle that continued for at least a decade, resulting in three scientific reports.[122] In 1954, Thomas Shipman, who had replaced Hempelmann as Health Division director, wrote to the AEC that

> The blood counts were done with extreme care . . . and we are satisfied that the changes in counts are actual and not imaginary. It is our belief, however, that they don't mean anything; if they do mean anything, we don't know what it is.[123]

The cause of these blood effects remains uncertain. The reported doses of roughly 10 rad per year are well below levels expected to produce any detectable blood changes, a fact that was known by 1950.[124] While it is possible the effect could have been due to undetected internal contamination,[125] a more likely explanation may be that the chemists were exposed to chemical compounds that produced the observed blood changes.[126]

It appears that in the latter part of the 1940s some Los Alamos officials worried about the possible consequences of publicly releasing data on health effects, including those related to the chemists. A 1946 internal Los Alamos memo records that Dr. Oppenheimer asked that "all reports on health problems be separately classified and issued at his request." The author of the memo indicated his belief that the purpose was to "safeguard the project against being sued by people claiming to have been damaged."[127] Two years later, Norman Knowlton, a Los Alamos hematologist, reported on the blood changes in ten workers at the lab. A 1948 memo from the AEC's insurance branch argued that releasing this report on blood counts could have "a shattering effect on the morale of the employees if they became aware that there was substantial reason to question the standards of safety under which they are working" and concluded that "the question of making this document public should be given very careful study."[128] The report was not classified, however, although later reports were stamped "Official Use Only."

While the remaining information on the Los Alamos chemists is fragmentary, the experience raises an enduring question: What are the obligations of the government and its contractors to notify and protect employees whose work may expose them to continuing hazards, even when the risk is known to be small or is uncertain? As is discussed in chapter 12, during the same period, issues of worker protection and notification were raised much more starkly in the case of the uranium miners, who were placed at significant risk, a risk they had not "knowingly and willingly" taken.

Informing the Public

Although many in Los Alamos—those who worked on bomb design—knew of the RaLa program and its potential hazards, there is no indication of any discussion with other workers or local communities. For example, from the mid- 1940s to the mid-1950s many Pueblo people who may not have been informed worked at the lab as day laborers, domestics, and manufacturers of detonators.[129] The first public mention appears to have come in 1963, when the Los Alamos laboratory newsletter printed an article describing the cleanup of Bayo Canyon.[130] Los Alamos reports that its first concerted efforts to tell the Pueblo people about the RaLa program did not occur until 1994, when Los Alamos began its review of the RaLa program.[131]

Representatives of the pueblos near Los Alamos most likely to be affected by the RaLa tests have complained about past and continuing failures of laboratory officials to communicate with Pueblo workers or communities. Recent efforts at Los Alamos to undo this legacy of secrecy have created a continuing sense of frustration; Pueblo representatives state that information and other relations with the lab are still too tightly controlled to be trusted completely.[132]

It is difficult for any outsider to appreciate fully the unique cultural and religious viewpoint from which the Pueblo Indians perceive the effects of environmental releases. In addition to having several holy sites located near Los Alamos, the Pueblo have a deep respect for the land, which appears to have been violated by many of the activities at Los Alamos.[133] The Pueblo continue to rely to some degree for the basic necessities of food, heat, and shelter on plants, animals, and the earth, and they suspect that they may be at added risk of exposure to radioactivity in the environment.[134]

George Voelz, a Los Alamos physician who was at the lab during some of the RaLa tests, told the Advisory Committee, "As far as I know there was not much communication going on with the people in the area. And that, in retrospect was a mistake."[135] As a result of these failures of communication, Los Alamos now faces a difficult challenge, five decades later, of attempting to establish trust with neighboring communities that have become more suspicious because of what they have learned. Here, as in Hanford, credibility is the casualty of silence and secrecy.

Studies of Environmental Risks and Safety

The Green Run and the radiological warfare and RaLa programs were by no means the only government-sponsored experiments in which radioactive materials were intentionally released into the environment. Scientists undertook a wide variety of studies designed to understand the risks of environmental exposure to radioactive materials. For example, tests of experimental nuclear reactors at the National Reactor Testing Station in Idaho and the National Reactor Development Station in Nevada were designed to simulate possible accident scenarios under carefully controlled and isolated conditions. Similarly, tests at the Nevada Test Site were designed to understand the possible effects of an accidental (nonnuclear) explosion of a nuclear weapon.[136]

In addition to intentional releases designed to test the safety of nuclear machinery, safety was also a concern in studies designed to understand the fate of radioactive materials in the environment. Many of these studies simply took advantage of releases that occurred accidentally or were incidental to other projects. In 1943, studies of the exposure of salmon in the Columbia River to the radioactive effluent from Hanford's reactors set in motion the growing and largely public science of radioecology. The environmental analogue of radioisotope tracer studies designed to better understand the workings of the human body, these studies were intended both to follow the course of radionuclides released into the environment during nuclear weapons production and testing, and use radionuclides to trace the basic workings of the environment. The deliberate release of very small quantities of radioactive material provided the opportunity for more-controlled environmental study than those studies that simply observed radionuclides already released into the environment.[137] The Advisory Committee did not attempt to survey the entire field of radioecology, but we have reviewed the following examples in some detail.

Project Chariot

Project Chariot was a component of Project Plowshare, the brainchild of physicist Edward Teller, who helped develop the first hydrogen bomb. Plowshare arose in the late 1950s in response to public protests against atmospheric nuclear testing and was intended to demonstrate that "clean" nuclear explosives would provide safe, peaceful uses of atomic energy.[138]

In 1958, Teller selected a site in northern Alaska for Project Chariot, the proposed excavation of an Arctic seaport using a series of nuclear explosions. The site chosen was near Cape Thompson, roughly thirty miles from the Inupiat Eskimo village of Point Hope. This proposal, which was the subject of public debate, died in 1962 in the face of popular opposition.[139] However, extensive observations of the Alaskan ecosystem were undertaken between 1958 and 1962 to provide a baseline for comparison with results of the planned nuclear explosions. These observations led to the first awareness of the environmental hazards of cesium 137 from distant (primarily Soviet)[140] atmospheric nuclear tests and led to a series of studies on cesium in the food chain and in humans.[141]

Most of the environmental studies in Project Chariot were purely observational, but one series of studies involved the intentional release of small quantities of radioactive materials—a total of 26 millicuries of iodine 131, strontium 85, cesium 137, and mixed fission products.[142] In several studies, researchers from the U.S. Geological Survey spread radioactive materials on the surface of small plots of land and observed their spread across the surface when sprayed with water to simulate rainfall. In another, researchers placed mixed fission products in a small pit and measured their transport through the subsurface clay, and in yet another, researchers studied the spread of radioactivity in a creek contaminated with radioactive soil from Nevada. After these studies, the contaminated soil was removed and buried in above-ground mounds. Although this was a technical violation of regulatory requirements, an AEC memo expressed general satisfaction with the cleanup, noting that burial in the permafrost would have been too difficult.[143]

After the initial cleanup, the site remained dormant for thirty years until 1992, when a researcher discovered correspondence between the AEC and USGS about the tracer studies. In response to public concerns, the Department of Energy undertook to clean up the mounds' potentially contaminated soil. A survey indicated no externally observable radioactivity, and very little, if any measurable, radioactive material was believed to remain. In 1993, the mounds of soil were removed for disposal at the Nevada Test Site.[144] Caroline Cannon, an Inupiat Indian resident of Point Hope, told the Advisory Committee at its public meeting in Santa Fe,

> I have lived in Point Hope all my life and eaten the food from the sea and the land and drank the water of Cape Thompson, along with the others. I have to wonder about my health, what impact the poison on the earth will have all through my lifetime, emotionally, physically, and most of all for my children and my grandchildren.[145]

Although the risk to the population was minimal, residents still wonder whether other experiments might have occurred and remain secret.[146] Here again, government secrecy in the past is undermining government credibility in the present. How much comfort are Ms. Cannon and others like her able to take in reassurances from the government about risks to future generations, a government that they perceive unjustifiably kept them in the dark?

Controlled Radioiodine Releases

A small number of intentional releases involved the deliberate exposure of human subjects to trace quantities of radioisotopes in the environment. The most systematic of these were five of the roughly thirty Controlled Environmental Radioiodine Tests (CERT), carried out at Idaho National Engineering Laboratory (INEL between 1963 and 1968. Small quantities of I-131 were released into the atmosphere under carefully monitored meteorological conditions.[147]

In one study, seven volunteers drank milk from cows that grazed on the contaminated pasture. The quantity of iodine was measured carefully in the air, on the grass, in the milk, and later in the volunteers' thyroids, allowing a quantitative reconstruction of the full environmental pathway.[148] The maximum exposure among these volunteers was reported as 0.63 rad to the thyroid, nearly a factor of 50 below the contemporary annual occupational exposure limits.[149] In four other studies, a total of about twenty volunteers stood downwind at the time of the release; their exposures, from inhaling I-131 in the air, were much lower.[150] Apparently, all these volunteers were members of the INEL staff.[151] Measurements of the radioactivity in their thyroids provided a quantitative reconstruction of the inhalation pathway.

Studies similar to the CERT took place at Hanford in 1962, 1963, and possibly in 1965. The 1963 Hanford test involved human volunteers from Hanford's health physics staff, as did studies of iodine uptake from milk.[152]

The subjects in all these studies are referred to as volunteers in the relevant documents. No evidence is available bearing on what these subjects knew or were told about the experiments or the conditions under which they agreed to participate. The subjects were all staff members of the agency (or its contractors) conducting the research. The documents suggest that these staff members included knowledgeable individuals who participated in these experiments in the spirit of self-experimentation.

Reconstructing, Comparing, and Understanding Risks

Thus far, we have only briefly characterized the risks associated with the intentional releases reviewed in this chapter. Just how risky were those intentional releases and how much of this risk materialized? Although these questions cannot be answered with certainty, the answers can be approximated. Actual and suspected failures to respect public health in the environmental practices of the past have often led to efforts to reconstruct the basic facts and estimate the likely harm from environmental releases of radioactive materials. This process of environmental dose reconstruction has become an essential part of informing the public.

The task of estimating past environmental exposures to radioactive materials is a complex, multistep process. The first step is to collect data from historical records on the amount of material released. The second is to use records on weather, actual measurements of radioactivity in the environment, and computer models to reconstruct where this material went. The third step is to estimate how this distribution of material might result in radiation exposures to humans. Finally, these exposure estimates can be combined with mathematical models of radiation risks to estimate the resulting harm to people who were exposed.

Radioactive materials released into the environment can affect humans in two ways. First, they can be a source of radiation external to the body: beta radiation, which affects the skin, or more penetrating gamma radiation. Second, they can enter the body from contaminated air, food, or water and provide an internal source of radiation. Of these environmental pathways to radiation exposure, the food pathway is by far the most complicated. Radionuclides can enter the food chain at many points, through contaminated air, water, and soil, resulting in contaminated fruits, vegetables, meat, and dairy products.

The hazards from environmental exposures to radionuclides differ in important quantitative ways from those due to medical procedures or participation in biomedical research. The natural dilution of materials in the environment means that individual exposures even from massive releases are often quite small, although the chemical and biological processes involved in exposures through the food chain can lead to effects that counteract this dilution. Finally, many more people may be exposed, with exposures that vary widely from person to person.

Because individual exposures are generally too low to produce any acute effects, the main form of injury possible from environmental radiation exposure is cancer, which may occur many years after the exposure, and the number of cases attributable to such exposures can be expected to be relatively small. Evidence of cancer from exposure to radiation is difficult to separate out from other possible causes of those injuries; for the intentional releases discussed in this chapter, it is essentially impossible. Instead, we must rely on models of risk based on studies of other human radiation exposures.

Increased cancer rates among Japanese survivors of the atomic bombings provide the basis for most current radiation exposure risk estimates.[153] Health effects from the massive accident at Chernobyl and from other sites in the former Soviet Union should also be detectable and eventually may improve our understanding of the risks of chronic, low-level radiation exposure. The uncertainties in these scientific analyses are a major component of the uncertainty in risk estimation from environmental exposures.

In addition to individual exposures, it is important to know how many people were exposed. The population dose—obtained by adding up the individual exposures—provides a measure of the overall risk to the exposed population. According to models used by the Environmental Protection Agency (EPA), we can expect about

Table 1. Magnitude of Radioactive Releases

Event (number)	*Location*	*Year(s)*	*Curies Released (Total)*	*Isotope*	*Risk (fatal cancers)*[a]
Chernobyl	Ukraine, Soviet Union	1986	950,000 1,900,000 17,000,000	Cs-134; Cs-137; I-131[b]	17,400 expected/2.9 billion exposed[c]
Household radon	United States	Lifetime	N/A	Ra-222	14,000 per year expected/240 million[d]
Atomic weapons testing (atmospheric)	Worldwide	1945-1980	~26 million(Cs-137);~18 million (Sr-90); ~19 billion (I-131); ~6.5billion (H-3); ~6 million (C-14)	Cs-137; Sr-90 I-131; H-3; C-14	12,000 expected/5 billion[e]
First A-bombs	Hiroshima & Nagasaki, Japan	1945	~250,000,000	Short-lived fission products[f]	300 estimated/~76,000 tracked[g]
Early Hanford operations	Hanford, Washington	1945-1947	700,000	I-131[h]	~1.6 cases of thyroid cancer expected/ 3,200[i]
Three Mile Island	Harrisburg, Penn-sylvania	1979	15 10,000,000	I-131; noble gases[j]	0.7/2 million exposed[k]
RaLa tests (254)	Los Alamos, New Mexico	1944-1962	250,000	La-140	0.4 cases/10,000 exposed[l]
Green Run	Hanford, Washington	1949	8,000 20,000	I-131; Xe-133	0.04 expected/30,000 exposed[m]
RW field tests (65)	Dugway, Utah	1949-1952	13,000	Ta-182[n]	Unknown[o]

a. For every event but one, this column displays the risk of excess cancer fatalities. For I-131 released during "Hanford early operations," it displays the risk of excess cases of thyroid cancer.

b. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), *Sources and Effects of Ionizing Radiations* (New York: United Nations, 1993), 114, basing findings on L. A. Ilyin et al., "Recontamination Patterns and Possible Health Consequences of the Accident at the Chernobyl Nuclear Power Station," *Journal of Radiological Protection* 10 (1990): 3–29. The radioactivity released in the Chernobyl accident would include other fission products, particularly long-lived ones, but isotopes of cesium and iodine posed the greatest health hazard.

c. Lynn R. Anspaugh, Robert J. Catlin, and Marvin Goldman, "The Global Impact of the Chernobyl Reactor Accident," *Science* 242 (1988): 1516.

d. Environmental Protection Agency, Public Health Service, *A Citizen's Guide to Radon* (Washington, D.C.: GPO, May 1992), 2.

e. United Nations Scientific Committee on the Effects of Atomic Radiation, *Ionizing Radiation: Sources and Biological Effects* (New York: United Nations, 1982), 212–226. While the list of fission products released is incomplete, other products do not contribute much in the way of effective doses.

f. This is the rough level of radioactivity remaining one day after each of the explosions, including biologically active and relatively active isotopes. Samuel Glasstone, ed., *The Effects of Atomic Weapons* (Washington, D.C.: GPO, 1950), 220. The level of radioactivity diminished rapidly thereafter. Prompt neutron and gamma radiation from the nuclear explosion, rather than fallout, was responsible for most of the radiation exposures.

g. "Life Span Study," in Hiroshima Radiation Effects Research Foundation [electronic bulletin board] (cited 31 May 1995); available from www.rerf.or.jp; World Wide Web. This is the number of excess cancer fatalities between 1950 and 1985 among the 76,000 for whom doses have been calculated.

h. Sara Cate, A. James Ruttenber, and Allen W. Conklin, "Feasibility of an Epidemiologic Study of Thyroid Neoplasia in Persons Exposed to Radionuclides from the Hanford Nuclear Facility between 1944 and 1956," *Health Physics* 59 (1990): 169.

i. Kenneth Kopecky et al., "Clarification of Hanford Thyroid Disease Study," *HPS Newsletter*, July 1995, 24–25.

one induced fatal cancer for every 1,940 person-rem of radiation exposure.[154] While the risk to any one person may be small, the exposure of a large population can lead to a statistically significant increase in the number of fatal cancers, but it will be impossible to attribute any particular cancer to radiation exposure.

The Committee was not equipped to reconstruct historical doses from intentional releases, but can make some rough judgments based on more formal analyses performed by others.

The Green Run

The Green Run took place after years of routine emissions of radioiodine from the wartime and early postwar operations of the Hanford plant, and it added a relatively small amount to the overall risk (see the accompanying table I, "Magnitude of Radioactive Releases"). In 1987 the Department of Energy established the Hanford Environmental Dose Reconstruction (HEDR) project to provide an estimate of all the exposures that might have resulted and continues to refine its estimates of the resulting radiation doses to people.[155] These exposures, primarily through the food chain, may have produced a measurable excess in thyroid disease. A follow-up study of the exposed population is attempting to ascertain whether excess thyroid disease can indeed be seen.

The Green Run represents only about 1 percent of all the radioiodine releases from Hanford. Fortunately for most nearby residents, it occurred at a time of year when people were not eating fresh garden vegetables or drinking milk from cattle grazing in open pastures. The estimated radiation dose to members of the public from Hanford's operations for all of 1949 probably did not exceed 600 mrad to the thyroid, and doses ten times lower were more typical of the most highly exposed population. The Committee estimates that the Green Run may have increased the expected number of fatal thyroid cancers in the exposed population by 0.04, within broad error margins.[156] This means it is highly unlikely that even one person died as a result of the Green Run. A larger incidence of benign thyroid conditions is likely, but there is no evidence to support a connection between the intentional releases and any other possible medical conditions.

Radiological Warfare

No formal dose reconstruction has been done for the radiological warfare field tests at Dugway. Although the radioactive tantalum used in these tests does not concentrate in the food chain, because of its long half-life there may have been many opportunities for people to be exposed. Weather and vehicle traffic could have spread some of the contamination outside the Proving Ground, and even repeated low-level exposures to uranium prospectors or hikers who regularly wandered onto the site may have been possible.

Whatever public health hazard the RW tests at Dugway may have posed at the time, the

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j. UNSCEAR, *Sources and Effects of Ionizing Radiation*, 114.

k. *Report of the President's Commission on the Accident at Three Mile Island: The Need for Change: The Legacy of TMI* (New York: Pergamon Press, 1979), 12.

l. This is an upper estimate based upon a preliminary dose reconstruction by staff of the Los Alamos National Laboratory of 1.1 mSV (1.1 rem). "Assuming an individual had been at the Los Alamos site continuously throughout the experiments, the total dose from the 18 year RaLa series was estimated to have been approximately 1.1 mSv." Using the average dose of 0.6 mSv (0.6 rem), the excess cancer risk falls to 0.24. Los Alamos notes, "A somewhat abbreviated approach could be used wherein a static population of 10,000 is assumed to be uniformly distributed across the Los Alamos of the 1950s. The dose as a function of distance could be used to estimate approximate population doses." D. H. Kraig, Human Studies Project Team, Los Alamos National Laboratory, fax to Gilbert Whittemore (ACHRE staff), 14 September 1995 ("Dose Reconstruction for Experiments Involving La140 at Los Alamos National Laboratory, 1944–1962") (ACHRE No. DOE-091495-A).

m. Maurice Robkin, "Experimental Release of I-131: The Green Run," *Health Physics* 62, no. 6 (July 1992): 487–495.

n. See, for example Chemical Corps, 1952 ("Explosive Munitions for RW Agents") (ACHRE No. NARA-112294-A-10); Chemical Corps, 1952 ("Testing of RW Agents") (ACHRE No. NARA-112294-A-7); George Milly, Chemical Corps, 27 June 1952 ("Report of Field Tests 623 and 624 Airburst Test of Two 1,000 Lb. Radiological Bombs") (ACHRE No. DOD-062494-A-16); E. Campagna, Chemical Corps, 18 September 1953 ("Static Test of Full Diameter Sectional Munitions, E83") (ACHRE No. DOD-062494-A-15).

o. The Advisory Committee knows of no dose reconstructions for these releases.

radioactive decay of the tantalum caused the risks to dissipate over time. By 1960, no more than a few millicuries of tantalum remained, dispersed so widely that by this time it posed no conceivable human or environmental hazard.

RaLa Tests

Los Alamos's 1995 report on the history of the RaLa test program contains basic information necessary for an environmental dose reconstruction, including the amount of radioactivity released, a rough indication of the amount of high explosive used in each test, and meteorological and fallout data where available.[157] Advisory Committee staff reviewed the process by which this information was assembled and reported that the historical reconstruction appears to be a reasonably accurate representation of what actually occurred.

Los Alamos is using this historical information to produce an environmental dose assessment, which it is providing to the state of New Mexico and plans to submit for publication in a peer-reviewed journal. The Committee was not in a position to judge the adequacy of the dose reconstruction, but the sources, methodology, and results will be available for review by outside experts.

Individual exposures from the full series of RaLa tests were somewhat higher than for the single release of the Green Run, and the exposed population was somewhat smaller. According to a preliminary dose reconstruction by the Human Studies Project Team at Los Alamos, the total dose for someone living continuously in Los Alamos for all eighteen years of the program was roughly 110 mrem. With a population of approximately 10,000 in Los Alamos County, 0.4 excess cancer deaths might be expected. The average dose would have been 60 mrem for someone living in Los Alamos.[158]

The General Accounting Office noted an Air Force report that a B-17 airplane detected radioactive debris from one of the tests as far as seventy miles away, over the town of Watrous, New Mexico, but it is unlikely that any significant risks extended to this distance. The Human Studies Project Team concluded, however, that the cloud could not have gone as far as claimed at the time of the observation and suggests that the atmospheric conductivity apparatus used by the Air Force was sensitive to effects other than radioactivity.[159]

Los Alamos has not attempted to reconstruct the doses to the Bayo Canyon chemists. Using data from one of the reports, however, it would appear that the total exposure for these chemists was high enough to place these individuals at some increased risk for developing a radiation-induced cancer.[160]

Other Intentional Releases

No risk estimates are available for the other releases the Committee has studied, and aside from DOE's Idaho National Engineering Laboratory, no dose reconstructions have been undertaken. It does appear, however, that the human health risks were small even compared with the minimal risks of the intentional releases discussed above and with other, more familiar exposures to radioactivity in the environment (see the accompanying table, "Magnitude of Radioactive Releases").

POLICIES AND PRINCIPLES GOVERNING SECRET INTENTIONAL RELEASES: THE EFFECTIVENESS OF CURRENT REGULATIONS

Policies and Practices in the Early Years

When the federal government set out to apply atomic energy to national needs, there were no specific rules or policies to govern the deliberate release of radionuclides into the environment. Nonetheless, the declassified record of the releases just reviewed shows that those responsible considered the basic issues that concern us today and that are today the subject of federal regulation. These include the need to limit risks, the question of who should bear those risks, and the extent of the obligation to inform affected citizens.

This record indicates that, for intentional releases as for biomedical experimentation, the government was most concerned with, and placed the highest priority on, limiting human health risks. At Hanford, for example, this was done by establishing limits for the permitted level of radioactive contamination. Some of these guidelines were exceeded, if only temporarily, by the Green Run. For the radiological warfare program, the Department of Defense established a panel of outside experts to safeguard against excessive risks to the general public.

The federal government struggled throughout these early years to clarify its obligations to protect the general public from the risks of radioactive contamination in the environment, particularly from atmospheric nuclear weapons testing (see chapter 10). The 1953 Nevada test series raised serious concerns about whether and how radioactive fallout from the expanding testing program was exposing nearby people and livestock to risk.[161] In an analysis that seems equally apt for intentional releases, Richard Elliott, information director of the AEC's Santa Fe Operations Office, argued at the time that the AEC had the obligation to show that the testing program was "vital to the nation and that it was conducted as safely as possible." He also asserted, however, that the agency had duties in addition to limiting risk, including

> (1) To inform concerned publics of the hazards created and of preventive action which may be undertaken; (2) To warn people in advance of potentially hazardous situations, or of situations which may alarm them; (3) To report after the fact not only with reassurances but also with details and interpretations; (4) And, to the extent of the agency's responsibility, to reimburse the public for its losses.[162]

For most of the intentional releases described in this chapter, information was withheld entirely, even when that information might have enabled the public to reduce its risk, however small, of exposure to ionizing radiation.[163] This secrecy appears to have been motivated by legitimate national security needs in the cases of the Green Run and the RaLa program. The radiological warfare field-testing program was kept secret primarily to avoid public awareness and controversy that might jeopardize the program. The extent of secrecy abated in later years, and many of the intentional releases that occurred from about 1960 onward involved relatively low risks and were made known to the public.

Obligations to limit risk, to consider who should bear the risk, and to inform the public, while recognized, were often subordinated to concerns for national security, which were sometimes joined or melded with concerns for public relations. The information that is available indicates that the physical harm from the radiation is probably less than the damage—to individuals, communities, and the government—caused by the initial secrecy, however well motivated, and by subsequent failures to deal honestly with the public thereafter. The legacy of distrust, as described in the histories presented above, is probably more significant than the legacy of physical harm.

Regulating the Levels of Risk the Government May Impose

The past fifty years has seen the development of a body of laws and regulations governing releases into the environment, including releases of radioactive materials. These laws and regulations give legal standing to moral considerations about limiting risk, fairness in the imposition of risk, and disclosure to and involvement of the public. When environmental releases take place today—for example, in the cleanup of the nuclear weapons complex—they are subject to rules that provide procedures for public review and comment on proposed federal actions and to rules that limit the amounts of radiation that can be released into the environment.

Environmental law contains a variety of quantitative standards designed to limit the risk to human health from exposure to environmental hazards. These limits apply both to private companies and to the federal government.

The Atomic Energy Act of 1954 and the Clean Air Act of 1970 impose the most important constraints on intentional releases of radioactivity into the environment.[164] Regulations under both of these laws limit the maximum exposure to any one person. These limits are often supplemented by secondary standards (for example, on concentrations in air and water) designed to prevent exposures from exceeding this limit. This basic form of regulation remains largely unchanged from the early days of radiation protection, although the quantitative limits have been greatly reduced over the years.[165]

The actual limits on radiation exposures to members of the public have dropped dramatically over time. The initial postwar standard was for occupational exposures: 0.1 R per day.[166] If a person were exposed at such levels for his or her entire working lifetime, about fifty years, a rough extrapolation of current risk models would predict that he or she would be more likely than not to die of radiation-induced cancer. In practice, however, it is extremely unlikely that any worker came close to that level of lifetime exposure. Once it was recognized that standards for the general public should be stricter than those for a potentially hazardous workplace, the exposure standard for members of the public was set a factor of ten below the occupational standard. In 1960, when the occupational standard was reduced to 5 rem per year, the standard for exposures to members of the general public was reduced to 500 mrem per year from all artificial environmental sources.[167]

Since that time, the Environmental Protection Agency and the Nuclear Regulatory Commission (NRC) were established as separate regulatory agencies,[168] and radiation protection standards have been tightened further. The DOE and NRC have adopted the stricter limit of 100 mrem per year for general population exposure, and the EPA has proposed adopting a similar standard. The EPA's standard for atmospheric emissions under the Clean Air Act is a factor of ten lower: 10 mrem per year. A lifetime of exposure at this level would produce an expected excess in cancer deaths of a few in 10,000.[169]

By way of comparison, the average human exposure to background radiation from naturally occurring cosmic rays and radioactive materials is roughly 300 mrem per year. Exposure limits that were initially much higher than natural backgrounds have since fallen substantially below those levels. Actual public exposures are much lower still, with average medical exposures of roughly 50 mrem per year and exposures from nuclear power at roughly 1 mrem per year for people living closest to nuclear power plants.[170] Although the risk associated with the maximum allowed exposure from human-controlled sources has fallen over the years, so that it is now below that from natural background levels, it remains higher than that for exposure to chemical carcinogens, which range from 1 in 10,000 to 1 in 1,000,000.[171]

However, standards based solely on limiting individual exposures would not address the possibility that—as in the case of intentional releases—large numbers of people might be exposed to risk, though likely at low levels. As described above, the population dose, obtained by adding up all the individual doses, provides a measure of the overall risk to a large exposed population. A more universal application of the population dose in the regulatory process would give greater weight to this overall risk.[172]

Under some circumstances, however, the federal government may invoke exceptions to these baseline standards—imposing greater risks on its citizens where national need dictates. Under the Clean Air Act, only the President may invoke such exceptions, and only on the basis of "national security interest." The President must report to Congress on any such exceptions at the end of the calendar year.[173] Under the Atomic Energy Act, however, the Department of Energy is largely exempt from external regulation. When its predecessor, the Atomic Energy Commission, developed regulations for the civilian nuclear power industry, it also committed to operate its own nuclear facilities according to certain safety provisions, but allowed itself an exemption "when over-riding national security considerations dictate."[174] Such an exception under the Atomic Energy Act could still be invoked today. These exemptions clearly allow national security interests to take precedence over public health concerns. The Advisory Committee is concerned that this could occur without adequate consideration or oversight, and without adequate protection of the public's interest in a safe environment and public notice. Once the exemption is invoked, there is no formal limit on the risks to which members of the public may be exposed, although the requirement to report to Congress could deter some actions.[175]

Public Disclosure and Formal Review

Today's environmental laws require public disclosures of the likely environmental impacts of federal government actions, subject to public and EPA review, and EPA oversight of federal compliance with environmental regulations. As we will discuss below, the classification of information for national security purposes requires certain exceptions to the general rules described here.

The National Environmental Policy Act (NEPA) of 1969 requires that the federal government take into account and publicize the environmental impact of its actions.[176] NEPA's requirements serve the dual purposes of informing the public and forcing agencies of the federal government to inform themselves of the environmental impact of their actions. NEPA requires an agency to prepare an environmental impact statement (EIS) for any proposed "major federal action" having a significant impact on the human environment.[177]

As long as an agency has followed the requisite procedures (and rationally explained its choices in the EIS) it may choose whatever course of action it likes, even the alternative that poses greater environmental risks. Nonetheless, the public process can have dramatic effects on the way agencies make decisions. Assessments that are subject to public comment and decisions that are open to public scrutiny force agencies to consider public reaction when they choose policy alternatives. The adequacy of the process is subject to review by EPA and, if members of the public sue, by the courts. However, environmental impact statements may be classified in whole or in part. The EPA is obliged to review and comment on the classified portions.[178]

The EPA is also charged with making sure the federal government complies with the substantive requirements of the Clean Air Act (and other environmental statutes), and shares oversight responsibilities under the Atomic Energy Act with DOE and the NRC. For example, EPA must approve the construction or expansion of a facility, certifying that such action would not exceed the limits of the Clean Air Act. Furthermore, agencies are required to report on their emissions to EPA and are subject to fines if they violate the emissions limits. Under the Federal Facility Compliance Act, EPA must list and review environmental compliance at all federal facilities.

Selection of Sites and Affected Communities

The sites selected for intentional releases, and thus the populations affected, do not appear to have been chosen arbitrarily, but rather for reasons that are arguably defensible, albeit open to a charge of unfairness. Most of the releases took place in and around "atomic energy communities" and military sites, a choice that had several obvious advantages. First, the sites offered the expertise and facilities, both indoors and out, for the evaluation of releases involving radioactivity. Second, the locations of most of these facilities were originally chosen because of their relative, if not complete, isolation from major "civilian" population centers. Residents near these sites were generally accustomed to secret government activities in their midst. The selection of these sites for repeated exposure to releases of radioactivity—whether experimental, accidental, or routine—probably resulted in fewer people being exposed, but it also meant that the same groups were repeatedly exposed to higher than normal risks.

While there is no formal analogue to the research rules regarding fairness in the selection of subjects in the context of environmental releases, the environmental impact process does provide for public review of, and comment on, the rationale for the choice of taking an action in one locale, as opposed to another. In addition, by a 1994 executive order, President Clinton called on decision makers to consider whether actions affecting the environment may have disproportionate impact on the environment of poor or minority populations.[179] When the environmental review and decisions are made in secret, however, opportunities for any group of citizens to make their concerns known are limited.

The Effects of Secrecy on Current Policies and Protections

As we have seen, current law permits the conduct of intentional releases in secret. Secret intentional releases pose two kinds of problems for the interests of the public—loss of assurance that secret releases comply with laws regulating risk exposure and loss of the protections afforded by public disclosure and comment.

Formally, at least, the regulations limiting radiation exposures to the public and requiring official environmental review and oversight of government programs apply equally to classified programs as to public ones. In practice, however, classification creates complications that have yet to be resolved. Efforts are now under way to put procedures into place to better address proper environmental compliance in classified programs.

For example, security classification can interfere with official oversight of environmental compliance. Even in recent times, environmental oversight of classified programs has not been the rule in practice. Until 1994, the Federal Facilities Enforcement Office at EPA, which is charged with environmental oversight of all federal facilities, had no personnel with suitable clearances to oversee "black" programs—programs so highly classified that their existence is not acknowledged.[180]

Lack of oversight creates opportunities for violations of environmental law to go undetected and unpunished. Some have charged that the Department of Defense, as recently as 1993, used secrecy as a cover for violations of environmental law. Recent lawsuits against the Department of Defense and the Environmental Protection Agency allege that (1) illegal open-air burning of toxic wastes took place at a secret Air Force facility near Groom Lake, Nevada, and that (2) EPA has not exercised its required environmental oversight responsibilities for this facility.[181] Responding to the second of these lawsuits, EPA reported that in early 1995 it had seven regulators on staff with Special Access clearance who inspected the Groom Lake facility.[182] The Committee believes that the federal government has a particular obligation to provide environmental oversight of classified programs and that there is no fundamental barrier to environmental oversight in classified programs. Regulators can be granted the appropriate clearances. For example, before its existence was openly recognized, the F-117 Stealth fighter base in Nevada was subject to oversight by Nevada state regulators who had received the necessary clearances.[183] Such oversight is not automatic; it requires active cooperation between the regulatory agencies and the agencies subject to regulation. The Department of Defense has undertaken a review of environmental compliance in its "black" programs and is working with EPA to establish mechanisms to provide continuing environmental oversight of those programs.[184]

Even when regulators have the appropriate clearances, however, other aspects of secrecy can create barriers to oversight. Providing clearances often entails lengthy background investigations, which can result in delays. Furthermore, it remains unclear what EPA can do if it detects a violation that results in a dispute with the agency in charge of the program. This is a basis for concern about the credibility of environmental oversight that occurs in secret.

The limits on outside oversight are ameliorated by the fact that both DOE and DOD have established environmental and health offices that are largely independent of their respective agencies' operational programs. Under most circumstances these offices can probably provide adequate oversight over their agencies' classified programs. Because of the potential institutional conflict of interest, however, it would be preferable to have further oversight by an independent entity.

The conduct of intentional releases in secret necessarily deprives the public of information to which it would otherwise be entitled. Security classification modifies or eliminates the various requirements for providing public disclosures. The agency states that its normal practice is to send an EPA employee with appropriate clearances to the agency in question to review the classified information; EPA, however, does not keep copies of the reviewed document or any other records of such reviews.[185] Moreover, review by an EPA employee is no substitute for a process open to public comment and scrutiny.

Secrecy, especially to the degree of "black" programs, severely limits or eliminates the ability of the public to influence decisions about environmental health, either through political action or through the courts,[186] and undermines public confidence that officials are carrying out their responsibilities to safeguard public health. As in the secret releases of the past, there are also concerns about whether and what kind of information can be given to the public about environmental and public health effects when releases are classified and if restrictions on information compromise the ability of members of the public to take protective actions.

CONCLUSION

While the intentional releases described in this chapter put people at risk from radiation exposures, with limited exception, they were not undertaken for the purpose of gathering research data on humans. Thus, in contrast with the biomedical experiments studied by the Advisory Committee, they were not intended as human experiments.

Fifty years ago, unlike today, there was no formal and published body of laws that defined and limited the ability of the government to release potentially hazardous substances into the environment. Nonetheless, the duty to limit risk and, by implication, the duty to balance risks against potential benefits was understood by those who engaged in intentional releases. In the case of the Green Run, risk from the intentional release could be gauged against preexisting guidelines for operational releases; in the case of radiological warfare tests, a separate safety panel was established to consider releases.

The intentional releases studied by the Committee often engaged national security interests and were conducted in secret. However legitimate and well-motivated the releases were, security classification prevented any public notice or discussion of the Green Run—an experiment conducted for intelligence purposes—the radiological weapons field tests, or the RaLa experiments testing atomic bomb components. The essentially complete secrecy surrounding these tests prevented any warnings that might have allowed members of the public to protect themselves from whatever risks might have been inherent in the tests.

In retrospect, and with limited information, it is difficult to know whether and how national security interests affected the decisions to conduct these intentional releases. In the case of the Green Run, for example, how did decision makers seek to balance the national security interests in learning about Soviet bomb testing (and the risks of not performing the Green Run and thus not gaining relevant information) against the potential risks to the local population of the release?

The health and safety risks posed by the intentional releases appear in retrospect to have been negligible (the Green Run, for example, in comparison with other exposures at Hanford). But this does not mean that the intentional releases were without negative consequences. The secrecy that surrounded the conduct of these releases and the failure to deal forthrightly with citizens after the fact has taken a substantial toll. People living in the affected communities have been robbed of peace of mind, and the government has lost the trust of some of its citizens.

Could this happen again? Could there be another Green Run? The answer is a qualified yes. In fact, an intentional release like the Green Run probably would not be contemplated (because the scientific and strategic value would seem minimal), but actions that raise similar concerns if undertaken in secrecy could still happen. Environmental regulations apply to secret programs, but the oversight procedures are not fully in place to ensure adherence to these regulations. The public review process that is at the heart of current environmental protections could be limited or rendered nonexistent if the government were to invoke exceptions for "national security interest" to avoid these constraints.

Any government action that is conducted in secret is likely to cause suspicion and distrust, even if the risks to members of the public are minimal or nonexistent. Public policy should operate with a strong presumption favoring public disclosure and openness. There doubtless are limited circumstances under which it is justifiable to conduct an intentional release in secret. The lesson of the Green Run and the other intentional releases is, however, that unless great care is taken to preserve and honor the public's trust, the cost to the body politic of such an action is likely to be substantial. The Committee believes that the current regulatory structure does not go far enough in this regard. Provisions must be made for timely public disclosure, and records must be created and maintained capable of satisfying the affected populations that their interests have been protected. And mechanisms need to be developed to approximate the scrutiny of the public when security interests require the classification of environmental impact statements or otherwise limit disclosure of information to the public. Without such protections, the greatest casualty of the Green Run—the distrust it engendered—cannot be prevented in the future; where this happens, official concern that the public cannot be trusted to appreciate sometimes-complex information about health and safety will become an ever-more-corrosive self-fulfilling prophecy.

NOTES

1. The story of the public discovery of the Green Run is recounted in Michael D'Antonio's *Atomic Harvest: Hanford and the Lethal Toll of America's Nuclear Arsenal* (New York: Crown, 1993), 116-145.

2. U.S. Congress, General Accounting Office, *Examples of Post World War II Radiation Releases* (Washington, D.C.: GPO, 1993) (ACHRE No. DOE-042894-B-1).

3. The Committee did not undertake to review in detail the general development of radioecology, which began during the Manhattan Project with research on the radiosensitivity of aquatic life around the Hanford Reservation and extended to research on flora and fauna in and around other AEC sites. For an introductory overview, see "Survey of Radioecology: Environmental Studies Around Production Sites," in J. Newell Stannard, *Radioactivity and Health: A History* (Springfield, Va.: Office of Science and Technical Information, 1988).

4. General Dwight D. Eisenhower, to Commanding General, Army Air Forces, 16 September 1947 ("Long Range Detection of Atomic Explosions") (ACHRE No. DOD-011595-A).

5. Charles A. Ziegler and David Jacobson, *Spying Without Spies: Origins of America's Secret Nuclear Surveillance System* (Westport, Conn.: Praeger, 1995), 133.

6. Ibid., 203-204. R. H. Hillenkoetter, Rear Admiral, USN, Central Intelligence Agency, 9 September 1949 memorandum ("Samples of air masses recently collected over the North Pacific . . .") (ACHRE No. CIA-011895-A).

7. Jack W. Healy, interview by Marisa Caputo (Department of Energy, Office of Human Radiation Experiments), transcript of audio recording, 28 November 1994 (ACHRE No. DOE-120894-D), 7. Nuclear explosions release larger quantities of short-lived fission products than do nuclear reactors, so the radioactive fallout from a nuclear test decays much more rapidly than emissions from a reactor.

8. "Statement by the President on Announcing the First Atomic Explosion in the USSR, 23 September 1949," reprinted in Robert C. Williams and Philip L. Cantelon, eds., *The American Atom: A Documentary History of Nuclear Policies from the Discovery of Fission to the Present, 1939-1984* (Philadelphia: University of Pennsylvania Press, 1984), 116-117.

9. For example, krypton 85 in the atmosphere comes entirely from atmospheric testing and nuclear fuel reprocessing. Chemically unreactive, with a half-life of roughly eleven years, it is well mixed in the atmosphere, so the concentration of Kr-85 measured at random sites on the globe will provide a rough measure of the total production of plutonium production over time. See Frank von Hippel, Barbara G. Levi, and David H. Albright, "Stopping the Production of Fissile Materials for the Weapons," *Scientific American* 253, no. 3 (September 1985): 43, 45.

10. Charles A. Ziegler and David Jacobson, *Spying Without Spies*, 181.

11. F. J. Davis et al., Department of Energy, 13 April 1949, ORNL-341, declassified with deletions as ORNL-6728, 2 September 1992 ("An Aerial Survey of Radioactivity Associated with Atomic Energy Plants") (ACHRE No. DOE-122194-B), 7, 13, 156-157. Pages 136 and 148 refer to the possibility of tracking a "really strong source" from the Hanford stacks.

12. [Deleted] to Commander, Military Air Transport Service, 10 November 1949 ("In furtherance of the research and development program . . .") (ACHRE No. DOD-032395-A); [deleted] to Dr. S. C. Schlemmer, Manager, Hanford Operations Officer, 10 November 1949 ("This letter will confirm the arrangements made . . .") (ACHRE No. DOD-032395-A). The name of the author of these memorandums remains classified.

13. GAO, *Examples of Post World War II Radiation Releases*, 9.

14. H. M. Parker, Department of Energy, 6 January 1950, HW-15550-E DEL ("Health Instruments Divisions Report for the Month of December 1949") (ACHRE No. DOE-050394-A-4); H. J. Paas and W. Singlevich, Department of Energy, 2 March 1950, HW-17003 ("Radioactive Contamination in the Environs of the Hanford Works for the Period October, November, December, 1949") (ACHRE No. DOE-050394-A-6). These two reports were among more than 19,000 pages of documents on Hanford's early operations released by the Department of Energy in 1986.

15. Lieutenant W. E. Harlan, D. E. Jenne, and Jack W. Healy, Hanford Works, Atomic Energy Commission, 1 May 1950, HW-17381 ("Dissolving of Twenty Day Metal at Hanford") (ACHRE No. DOD-121494-C). This document was originally classified Secret, Restricted Data, but has been declassified in several stages; this citation is to the version that was declassified most recently and completely, on 13 December 1994. The GAO report *Examples*

of Post World War II Radiation Releases also relies on interviews with several people connected with the Green Run, including one who was involved directly in the intelligence aspects of the Green Run, but who has since died.

16. Harlan, Jenne, and Healy, "Dissolving of Twenty Day Metal," 26.

17. Ibid., 7.

18. Hanford workers managing the Green Run estimated the release at 7,780 curies. Ibid., 28. Subsequent estimates have ranged from 7,000 curies to 11,000 curies. Maurice Robkin, "Experimental Release of 131I: The Green Run," *Health Physics* 62 (June 1992): 487-495. Roughly 20,000 curies of xenon 133 were also released, but because this gas does not concentrate in the food supply or in the thyroid, it posed relatively little danger. The section "Reconstructing, Comparing, and Understanding Risks" discusses the significance of these numbers.

19. M. S. Gerber, Department of Energy, May 1994, WHC-MR-0452 ("A Brief History of the T Plant Facility at the Hanford Site") (ACHRE No. DOE-112294-A), 25-32.

20. Harlan, Jenne, and Healy, "Dissolving of Twenty Day Metal," 10-11.

21. Ibid., 12-14. See also 8, 32.

22. Healy, interview with Caputo (Office of Human Radiation Experiments), 28 November 1994, 12; Jack Healy, interview with Mark Goodman (ACHRE staff), 8 March 1995 (ACHRE Research Project Series, Interview Program File, Targeted Interview Project), 26-27. Healy has compared the contamination with that resulting from the 1957 Windscale nuclear reactor accident in the United Kingdom. Although Windscale released a greater quantity of radioiodine, the Green Run contaminated an area five to ten times as large. Healy attributed the high levels of contamination to the weather.

23. Normally the temperature of the atmosphere falls with increasing altitude. An inversion occurs when the temperature near the ground rises before falling at higher altitudes. This traps contamination in the lower levels of the atmosphere.

24. F. J. Davis et al., "An Aerial Survey of Radioactivity Associated with Atomic Energy Plants," 112-116. The Air Force had found it difficult to track radioactivity from Oak Ridge's operations in the hills and valleys of Tennessee.

25. Harlan, Jenne, and Healy, "Dissolving of Twenty Day Metal, 5-6.

26. Healy, interview with Caputo (Office of Human Radiation Experiments), 28 November 1994, 13.

27. Harlan, Jenne, and Healy, "Dissolving of Twenty Day Metal," 20-25; Bruce Napier, Battelle Pacific Northwest Laboratory, to John Kruger (ACHRE staff), 18 August 1995.

28. Harlan, Jenne, and Healy, "Dissolving of Twenty Day Metal," 70. Also, W. E. Harlan, interview by Mark Goodman (ACHRE staff), transcript of audio interview, 10 April 1995 (ACHRE Research Project Series, Interview Program File, Targeted Interview Project). Harlan recalls no plans to track the plume to greater distances.

29. The "permanent tolerance value" at the time was 0.009 microcuries per kilogram (FCi/Kg) of vegatation. Harlan, Jenne, and Healy, "Dissolving of Twenty Day Metal," 3. Readings from the Green Run were as high as 4.3 *m*Ci/kg. The current intervention level is .013 *m*Ci/kg. Al Conklin, Washington Department of Health, 7 November 1994, personal communication with Mark Goodman (ACHRE staff).

30. In mid-1949, the standard was lowered from 0.2 FCi/kg to 0.1 FCi/kg. Manager, Health Instruments Division, Hanford, to AEC, Hanford Operations Office, 8 November 1950 ("Radiation Exposure Data"), which is still ten times higher than described in Harlan, Jenne, and Healy, "Dissolving of Twenty Day Metal," 3. A footnote in the November 1950 report suggests that the lower level (0.01FCi/kg) was still controversial and considered by the author to be overly cautious.

31. H. M. Parker, "Health Instruments Divisions Report for December 1949," 2; Harlan, Jenne, and Healy, "Dissolving of Twenty Day Metal," 3, 65.

32. Healy, interview with Caputo, 28 November 1994, 8-9. The largest hazard is now known to come from drinking milk from cows that graze on pastures contaminated with radioiodine. The earliest reference from Hanford to the milk pathway is H. M. Parker, "Radiation Exposure from Environmental Hazards," presented at the United Nations International Conference on the Peaceful Uses of Atomic Energy, August 1955, reprinted in Ronald L. Kathren, Raymond W. Baalman, and William J. Bair, eds., *Herbert M. Parker: Publications and Other Contributions to Radiological and Health Physics* (Richland, Wash.: Battelle Press, 1986), 494-499. A reference to concern over milk contamination in Utah from a 19 May 1953 atmospheric test appears in "Transcript of Meeting on Statistical Considerations on Field Studies on Thyroid Diseases in School Children in Utah-Arizona, December 3, 1965, Rockville, MD" (ACHRE No. HHS-022395-A), 4.

33. Herbert Parker, Chief Supervisor, to S. T. Cantril, Assistant Supervisor, 11 December 1945 ("Xenon And Iodine Concentration in the Environs of the T and P Plant") (ACHRE No. IND-120294-A-1); Herbert Parker to File, 17 December 1945 ("Proposed Revision of Tolerances for I 131") (ACHRE No. IND-120294-A-2); Herbert M. Parker, Department of Energy, 14 January 1946 ("Tolerance Concentration of Radio-Iodine on Edible Plants") (ACHRE No. IND-120294-A-3). This was confirmed by later dose reconstructions. The estimated doses range up to several hundred rad (a few tens of rem) to the thyroid. Technical Steering Panel, Department of Energy, 10 February 1990 ("Hanford Environmental Dose Reconstruction Project: Find-

ing the facts about people at risk.") (ACHRE No. DOE-050694-B-3).

34. Estimates from ARH-3026, by J. D. Anderson as cited in the Technical Steering Panel of the Hanford Environmental Dose Reconstruction Project, Department of Energy, March 1992 ("The Green Run") (ACHRE No. ORE-110794-A).

35. Parker, "Tolerance Concentration of Radio-Iodine on Edible Plants," Kathren, Baalman, and Bair, *Herbert M. Parker: Publications and Other Contributions to Radiological and Health Physics*, art. IV-7.

36. "Report of Safety and Industrial Heath Advisory Board," as cited in Daniel Grossman, *A Policy History of Hanford's Atmospheric Releases* (Ph.D. diss., Massachusetts Institute of Technology, 1994), 169.

37. F. A. R. Stainkan to R. S. Ball, "Stack Gas Conference—Washington, D.C.," 8 September 1948, HW-10956. Michele S. Gerber, *On the Home Front: The Cold War Legacy of the Hanford Nuclear Site* (Lincoln: University of Nebraska Press, 1994), 89.

38. Parker, "Health Instrument Divisions Report for Month of December, 1949," 3.

39. Healy, interview with Caputo, 28 November 1994, 8.

40. [Deleted] to Dr. Schlemmer, 10 November 1949, 2.

41. "Green Run," an Air Force official noted in a 1995 comment on this omission, "was beset by numerous technical and meteorological problems that significantly compromised the value of the results obtained. In our view, then, this omission implies the Green Run was not useful, rather than unnecessary." Major Meade Pimsler, USAF, to ACHRE Staff, 19 June 1995 ("Comments on 5th Set of Review Chapters").

42. ACHRE Research Project Series, Mark Goodman Files, 6-21. The device in question was the atmospheric Conductivity Apparatus; it was used in Operation Fitzwilliam, at the radiation survey flights at Oak Ridge and Hanford, at the Green Run, and in radiation survey flights at the Los Alamos radiolanthanum tests described in this chapter.

43. Grossman, *A Policy History of Hanford's Atmospheric Releases*, 230-232 (references 24 and 35).

44. Neal D. Hines, *Proving Ground: An Account of the Radiobiological Studies in the Pacific 1946-61* (Seattle: University of Washington Press, 1962).

45. Stannard, *Radiactivity and Health: A History*, 761-762.

46. Decision on AEC 180/1 and 180/2, as cited in Grossman, *A Policy History of Hanford's Atmospheric Releases*, 244-245.

47. AEC 180/1; Ibid., 245.

48. Herbert Parker, 19 August 1954 ("Columbia River Situation—A Semi-Technical Review") (ACHRE No. DOE-053095-A), 5.

49. William Bale, Advisory Committee for Biology and Medicine, transcript of proceedings of 13-14 January 1950 (ACHRE No. DOE-072694-A). The ACBM decided at this meeting that it might be possible to publish a sanitized version of the report to aid scientists studying the contamination problem. It is unclear whether the report was published.

50. Lynne Stembridge, Advisory Committee on Human Radiation Experiments, transcript of proceedings of 21 November 1994 (Spokane, Wash.).

51. For the perspective of a government-sponsored expert involved in the reconstruction of the risk at Hanford and other nuclear weapons sites on the necessity of public participation in dose reconstruction activities, see John Till, "Building Credibility in Public Studies," *American Scientist* 83, no. 5 (September-October 1995).

52. Scott Davis, Ph.D., et al., Fred Hutchinson Research Center, 24 January 1995 ("Hanford Thyroid Disease Study: Final Report") (ACHRE No. DOE-061295-A).

53. Tom Bailie, Advisory Committee on Human Radiation Experiments, transcript of proceedings, 21 November 1994 (Spokane, Wash.), 121-122.

54. Quoted in Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon and Schuster, 1986), 365. See also Henry DeWolf Smyth, *Atomic Energy for Military Purposes* (Stanford, Calif.: Stanford University Press, September 1, 1945), 71. Princeton physicists Henry DeWolf Smyth and Eugene Wigner reported later that year that the fission products produced in one day's operation of a 100-megawatt reactor could render a large area uninhabitable. Eugene Wigner and Henry D. Smyth, National Academy Project, 10 December 1941 ("Radioactive Poisons") (ACHRE No. NARA-033195-A).

55. J. Robert Oppenheimer to Enrico Fermi, 25 May 1943, reproduced in Barton Bernstein, "Oppenheimer and the Radioactive Poison Plan," *Technology Review* 88, no. 14 (May 1985).

56. These included Dr. Joseph Hamilton of Berkeley, who had performed pioneering studies of the fate of radioactive materials in the bodies of animals and humans (see chapter 5). Joseph Hamilton, M.D., to K. D. Nichols, 31 December 1946 ("Radioactive Warfare") (ACHRE No. DOD-010395-C-1); Lee Bowen, U.S. Air Force ("A History of the Air Force Atomic Energy Program, 1943-1953, volume IV: The Development of Weapons") (ACHRE No. SMITH-120994-A-1), 323.

57. Joseph Hamilton to D. T. Griggs, Project Rand, Douglas Aircraft Co., 7 April 1948 ("I wish to thank you . . .") (ACHRE No. DOE-072694-B-34).

58. For example, General Douglas MacArthur proposed in 1950 to lay down a line of highly radioactive cobalt 60 to block a Chinese return to the Korean Peninsula. Bruce Cummings, *The Origins of the Korean War, volume II: The Roaring of the Cataract, 1947-1950* (Princeton, N.J.: Princeton University Press, 1981), 750.

59. The Armed Forces Special Weapons Project, the Air Force, and the Army's Chemical Corps were

interested in both offensive and defensive radiological warfare, while the Naval Radiological Defense Laboratory focused on defense.

60. This research program, led by Dr. Franklin McLean, used animals to test the toxicity of various candidate radiological warfare agents. The Advisory Committee's research has uncovered no evidence that human subjects were used in any of these studies. The Toxicity Laboratory also performed studies using human subjects on the inhalation of aerosols, but available documents do not indicate any use of radioactive material as tracers or otherwise. These studies may have been related to the Chemical Corps's programs in chemical and biological wareface. Frank C. McLean to Shields Warren, Director, Division of Biology and Medicine, 5 October 1948 ("Program of Chicago Toxicity Laboratory") (ACHRE No. DOE-082294-B-18); Walter J. Williams, Acting General Manager, to Major General A. H. Waitt, Chief, Chemical Corps, 12 April 1948 ("For some time we have been considering ways and means of enlarging programs . . .") (ACHRE No. DOE-012595-B-2); Shields Warren to Frank C. McLean, 4 May 1950 ("In light of our conversations of January 25, 1950 . . .") (ACHRE No. DOE-012595-B-1).

61. Joint AEC-NME Panel on Radiological Warfare, 20 November 1950 ("Radiological Warfare Program Status Report: Sixth Meeting of the Joint AEC-NME Panel on Radiological Warfare") (ACHRE No. CORP-010395-A-2). See also, Atomic Energy Commission, Division of Military Application, 26 December 1950 ("Conclusions and Recommendations of the Sixth Meeting of the RW Panel") (ACHRE No. DOE-092694-B-3).

62. Major Thomas A. Gibson, Chemical Corps, Radiological Branch, to Chief of Staff, AFSWP, 23 April 1952 ("A Technical Study Group to Review the Technical Aspects of Radiological Warfare") (ACHRE No. NARA-033195-A).

63. These two tests appear in the Advisory Committee's charter. One test involved three sources of roughly 1,280, 100, and 20 curies of radioactive lanthanum: Karl Z. Morgan and C. N. Rucker, Oak Ridge National Laboratory, 23 July 1948 ("Single Source Lanthanum Test—AHRUU Program") (ACHRE No. DOE-051094-A-122). The other used 156 tantalum sources of roughly 100 millicuries each distributed in an uniform grid; Karl Z. Morgan, Oak Ridge National Laboratory, 11 August 1948 ("Uniformly Distributed Source, AHRUU Program") (ACHRE No. DOE-051094-A-118).

64. R. W. Cook to Brigadier General James McCormack, Division of Military Applications, 4 May 1949 ("Irradiation of Tantalum for RW Tests") (ACHRE No. DOE-120994-A-24).

65. Atomic Energy Commission, Division of Military Application, 26 December 1950 ("Conclusions and Recommendations of the Sixth Meeting of the RW Panel"), 3.

66. AFSWP to Chief, Chemical Officer, Department of the Army, 31 December 1952 ("Re-evaluation of the Research and Development Program on Offensive Radiological Warfare") (ACHRE No. CORP-010395-A-5); this memo makes reference to the proposed production of zirconium and niobium radioisotopes.

67. Joseph Hamilton had written in 1948: "In concluding, I would like to emphasize that all of the potentialities, including the rather repellent concepts of the use of fission products and other radioactive materials as internal poisons, should be explored up to and including a level of pilot experiments on a fairly large scale. I feel very strongly on the point that unless we ourselves learn all we can about the use and possible methods of protection against these agents and a wide variety of their potential applications as military weapons, we shall have failed to explore the necessary measures which may be desperately needed for the protection of our own people." Joseph Hamilton to D. T. Griggs, Project Rand, Douglas Aircraft Co., 7 April 1948 ("I wish to thank you very much for . . .") (ACHRE No. DOE-072694-B-34), 3.

68. C. B. Marquand, Secretary, Test Safety Panel, to Joseph Hamilton, Director, Crocker Laboratory, 24 August 1949 ("Meeting of the Test Safety Panel at Dugway Proving Ground on August 2, 1949") (ACHRE No. DOE-072694-B-29), 3.

69. Joseph Hamilton to C. B. Marquand, Office of the Chief, Chemical Corps Advisory Board, 6 July 1949 ("I am sorry not to have had some more definitive information . . .") (ACHRE No. DOE-072694-B-3).

70. C. B. Marquand, Secretary, Test Safety Panel, and S. C. Hardwick, Assistant Secretary, Test Safety Panel, Atomic Energy Commission, 5 August 1949 ("Preliminary Report of the Test Safety Panel Meeting at Dugway Probing Ground—August 2, 1949") (ACHRE No. CORP-010395-A-1).

71. G. Failla, Columbia University, to Joseph Hamilton, 13 May 1950 ("In answer to your letter of May 10th, I . . .") (ACHRE No. DOE-072694-B-4).

72. Karl Z. Morgan to Joseph Hamilton, 9 September 1949 (ACHRE No. DOE-072694-B-5).

73. Joseph Hamilton to Albert Olpin, President, University of Utah, 10 May 1950 ("Please find enclosed my report and recommendations for . . .") (ACHRE No. DOE-072694-B-7); Failla to Hamilton, 13 May 1950; Albert Olpin to Joseph Hamilton, 17 May 1950 ("It was good to hear from you again . . .") (ACHRE No. DOE-072694-B-55); Joseph Hamilton to C. B. Marquand, 1 June 1950 ("At long last I have received agreement from . . .") (ACHRE No. DOE-072694-B-21); Joseph Hamilton to C. B. Marquand, 4 August 1949 ("This letter is to confirm") (ACHRE No.CORP-010395-A-1).

74. Joseph Hamilton to C. B. Marquand, 18 November 1952 ("Last week, I spent a profitable two days . . .") (ACHRE No. DOE-072694-B-23). See also,

Joseph Hamilton to John Bugher, Director, Division of Biology and Medicine, 25 February 1953 ("In my opinion . . .") (ACHRE No. DOE-072694-B-49).

75. Department of Defense, 11 May 1953 ("An Evaluation of the Airborne Hazard Associated with Radiological Warfare Tests") (ACHRE No. DOE-072694-B-50), iii.

76. Brigadier General William M. Creasy to Chief Chemical Officer, Department of the Army, 24 June 1953 ("Minimum Fund Requirement") (ACHRE No. DOD-030895-F-3); U.S. Army Chemical Corps, 31 December 31 1953 ("RDB Project Card: Progress Report, Project No. 4-12-30-002") (ACHRE No. NARA-112294-A-1); Joseph Hamilton to C. B. Marquand, 23 July 1953 ("I regret to hear that the RW Program has been so drastically reduced . . .") (ACHRE No. DOE-072694-B-51).

77. Lee Bowen, United States Air Force Historical Division, "A History of the Air Force Atomic Energy Program, 1943-1953, vol. 4: The Development of Weapons" (ACHRE No. SMITH-120994-A-1), 331-332.

78. Merril Evans, 3 June 1953 ("RW Decontamination and Land Reclamation Studies") (ACHRE No. DOD-062494-A-11); also Chemical Corps, 1952 ("Testing of RW Material for Detection, Protection and Decontamination") (ACHRE No. NARA-112294-A-5).

79. Lee Bowen, "The Development of Weapons," 333-337.

80. The Chemical Corps recognized Hamilton's support for the radiological warfare program. A 1952 Chemical Corps memorandum, Lieutenant Colonel Truman Cook to Secretariat, Chemical Corps Advisory Council, 7 April 1952 ("Radiological Warfare Test Saftey Panel") (ACHRE No. DOE-072694-B-46), noting the greater risk associated with planned large-scale tests, including possible plutonium contamination from the use of fission products, recommended that the test safety panel should be dissolved and Hamilton and someone chosen by him be retained as a consultant.

81. Joseph Hamilton's papers, including those dealing with the radiological warfare test safety panel, were declassified in 1974, but the GAO report provided the first opportunity for most people to learn about it.

82. Atomic Energy Commission, Ad Hoc Panel on Radiological Warfare, proceedings of 23 May 1948 (ACHRE No. CORP-051894-A-1). Restricted Data are atomic energy secrets as classified by statute under the Atomic Energy Act. Information may also be classified Confidential, Secret, or Top Secret, depending on its importance to national security, under the authority of an executive order by the President. See chapter 13 on secrecy for details.

83. Chemical Corps, 1 January 1948 ("Quarterly Technical Progress Reports") (ACHRE No. NARA-121594-B).

84. Joint NME-AEC Panel on Radiological Warfare, 29 August 1948 ("Radiological Warfare Report—Second Meeting") (ACHRE No. DOD-041295-A), 72.

85. Atomic Energy Commission, Advisory Committee for Biology and Medicine, proceedings of 11-12 June 1948 (ACHRE No. DOE-072694-A). The ACBM reiterated this recommendation at its next meeting on 11 September 1948. Atomic Energy Commission, Advisory Committee for Biology and Medicine, proceedings of 11 September 1948 (ACHRE No. DOE-082294-B-15), 15.

86. The eight members included future President Dwight D. Eisenhower, who was president of Columbia University at the time, and New York lawyer John Foster Dulles, who would serve as secretary of state in the Eisenhower administration. See James Hershberg, *James B. Conant: Harvard to Hiroshima and the Making of the Nuclear Age* (New York: Alfred A. Knopf, 1993), 378-383. The story of the Conant Committee is told in chapter 20 of Hershberg's book.

87. Ibid., 390.

88. Ibid., 383. The members of the majority opposed to further release included Eisenhower and Dulles.

89. Marshall Stubbs to Joseph Hamilton, 30 August 1949 ("Following your suggestion that we prepare . . .") (ACHRE No. DOE-072694-B-1). Stubbs concluded by reporting, "Both Colonel Cooney and Captain Winant reiterated that regardless of the actions noted above, such a release is not desirable."

90. William Webster to Secretary Johnson, Department of Defense, 11 May 1949 ("Memorandum for the President: This memorandum is to inform you of planned activities . . .") (ACHRE No. DOD-071194-A-4).

91. Joseph Hamilton to C. B. Marquand, Secretary, Test Safety Panel, 4 August 1949 ("This letter is to confirm the decisions . . .") (ACHRE No. CORP-010395-A-3).

92. Ibid., 3.

93. The proposed press release falsely described the program as intended only "to determine a proper defense," involving "the distribution of small amounts of radioactive materials on various types of simulated targets in the field." Marshall Stubbs to Joseph Hamilton, 30 August 1949 ("Following your suggestion . . .") (ACHRE No. DOE-072694-B-1), 2.

94. Ibid.

95. Colonel William M. Creasy, Chief, Research and Engineering Division, U.S. Army Chemical Corps, to Director of Logistics, U.S. Army General Staff, 3 October 1949 ("Public Release On R[adiological] W[arfare] Tests at Dugway Proving Ground") (ACHRE No. DOD-071194-A-1). The letter notes the draft press release contains "no reference to the general RW program or to the use of radioactive materials as agents of warfare. It does indicate the use of radioactive materials in the Dugway area for the purpose of formulating defensive doctrine."

96. C. G. Helmick, Deputy Director for Research and Development, to Robert LeBaron, Chairman,

Military Liaison Committee, 3 January 1950 ("Public Release on RW Tests at Dugway Proving Ground") (ACHRE No. DOD-071194-A-1); Robert LeBaron to C. G. Helmick, 19 January 1950 ("Public Release on RW Tests at Dugway Proving Ground") (ACHRE No. DOD-071194-A-1).

97. Louis N. Ridenour, "How Effective Are Radioactive Poisons in Warfare?" *Bulletin of the Atomic Scientists* 6 (1950): 199-202. On the birth of *Bulletin of the Atomic Scientists* and, more generally, the history of the physics community that worked on the bomb, see Daniel J. Kevles, *The Physicists: The History of the Scientific Community in Modern America* (New York: Vintage, 1979), 351.

98. Atomic Energy Commission, Declassification Branch, 30 September 1949 ("Classification Guide for Radiological Warfare") (ACHRE No. DOE-070695-C).

99. U.S. Department of Defense, *Semiannual Report of the Secretary of Defense and the Semiannual Reports of the Secretary of the Army, Secretary of the Navy, Secretary of the Air Force, July 1 to December 31, 1949* (Washington, D.C.: GPO, 1950), 65-69; Samuel Glasstone, executive editor, *The Effects of Atomic Weapons* (Washington, D.C.: GPO, 1950), 287-290.

100. U.S. Department of Defense, *Semiannual Report of the Secretary of Defense and the Semiannual Reports of the Secretary of the Army, Secretary of the Navy, Secretary of the Air Force, January 1 to June 30, 1951* (Washington, D.C.: GPO, 1951) (ACHRE No. DOD-052695-A), 36. In an August 1951 letter to AEC Chairman Dean, Acting Secretary of Defense Rovert Lovett noted: "The Director of Public Information, Department of Defense, has been directed to undertake a program of public information in this field as recommended by the [Noyes] Panel."

A further memo to the Director, Office of Public Information, the author of which is unclear, cited the Noyes panel's recommendation that civil defense agencies and the public be apprised "concerning the nature and possibilities of radiological warfare as well as possible countermeasures so as to avoid the possibility of panic should an enemy carry out an attack . . . and that studies be made of the psychological effects to be expected." Robert Lovett to Gordon Dean, 6 August 1951 ("The Final Report of the Joint AEC-NME Panel . . .") (ACHRE No. DOD-081695-A); memorandum to Director, Office of Public Information, undated ("Public Information Program on Radiological Warfare") (ACHRE No. DOD-021095-A).

101. U.S. Department of Energy, Office of Declassification, *Drawing Back the Curtain of Secrecy: Restricted Data Declassification Policy, 1946 to the Present* (RDD-1) (1 June 1994), 82.

102. Human Studies Project Team, Los Alamos National Laboratory, March 1995 ("The Bayo Canyon Radioactive Lanthanum [RaLa] Program [draft]") (ACHRE No. DOE-031095-B-1). This report lists 254 RaLa tests, but 1 planned test was never fired, and the last 9, conducted for different purposes, did not release radiolanthanum into the environment.

103. D. P. MacDougall to N. E. Bradbury, 22 June 1961 ("RaLa Shots in Bayo") (ACHRE No. DOE-040695-A-13), concludes that the RaLa program should not be dismantled until the replacement procedure, Phermex, was operating. Jane H. Hall to Distribution, 8 February 1963 ("Subject: Rala") (ACHRE No. DOE-040695-A-8), reports that "RaLa may no longer be released into the Bayo Canyon atmosphere."

104. GAO, *Examples of Post World War II Radiation Releases*, 16.

105. The fourth experiment was not an intentional release; like the Oak Ridge radiological warfare experiments, it involved a sealed source of radiation that was later returned to the laboratory. Samuel Coroniti, Los Alamos Scientific Laboratory, 19 July 1950 ("Radiation Test Conducted at Los Alamos, New Mexico on 19 July 1950") (ACHRE No. DOE-051095-B).

106. Human Studies Project Team, Los Alamos National Laboratory, March 1995 ("The Bayo Canyon/Radioactive Lanthanum RaLa Program [draft]"), 6. The GAO report states that the Air Force Cambridge Research Laboratories and Los Alamos jointly performed the explosions; Samuel C. Coroniti, Air Force Cambridge Research Laboratories, 26 May 1950 ("Report on the Atmospheric Electrical Conductivity Tests Conducted in the Vicinity of Los Alamos, Scientific Laboratories, New Mexico") (ACHRE No. DOD-120294-A-1). S. V. Burriss, Los Alamos Scientific Laboratory, to Colonel Benjamin G. Holzman, Research and Development, Pentagon, 11 October 1949 ("Cloud Studies at Los Alamos") (ACHRE No. DOE-060295-B), indicates that the Air Force simply took advantage of releases that occurred for other purposes.

107. L. H. Hempelmann to David Dow, 29 June 1944 ("Safety of Radiolanthanum Experiment in Bayo Canyon") (ACHRE No. DOE-051094-A-15); Los Alamos Scientific Laboratory, Safety Committee, proceedings of 7 March 1945 (ACHRE No. DOE-052395-B-1).

108. Ralph G. Steinhardt, Jr., to Joseph Hoffman, 19 June 1945 ("Summary Report on Health Conditions in RaLa Program") (ACHRE No. DOE-052395-B-2).

109. T. L. Shipman to R. E. Cole, Atomic Energy Commission, Office of Engineering and Construction, through N. E. Bradbury, 4 April 1950 ("Health Hazards—Guaje Canyon and Vicinity") (ACHRE No. DOE-052395-B), 1.

110. If the wind was blowing toward the main access road to the Los Alamos mesa, tests could not be conducted in the late afternoon. T. L. Shipman to Donald Mueller through N. E. Bradbury and Duncan MacDougall, 28 April 1949 ("Precaution for Bayo Canyon Shots") (ACHRE No. DOE-042495-C).

111. Los Alamos Scientific Laboratory, 8 March 1952 ("H-1 Program for Bayo Canyon Shots")

(ACHRE No. DOE-042495-C); Los Alamos Scientific Laboratory, 23 July 1952 ("H-1 Program for Bayo Canyon Shots") (ACHRE No. DOE-042495-C); Los Alamos Scientific Laboratory, 1 April 1958 ("H-1 Program for Bayo Canyon Shots") (ACHRE No. DOE-042495-C); and C. D. Montgomery, D. W. Mueller, R. O. Niethammer, 30 June 1954, revised 15 January 1960 ("Clearance, Firing, and Monitoring Procedures for Bayo Canyon Site") (ACHRE No. DOE-040695-A-14), 8, all describe the continuing requirements for weather forecasting. N. E. Bradbury to Distribution, 8 March 1956 ("Meteorological Forecasting Service") (ACHRE No. DOE-040695-A-12), notes the continuing need for weather forecasting in the context of an Air Force threat to withdraw two meteorologists.

112. Tyler Mercier, Advisory Committee on Human Radiation Experiments, transcript of proceedings of 30 January 1995, Santa Fe, N.M., 35.

113. Glenn Vogt, General Monitoring Section, Los Alamos, to Dean Meyer, Group Leader, 20 April 1956 ("Bayo Canyon Activities, April 12, 16, 18, 1956") (ACHRE No. DOE-041295-C).

114. D. W. Mueller to RaLa Committee, 22 September 1952 ("RALA Shots") (ACHRE No. DOE-071095-B).

115. Steinhardt to Hoffman, 19 June 1945.

116. The National Reactor Testing Station was established near Idaho Falls in 1950, and plans to process Ba-140 for Los Alamos at Idaho Chemical Processing Plant were made on 5 November 1952. Dick Duffey, Atomic Energy Commission, to W. B. Allred, Chief, Reactor Division, Oak Ridge Operations Office, and H. Leppich, Idaho Operations Office, 5 November 1952 ("This will confirm our telephone conversation . . .") (ACHRE No. DOE-040695-A).

117. The third test had taken place two days earlier, on 14 October 1944. Human Studies Project Team ("The Bayo Canyon [RaLa] Program"), appendix A-1.

118. Louis Hempelmann, M.D., to Colonel Stafford Warren, 16 October 1944 ("Enclosed is an excerpt of my report about the health hazards . . .") (ACHRE No. DOE-071494-A-10).

119. Louis Hempelmann to Norris E. Bradbury, 30 August 1946 ("Excessive Exposures at Bayo Canyon") (ACHRE No. DOE-062295-A-1).

120. E. R. Jette, Acting Director, to Technical Board Members, 3 September 1946 ("The main topic for discussion at the Technical Board meeting . . .") (ACHRE No. DOE-062295-A-2) .

121. Ibid.

122. Norman Knowlton, Los Alamos Scientific Laboratory, "Changes in the Blood of Humans Chronically Exposed to Low Level Gamma Radiation," LA-587, 1948 (ACHRE No. DOE-033095-A-2); Robert Carter and Norman Knowlton, "Hematological Changes in Humans Chronically Exposed to Low-Level Gamma Radiation," LA-1092, 1950 (ACHRE No. DOE-030695-A); Robert E. Carter et al., Los Alamos Scientific Laboratory, July 1952, LA-1440 "Further Study of the Hematological Changes in Humans Chronically Exposed to Low-Level Gamma Radiation" (ACHRE No. DOE-033095-A).

123. Thomas Shipman, Health Division Leader, Los Alamos Scientific Laboratory, to Gordon Dunning, Division of Biology and Medicine, 21 July 1954 ("When we finally decided to issue LA-1440 . . .") (ACHRE No. DOE-020795-D-4).

124. Samuel J. Glasstone, ed., *The Effects of Atomic Weapons* (Washington, D.C.: Atomic Energy Commission, 1957), 342.

125. This dosimetry appears to have been a subject of some care. See Louis Hempelmann to Stafford Warren, 16 October 1944 ("Enclosed is an excerpt . . .") (ACHRE No. DOE-071494-A-10), and William C. Inkret, Human Studies Project Team, Los Alamos National Laboratory, to Michael Yuffee, Office of Human Radiation Experiments, Department of Energy, 16 May 1995 ("This letter is a follow-up to the other materials we have sent . . .") (ACHRE Request No. 032995-C).

126. For example, organic solvents such as benzene and toluene can cause depressed white blood cell counts. The first of the Los Alamos reports (Knowlton, LA-587, 1948) notes that the control group was not exposed to organic solvents, suggesting that the researchers were aware of this fact, but does not consider this as a factor in the chemists' blood counts.

127. J. F. Mullaney to N. E. Bradbury, 3 January 1946 ("Biological Effects of July 16th Explosion"), 1. See also Bradbury to Mullaney, 7 January 1946.

128. Clyde Wilson, Chief, Insurance Branch, to Anthony C. Vallado, Deputy Declassification Officer, 20 December 1948 ("Review of Document by Knowlton") (ACHRE No. DOE-120894-E-32).

129. Leon Tafoya, interview with Mark Goodman (ACHRE staff), 10 March 1995 (ACHRE Research Project Series, Interview Program File, Targeted Interview Project).

130. "Bye Bye Bayo Site," *LASL News*, 23 May 1963 (ACHRE No. DOE-051094-A-622), 7.

131. William C. Inkret, Los Alamos Human Studies Project Leader, to Mark Goodman and Dan Guttman (ACHRE staff), 17 April 1995 ("Attached are the answers to questions 6 and 7 of . . .") (ACHRE No. DOE-042495-C), 4-5.

132. Leon Tafoya, interview with Mark Goodman (ACHRE staff), 10 March 1995; and Gilbert Sanchez, interview with Mark Goodman (ACHRE staff), 9 March 1995 (ACHRE Research Project Series, Interview Program File, Targeted Interview Project).

133. Leon H. Tafoya, "Biocultural Dimension of Health and Environment," *Hazardous Waste and Public Health* (1994): 245-252.

134. Sanchez, interview with ACHRE staff, 9 March 1995.

135. Dr. George Voelz, Advisory Committee on Human Radiation Experiments, transcript of proceedings of 30 January 1995, Santa Fe, N.M., 43.

136. Department of Energy, *Human Radiation Experiments: The Department of Energy Roadmap to the Story and the Records* (Springfield, Va.: National Technical Information Service, February 1995), 214-222.

137. The story of this early Hanford research is told in Hines, *Proving Ground.* See also, Stannard, *Radioactivity and Health*, 745-1368.

138. Daniel O'Neill, *The Firecracker Boys* (New York: St. Martin's Press, 1994), 28, 31-46. Some tests were designed to see whether nuclear explosions could stimulate the release of deep deposits of natural gas. Others were conducted in Nevada to test the ability to conduct massive civil engineering projects using nuclear explosions. The possibility of using nuclear explosions to excavate a second Panama Canal received serious theoretical attention.

139. Ibid., 239-257.

140. The Soviet test site at Novaya Zemla lies north of the Arctic Circle and was responsible for most of the fallout in Alaska and other Arctic locations.

141. Wayne Hanson, interview by Daniel O'Neill, 4 May 1988, transcribed by ACHRE staff, 9 March 1995 (ACHRE No. ACHRE-031395-A), 56.

142. Nevada Environment Restoration Project, Department of Energy, *Project Chariot Site Assessment and Remedial Action Final Report* (Springfield, Va.: National Technical Information Service, 1994), 1-5. See also Arthur Piper and Donald Eberlein to John Phelps, Director, Special Projects Division, 9 October 1962 ("Your letter of September 27, 1962, to . . .") (ACHRE No. DOE-050295-E), 3-4.

143. Ray Emens, Director, Support Division, to John Phillip, Director, Special Projects Division, 10 April 1963 ("Radioactive Waste Mound At Project Chariot Site") (ACHRE No. CORP-013095-A-1), 1.

144. Nevada Environmental Restoration Project, *Project Chariot Site Assessment and Remedial Action Final Report*, 1-2.

145. Caroline Cannon, Advisory Committee on Human Radiation Experiments, transcript of proceedings of 30 January 1995, Santa Fe, N.M., 136.

146. North Slope Borough Science Advisory Committee, April 1994, "A Preliminary Review of the Project Chariot Site Assessment and Remedial Action Final Report" (ACHRE No. DOE-121494-E-2).

147. C. A. Hawley et al., Health and Safety Division, AEC, Idaho Operations Office, "Controlled Environmental Radioiodine Tests at the National Reactor Testing Station," IDO-12035, June 1964 (ACHRE No. DOE-060794-B-37), 6. After 1968, a variety of radioisotopes were used, and the name of the series was changed to the Controlled Environmental Release Tests.

148. Ibid., iii.

149. Ibid., 31. The exposure limits at the time were 30 rem to the thyroid per year. Richard Dickson, Idaho National Engineering Laboratory, to Bill LeFurgy, Office of Human Radiation Experiments, 16 May 1995 ("Comments on Draft Advisory Committee Report").

150. Data on tests 2, 7, 10, and 11 are contained in C. A. Hawley, Jr., ed., Idaho Operations Office, AEC, "Controlled Environmental Radioiodine Test at the Nuclear Rector Testing Station: 1965 Progress Report," IDO-129457, February 1966, (ACHRE No. DOE-060794-B-37); D. F. Bunch, ed., Idaho Operations Office, AEC, "Controlled Environmental Radioiodine Tests: Progress Report Number Two," IDO-12053, August 1966, (ACHRE No. DOE-060794-B-39), 26-30; D. F. Bunch, ed., Idaho Operations Office, AEC, "Controlled Environmental Radioiodine Tests: Progress Report Number Three," IDO-12063, January 1968 (ACHRE No. DOE-101194-B-3), 14.

151. Dr. George Voelz, interview with Marisa Caputo (DOE Office of Human Radiation Experiments), transcript of audio recording, 29 November 1994 (ACHRE No. DOE-061495-A), 16-18. Members of the INEL's Human Radiation Experiments Team state that the identities of these subjects could be determined from records.

152. [Deleted] Senior Engineer to R. F. Foster (PNL-9370), 1 August 1963 ("Monthly Report: July 1963 [handwritten draft]") and PNL-9369-DEL, 23 August 1963 ("Monthly Report: August 1963"). A proposal for a second Hanford iodine 131 field release test was never implemented. E. C. Watson, BWWL-CC-167, 22 July 1965 ("Proposal for a Second Iodine-131 Field Release Test") (ACHRE No. DOE-033095-A-1). A handwritten notation on the cover sheet reads: "This test was not run. D Gydesen, 3/24/86." The DOE interview with Jack Healy includes descriptions of his role in a study involving iodine uptake through milk. Jack Healy, interview with Mark Goodman (ACHRE staff), 8 March 1995, transcript of audio recording (ACHRE No. DOE-050295-A), 32.

153. The exposures at Hiroshima and Nagasaki came primarily from acute exposure to gamma and neutron radiation, rather than from radioactive fallout.

154. U.S. Environmental Protection Agency, *Estimating Radiogenic Cancer Risks*, EPA, 402-R-93-076, June 1994 (DOE-061195-A). One person-rem corresponds to an aggregate dose of 1 rem spread over any number of people. The result from BEIR V is roughly one cancer fatality for every 1,120 person-rem (see chapter 4, "BEIR V"), but this is from a single exposure to gamma radiation.

155. This project has since been transferred to the Centers for Disease Control and Prevention.

156. The Committee has not attempted to estimate the range of uncertainty in this estimate. Some of the relevant figures are the estimated maximum 600-mrad thyroid dose from Hanford emissions in 1949, the more typical 180-mrad dose for residents of Richland and the roughly 30,000 population of the

Richland area at the time, suggesting a total population exposure of roughly 5,400 person-rad to the thyroid. See W. T. Farris et al., Hanford Environmental Dose Reconstruction Project, PWWD-2228 HEDR, April 1994, ("Atmospheric Pathway Dosimetry Report, 1944-1992 [draft]"), C. 6. Using NCRP risk estimates of 7.5 excess cancer deaths per million person-rad to the thyroid, this leads to an estimate of 0.04 excess thyroid cancer deaths. The corresponding estimate for nonfatal thyroid cancer is a factor of 10 higher. There are many uncertainties in this estimate, but they do not consistently overstate or understate the risk. For example, we have ignored the smaller exposures to other population centers and the relatively high doses and risks to children, as well as the offsetting facts that the Green Run represented only about 80 percent of Hanford's I-131 emissions in 1949 and occurred in December when the food pathway was suppressed.

157. Meteorological and fallout data are more or less complete after 1950. A total of roughly 250,000 curies of radiolanthanum were released (remarkably, less than half a gram) from 1944 to 1960, with releases peaking in 1955 and 1956 at roughly 40,000 curies a year. Strontium 90 was a minor contaminant, with total releases of about 200 millicuries. Los Alamos Human Studies Project Team (draft, 9 March 1995) ("Bayo Canyon/[RaLa] Program"), 15, appendix A.

158. D. H. Kraig, Human Studies Project Team, Los Alamos National Laboratory, 1995 ("Dose Reconstruction for Experiments Involving La140 at Los Alamos National Laboratory, 1944-1962") (ACHRE No. DOE-091495-A).

159. General Accounting Office, *Examples of Post World War II Radiation Releases*, 16. Los Alamos Human Studies Project Team, "Bayo Canyon/RaLa Program," 9-10. In tandem with its historical reconstruction, the Human Studies Project Team at Los Alamos is preparing a report estimating radiation exposures to the general population.

160. According to LA-1440, ten workers were exposed to an average exposure of at least 34 R, and the total exposure was at least 340 person-R, corresponding to roughly 0.2 fatal cancers. Knowlton reports that ten men received an average of 16.21 R over a 77-week period. Knowlton, LA-587, 2.

161. Barton C. Hacker, *Elements of Controversy: The Atomic Energy Commission and Radiation Safety in Nuclear Weapons Testing, 1947-1974* (Berkeley: University of California Press, 1994), chapters 4 and 5.

162. Richard Elliott, Director, Public Information Division, San Francisco Office, AEC, to Public Information Officers, Division Offices, AEC, 2 December 1953 ("The Public Relations of Atmospheric Nuclear Tests") (ACHRE No. DOE-030195-C), 2. Hacker, in *Elements of Controversy*, provides some of the background for the discussion of Elliott's paper, including high levels of fallout observed in communities in southern Utah and injuries and death to livestock that had grazed in the fallout area.

163. We should emphasize that public notification does not mean that members of the public would need to or could take precautionary actions that would not otherwise be taken. Given the relatively low risk posed by the intentional releases, evacuation could have had costs greater than the possible benefits. In the case of the Green Run, a warning not to eat certain foods might have been useful; however, the food pathways were not known at the time. On the other hand, the prospectors around the Dugway site and the Pueblo Indians around Los Alamos could have been warned not to wander into certain areas that may have posed some hazard, however small.

164. Both statutes have since been amended by subsequent legislation. The relevant provisions of the Clean Air Act are the National Emission Standards for Hazardous Air Pollutants (42. U.S.C. 7412), and those of the Atomic Energy Act are 42 U.S.C. 2114, 2133. Other environmental statutes either explicitly exempt most radioactive materials (the Clean Water Act) or are less directly relevant to intentional releases (the Safe Drinking Water Act, the Resource Conservation and Recovery Act, and the Comprehensive Environmental Compensation, Response, and Liability Act).

165. As noted in the Introduction, radiation standards were initially established as recommendations by two private advisory bodies: the International Commission on Radiological Protection (ICRP) and the U.S. National Committee on Radiation Protection, now the National Council on Radiation Protection and Measurements (NCRP). Over time federal and state agencies have based regulatory standards on these recommendations.

166. As noted above, this standard was a recommendation by the NCRP, later adopted as policy by the AEC. Carroll Wilson to Lauriston Taylor, 10 October 1947, as cited in Gilbert Whittemore, "The National Committee on Radiation Protection, 1928-1960: From Professional Guidelines to Government Regulation" (Ph.D. diss., Harvard University, 1986), 326-327.

167. This standard took the form of guidance issued by the Federal Radiation Council in 1960, "Radiation Protection Guidance for Federal Agencies," in Fed. Reg. 25, 4402-4403 (1960); and Fed. Reg. 26, 9057-9058 (1961). See also, D. C. Kocher, "Perspective on the Historical Development of Radiation Standards," *Health Physics* 61, no. 4 (October 1991).

168. The EPA was established by President Nixon. The NRC was formed in 1974 under the Energy Reorganization Act to take over the regulatory functions of the AEC. See 42 U.S.C. 5801 et seq.

169. U.S. General Accounting Office, *Consensus on Acceptable Radiation Risk to the Public is Lacking*, GAO/RCED-94-190, summarizes the existing radiation protection standards in the federal government (see especially table 1, p. 5).

170. Committee on the Biological Effects of Ionizing Radiation, *BEIR V*, 18. Table 1-3 provides a comparison on typical exposure to natural and artificial sources of ionizing radiation.

171. 54 Fed. Reg. 51657; 54 Fed. Reg. 51655; 56 Fed. Reg. 33080, as cited in David O'Very and Allan Richardson, unpublished, "Regulation of Radiological and Chemical Carcinogens: Current Steps Toward Risk Harmonization," 1995.

172. Some regulations already take the population dose into account. The DOE and NRC use the population dose in implementing the principle that radiation exposures be made as low as reasonably achievable (a principle that goes by the acronym ALARA), applying cost-benefit analysis to reduce population doses from the operation of a given facility. As another example, releases of Kr-85 from nuclear power plants are limited on the basis of population doses. 40 C.F.R. 190.10(b).

173. The national security interest exemption to the Clean Air Act is provided in 42 U.S.C. 7412(i)(4): "The President may exempt any stationary source from compliance with any standard or limitation under this section for a period of not more than two years if the President determines that the technology to implement such standard is not available and is in the national security interest of the United States to do so." Other environmental statutes have similar exemptions.

174. AEC 132/64, 7 January 1964, cited in J. Samuel Walker, *Containing the Atom* (Berkeley: University of California Press, 1992), 11-12. Except for such circumstances, the AEC declared its intention to ensure that "reactor facilities are designed, constructed, operated, and maintained in a manner that protects the general public, government and contractor personnel, and public and private property against exposure to radiation from reactor operations and other potential health and safety hazards."

175. The ability to delay any report to Congress by as much as a year greatly limits the effectiveness of this reporting requirement. There also remains the possibility that the information provided to Congress would be classified, and so the report would not be made public.

176. See 42 U.S.C. 4321 et seq.

177. The basic requirements for environmental impact analyses appear at 40 C.F.R. part 1500 et seq. As a preliminary step, an environmental assessment may be done to determine whether the "significant impact" threshold is met and a full EIS is necessary. This EIS must include an analysis of the environmental impact alternatives to the proposed action. Normally, a draft EIS must be made available for public information and comment, and the agency must respond to any comments of the public.

178. The regulations implementing NEPA provide that "environmental assessments and environmental impact statements which address classified proposals may be safeguarded and restricted from public dissemination in accordance with agencies' own regulations applicable to classified information." 40 C.F.R. 1507.3(c). This provision for secret procedures does not relieve an agency of the obligation to inform itself of the environmental impacts of its actions, nor does it relieve EPA of the requirement to review those impacts.

179. On 11 February 1994, President Clinton signed Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," which requires each federal agency to address disproportionate human health or environmental effects of its policies. This includes requirements to assess those impacts and to seek greater public participation in environmental planning and policymaking. Executive Order 12898, 59 Fed. Reg. 7629 (16 February 1994).

180. Richard Sanderson, Director, Office of Federal Activities, EPA, to Donald Weightman (ACHRE Staff), 22 March 1995 ("NEPA Oversight of Classified Documents"). Such programs are offically referred to as Special Access programs.

181. See *Helen Frost et al. v. William Perry, Secretary of the United States Department of Defense et al.*, Civil Action no. CV-S-94-795-PMP (RLH), filed August 15, 1994 (ACHRE No. 5WU-041495-A), and *John Doe et al. v. Carol M. Browner, Administrator, United States Environmental Protection Agency*, Civil Action no. CV-S-94-795-DWH (LRL), both of which were filed in the U.S. District Court for the District of Nevada.

182. Craig Hooks, Associate Director, Federal Facilities Enforcement Office, EPA, to Donald Weightman (ACHRE staff), 11 April 1995 ("Please find enclosed . . .") (ACHRE No. EPA-041395-A).

183. Gary Vest, Deputy to the Assistant Secretary of Defense for Environmental Security, interview with Mark Goodman (ACHRE staff), 13 December 1994, staff notes (ACHRE Contact Database).

184. Mark Hamilton, USAF, telephone interview with Mark Goodman (ACHRE staff), 4 January 1995, staff notes (ACHRE Contact Database).

185. Richard Sanderson, Director, Office of Federal Activities, EPA, to Donald Weightman (ACHRE Staff), 22 March 1995 ("NEPA Oversight of Classified Documents").

186. The Supreme Court has ruled that the question of an agency's compliance with NEPA is "beyond judicial scrutiny" when a trial of the case would "inevitably lead to the disclosure of matters which the law itself regards as confidential, and respecting which it will not allow the confidence to be violated." *Weinberger v. Catholic Action of Hawaii/Peace Education Project*, 454 U.S. 139, 146 (1981).