ATOMIC BA: THE LOSS OF NUCLEAR EXPERTISE IN THE COLD WAR

by

Charissa M. Fuhrmann

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After World War II, the American government and people turned to government nuclear experts, trusting them to ensure the United States' safety from the threat of Communism. For the three decades after the war, this largely unquestioning trust and support of the ideas, goals, and work of nuclear experts allowed the government to develop a highly productive nuclear weapons industry.[1] This mandate fits the technological enthusiasm that Thomas Hughes discusses in *American Genesis* and David Nye explores in *American Technological Sublime.* Both authors argue that during the 20th century an emphasis on technology was an important American societal factor and dominated American thought.[2] This tradition carried into the emphasis placed on the necessity of atomic weapons to win the Cold War. However, by the end of the Cold War, Americans' faith in the ability of nuclear scientists and engineers to lead the country to victory in the Cold War had faded. Instead of rallying behind atomic experts, Americans living near nuclear facilities, environmentalists, non-AEC scientists and other groups increasingly questioned the atomic experts' motives and knowledge, and ultimately their suitability as American leaders. In just a few decades, the government scientists and engineers behind the development of the "Atomic Age" had lost the trust of most Americans. During these years a

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[1] This authority to dictate public policy was not entirely unheard of in the engineering and scientific professions. As Edwin Layton discusses in *Revolt of the Engineers: Social Responsibility and the American Engineering Profession* (Baltimore: Johns Hopkins University Press, 1986) the engineering and scientific professions had a history of believing their scientific knowledge uniquely situated them to act as a force for human progress, enlightenment, and advancement. Layton examines engineers during the Progressive Era, when engineers became involved in social issues, such as conservation, attempting to apply scientific knowledge to society. This legacy continued to resonate throughout World War II and the Cold War with the atomic project. See also, Samuel Hays, *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890-1920* (Pittsburgh: University of Pittsburgh Press, 1999), which explores engineers' involvement in the Conservation movements of the Progressive Era. The book has a similar argument as Layton, claiming that the engineers felt they should direct conservation policies, because they were the logical, scientifically-based, and unbiased viewers of American society and problems. See also: William E. Akin, *Technocracy and the American Dream: The Technocrat Movement, 1900-1941*(Berkley: University of California Press, 1997).

[2] See Thomas Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm, 1870-1970* (Chicago: University of Chicago Press, 1989) and David Nye, *American Technological Sublime* (Cambridge: MIT Press, 1994) for a more detailed study of the American relationship with technology during the 20th century. Both authors emphasize the importance of the technological in shaping American ideas of culture, advancement, and the modern nation. Also see: Howard P. Segal, *Technological Utopianism in American Culture* (Chicago: University of Chicago Press, 1985).

critical change in the experts' role and place in society occurred, because changes in an organization's physical space directly affect the organization's intellectual space. As the government's nuclear experts lost control of the physical boundaries of their work sites, their intellectual niche and public standing weakened, ultimately leading to their diminished power to determine the course of American domestic nuclear policy.

In 1946, the United States' Congress created the Atomic Energy Commission (AEC), to oversee all further nuclear production, whether for military or civilian purposes. Headed and run by civilian nuclear scientists and engineers, such as Arthur Compton, David Lillenthal, and Vannevar Bush, the AEC oversaw every aspect of nuclear weapon and energy production, from the gathering of raw materials to the finished product, whether an atomic bomb or a nuclear power plant. The AEC operated facilities across the country with centers in South Carolina (Savannah River), Washington (Hanford), Nevada (Test Site), and elsewhere. Enmeshed in Cold War fears and hot war realities in Korea, the American government demanded maximum production and research from their facilities.[3] In order to meet these requirements, the AEC created what contemporary industrial engineers call ba, a space within which an organization or business operates that includes both physical and intellectual spaces.[4] The first aspect of a nuclear production and testing facility's ba usually consisted of an isolated physical environment that contained a laboratory or production facility, which restricted access only to those involved with research or development of atomic technology. The second aspect of a nuclear facility's ba

[3] There is a large body of literature on mass production. See, David Hounshell, *From the American System to Mass Production, 1800-1932: Development of Manufacturing Technology in the United States*, reprint edition (Baltimore: Johns Hopkins University Press, 1986); David Noble, *Forces of Production: A Social History of Industrial Automation* (Oxford: Oxford University Press, 1984). For a discussion on the development of modern big science, see: L. Badash, J.O. Hirschfelder, and H.P Broida, eds., *Reminiscences of Los Alamos 1943-1945* (New York: Springer, 1980). This work is a collection of lectures given by various members of the Los Alamos community during the Cold War, which reflect on the work, life, and community of the wartime town.
[4] The modern theory of ba is discussed in Ikujiro Nonaka and Noboru Konno. "The Concept of 'Ba': Building a Foundation for Knowledge Creation." *California Management Review* 40 no. 3 (1998): 40-54.

was a similarly closed intellectual space, in which the AEC classified all information and technology as top secret. Within this closed ba, the government gave the experts the ability to make nuclear decisions without facing outside interference. Because this tightly controlled intellectual and physical ba provided a largely secure environment, the AEC, government, and the corporate managers of nuclear facilities believed they could continue to rapidly develop new technologies.

Advocates of the modern theory of ba argue that an organization must control both the physical and intellectual aspects of their organization, if it wishes to continue producing both products and knowledge at a desired pace.[5] Since the two aspects of ba are intertwined, the theory suggests that any weakness in one part will negatively affect the other. The AEC and its subcontracting corporations according to ba had to control not only the knowledge they used and created within a facility, but also the environment that surrounded a facility.[6] This idea is very different than those presented in earlier literature on experts, their position, and their roll in society. David Noble in *America By Design* argues that engineers dominated the practice of scientific technology, because they had access to a particular knowledge set, which distinguished them from most other Americans. Modern corporations, including the government, employed large numbers of engineers, resulting in these engineers becoming the center of technological development.[7] This argument claims that as long as engineers (experts) retain control over their

[5] "The Concept of 'Ba'" article was composed in 1998. This term was developed in conjunction with this article, and therefore was not a term that a member of the AEC would have known. It is included in this paper, because it provides a concrete term and a framework to analyze how and why experts' roles changed.
[6] In recent years, there has been a large amount of literature written about the relationship between science and space, see: Peter Galison and Emily Thompson eds., *The Architecture of Science* (Cambridge: MIT Press, 1999); Crosbie Smith and Jon Agar, eds., *Making Space for Science: Territorial Themes in the Shaping of Knowledge* (New York: Palgrave MacMillan, 1998).
[7] David Noble, *America By Design: Science, Technology and the Rise of Corporate Capitalism* (New York: Alfred A. Knopf, 1977), xxiv. Noble's book traces the professionalization of engineers, attempting to show how technology is a social force and process. Noble argues that technology is not the driving force behind social change, rather modern capitalist use engineers to craft technology to their needs and wants for society. For a study of the

body of knowledge, they will remain in power. The concept of ba challenges this idea, complicating the concept of an experts' power, positing that the expert is just as dependent upon the control of physical environments, as of intellectual knowledge and ideas.

This idea of interdependent physical and intellectual spaces provides powerful insights into the changing role and status of nuclear experts during the Cold War. For nuclear weapons facilities, the physical "ba" broke down first. Hanford Engineering Works in Richland, Washington, the Savannah River Plant near Aiken, South Carolina, and the Nevada Test Site in southern Nevada all experienced unintentional (and in one case intentional) passing of radioactivity beyond site boundaries, the edges of the physical ba.[8] These releases occurred in three basic ways: into the atmosphere, waterways, and subterranean groundwater. These physical breaches transformed the physical ba of nuclear facilities to a larger more uncontrolled area and forced breaches and expansion of the intellectual ba. Faced with this breakdown in controls, 'the experts' of the AEC were forced to step outside of their typical operating parameters of rapid research and production and alter basic processes and ideas. Atomic experts had to slow production to limit these dangerous releases and had to expand their own ideas of safety and risk. Ultimately, the experts' loss of atomic ba created increasing conflict with public groups, such as down winders and atomic workers, when Americans learned about the dangers they faced from escaping radioactivity.

While the concept of ba is a fairly recent creation, one can use it to look at the organization of the AEC. The Manhattan District, the AEC, and their contractors understood and

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development of the physics community, see Daniel Kevles, *The Physicists: The History of a Scientific Community in Modern America* (New York: Knopf, 1977).

[8] This intentional release refers to the Green Run, which occurred in December 1949, when the managers released radioiodine into the air to see how it would concentrate in spread throughout the environment. See, Michele Gerber, *One the Home Front: The Cold War Legacy of the Hanford Nuclear Site* (Lincoln: University of Nebraska Press, 1992), 78 for a detailed discussion of this experiment.

emphasized an idea similar to ba half a century ago. Atomic experts implicitly recognized the importance of maintaining physical boundaries between the radioactive materials of the weapons facilities and the American public. Operators knew that any inkling of radiation reaching the public could quickly lead to difficulties for the AEC and the atomic program. By the late 1940s, the Americans had an understanding through observation of the survivors at Hiroshima and Nagasaki that radiation exposure could cause illness and even death. Most Americans did not understand the difference between a safe or unsafe dose of radiation, however, tending to view almost any exposure to radiation - outside of the typical X-ray exposure – as a major concern. By the 1950s, Americans also constantly heard warnings from television and government films about the dangers of nuclear attack, heightening American concerns about nuclear materials.[9] Therefore, during the early years of testing at the Nevada Test Site as with many other nuclear sites, the AEC emphasized radiation safety mainly to ensure that the site would continue to exist. The AEC strongly believed that any breech in safety could cause people to call for the closure of the site.[10] A similar attitude pervaded all various AEC facilities; the goal was to keep radiation away from the American people.

Because of safety and production concerns, the Manhattan District and AEC took special care in selecting facility sites, seeking locations that best met specific criteria to create a safe, controlled physical ba. Originally articulated during World War II, the AEC later refined the

[9] For a detailed study of the cultural impacts of the bomb during the five years immediately following World War II (1945-1950), see Paul Boyer's *By The Bombs Early Light: American Thought and Culture at the Dawn of the Atomic Age* (Chapel Hill: University of North Carolina Press, 1985). Boyer argues that "Hiroshima bisected history," causing massive change in American culture. During the first five years after World War II, Boyer argues that the atomic bomb played a large role in American society through books, movies, the scientist and world government movements, and a variety of ideas about the nature of an atomic world. This period, Boyer argues, was marked by great public debate and concern about atomic weapons, and Americans worried about the dangers of living in an atomic world. Boyer later shows how the start of the Korean War and the first Soviet weapon test in 1949 changed American's ideas on nuclear weapons. The increased tension of the Cold War brought a new surge of approval and demand for the United States to develop more weapons.

[10] Barton Hacker, *Elements of Controversy: The Atomic Energy Commission and Radiation Safety in Nuclear Weapons Testing, 1947-1974* (Berkley: University of California Press, 1994), 77.

criteria. A site did not have to meet all criteria to be chosen; it simply had to perform better than other potential locations. The Savannah River site, for example, did not meet all of the criteria, but DuPont reports stated that it was the best of the many options, and therefore the AEC should work around the weakness (higher rainfall amounts than the criteria considered acceptable).[11] The emphasis placed on finding sites that met the nuclear experts' criteria portrays their recognition that they had to understand the environment, the physical ba, of nuclear weapons facilities to keep radiation away from the public, showing the importance of the physical ba to an organization.

One of the most important and seemingly contradictory criterion was the distance a facility should be from centers of population. The wartime Manhattan District and later the civilian run AEC both wanted their facilities isolated from cities and towns to provide a buffer in case an accident occurred with radioactivity. Even before the Manhattan District chose the Hanford site, scientists emphasized the necessity of isolation. Robert Oppenheimer described the intensely radioactive gases that creating plutonium would produce and emphasized the necessity of a remote and isolated location to General Leslie Groves.[12] Yet Groves, and later Compton and others, also wanted the facilities close enough to those same towns and cities to take advantage of the utilities and services found within population centers. In order to meet this contradictory physical criterion, the leaders of the atomic industry set detailed requirements for the distances a facility should be from a center of population. In most cases, the requirement called for a facility to be a minimum of fifteen miles and a maximum of thirty-five miles away from a town of

[11] DuPont Atomic Energy Division, Explosive Department (hereafter referred to as AED). "Project 8980: Atomic Energy Production Plant Site Survey," 10 November 1950, E.I. DuPont de Nemours & Company, AED records, Hagley Museum and Library, Greenville Delaware.
[12] Gerber, *On the Home Front,* 25.

25,000 people.[13] Smaller towns could be a little closer than the fifteen mile mark, because the smaller population meant less people would be affected if an accident occurred.

In addition, the Manhattan District and AEC focused a great deal of attention on other environmental aspects such as water, meteorology, seismic history, and soil constitution, as they realized that each of these factors was an important part of the physical ba and would influence the stability of a nuclear weapons facility physical space. For weapons production plants, easy access to water, preferably from a nearby river, was important. Following World War II, DuPont officials stressed that water was so important that only a few sites could meet the requirements.[14] Most of the AEC's nuclear reactor designs used water as a coolant, including those found at Hanford and Savannah River. Because it was used as a coolant, changes in temperature of the river were also very important; if river water became too warm during the summer months the AEC would need to build additional facilities to cool the water, adding to the cost of construction and operation and decreasing efficiency. The river also had to be large enough to provide ample amounts of water to meet reactor demands. The other important factor for rivers was that they not be subsequently used to supply drinking water for at least fifty miles down stream. At Savannah River, for example, the water was not used for drinking for one hundred miles from the site. This particular criterion regarding drinking water was sometimes sacrificed if other criteria that the AEC considered more important were met, as access to a natural water source was a central aspect of atomic ba.

The AEC considered meteorological conditions important, because weather patterns could affect where radioactive wastes would spread if nuclear experts could not control radioactive releases. Because atomic experts could not guarantee complete control of nuclear

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[13] AED, "Basic Criteria," 26 June, 1950, E.I. Dupont de Nemours & Company, AED Records, Hagley.
[14] AED, "Preliminary Draft of Site Report: Project 8980," 12 October 1950, AED Records, Hagley.

materials, the AEC expanded the physical ba to consider areas outside of plant boundaries. In Dupont's report on the Savannah River site's suitability for nuclear operations, they discussed the need for prevailing wind patterns to blow away from major population centers within twenty miles of facility boundaries at average speeds of greater than three miles per hour.[15] This wind speed would ensure that radioactive particles would disperse over a larger area, therefore lessening the density in any one area. In addition, the amount of precipitation an area received was important, because radioactivity concentrates in rain or snow, therefore increasing the radioactive burden on areas where rain fell regularly. The AEC looked for sites that were semi-arid or arid with only small amount of rainfall. Finally, year-round temperature was important. Either extreme hot or extreme cold could slow construction projects and cause operational difficulties, such as extreme water temperatures.

Because an earthquake could cause the destruction of buildings, AEC and subcontracting business' experts also focused on the seismic history of possible nuclear sites. This was particularly important at Hanford and Savannah River as an earthquake could cause a reactor system failure, leading to a meltdown and the possible release of large quantities of radioactivity. Prevention of such a disaster was a high enough priority that the AEC and DuPont hired outside firms to conduct earthquake risk studies, such as John A Blume and Associates, who conducted a comprehensive seismic survey on the Savannah River site.[16] A history of minor earthquakes in a region was acceptable, as buildings could be designed and safeguarded against minor tremors.

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[15] AED, "Preliminary Draft of Site Report: Project 8980," 12 October 1950, AED Records, Hagley.

[16] Correspondence between Dr. Housner and A.E. Daniel Jr, 28 July 1967, AED files, Hagley. For the detailed report on the Savannah River site's seismic history, see "Geology and Seismic History of the Savannah River Plant Area, South Carolina," 1967, AED Records, Hagley. The report describes the geology of the Savannah River area and provides accounts all of earthquakes known to have affected the area. The report concluded that it was nearly impossible for a large scale earthquake to occur near Savannah River.

Finally, soil type and structure were important, as scientists recognized that they would need to store some waste underground and certain soil constitutions were better for construction. While flat, sandy soil topography was best for construction, the AEC paid attention to the deeper layers of soil to see how radioactivity might spread if it leaked underground. The AEC preferred dense soil with clay deposits or salt formations because it expected that these formations would slow the spread of radioactivity into groundwater.[17] In addition, the AEC favored areas with a deep or no groundwater table, so that radioactive materials would have to seep further down before contaminating groundwater.

Because atomic experts felt these criteria would create a safe and controllable environment or ba, the Manhattan District and later the AEC chose the three sites examined in this paper based on these criteria: Hanford, Savannah River, and the Nevada Test Site. The Hanford site (Figure 1), selected in 1942 by Manhattan District leader General Leslie Groves, processed uranium into plutonium during World War II and the Cold War.[18] Located in South Central Washington state, the Hanford Engineering Works covers 560 square miles around the Columbia River, which runs through the northern half of the site. At the time the Manhattan Project chose Hanford about 1,200 people lived on or immediately adjacent to the site. The government forced these families to clear out the location. The towns of Richland, Kennewick, and Pasco are all less than twenty-five miles from the Hanford site, and while initially small, soon grew to provide the necessary facilities and support for site operations.

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[17] AED, "Preliminary Draft of Site Report: Project 8980," 12 October 1950, AED Records, Hagley

[18] For more on the development of the Hanford Nuclear Site, see: Harry Thayer, *Management of the Hanford Nuclear Works in World War II: How the Corps, DuPont and the Metallurgical Laboratory fast tracked the original plutonium works.* (New York: ASCE Press, 1996). Thayer's work provides an in depth study of the site selection and early development of the Hanford site during World War II. Thayer provides details about the management and organization system that DuPont and the Manhattan District developed to produce plutonium for nuclear weapons.

The temperatures in south-central Washington are moderate year round; today the average low in January is twenty-six degrees and the average high in July and August is eighty-eight degrees.[19] These moderate temperatures help to keep the Columbia River water reasonably cool year round, making the water ideal for cooling nuclear reactors. The Columbia begins in two lakes nestled between the continental divide and the Selkirk Mountains of British Columbia. Along the river's 1,200 mile course, it is a watershed for seven states: Oregon, Washington, Idaho, Montana, Nevada, Wyoming, and Utah.[20] The river's cool temperatures, good for nuclear production, also make it a prime breeding ground for salmon, which are plentiful in its waters. Just up the river from the site was the Grand Coulee Dam, built in 1934 under President Franklin Roosevelt's New Deal.[21] The dam provided the electricity needed by the Hanford atomic site. The climate near Hanford is semi-arid, receiving less than ten inches of rain a year, creating a high desert ecosystem, with loose sandy soil and many low laying plants, such as sagebrush. This climate met important AEC criteria, as rain would rarely concentrate radioactive wastes in the air. The area is also very windy, with winds strong enough to create frequent dust storms and to ensure that radiation would scatter far therefore lessening the levels in any one area. The topsoil is well suited to agriculture, and prior to the opening of Hanford, most locals worked in agricultural businesses.

The AEC and its subcontractor E.I. DuPont de Nemours & Company selected the Savannah River site (Figure 2), which opened following World War II, to process nuclear fuel. The site is located in southwestern South Carolina, along its namesake the Savannah River, which borders the southwestern edge of the site. Per the ba criteria, the Savannah River was not

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[19] All average temperature information taken from Weather.com at http://www.weather.com.
[20] Gerber, *On the Home Front*, 12-14; Center for Columbia River History, http://www.ccrh.org/river/history.htm (22 March 2005).
[21] Gerber, *On the Home Front*, 22.

used for drinking water by the neighboring communities. It was not until Savannah and Augusta, Georgia, which are 125 miles downstream that humans consumed Savannah River water.[22] Dozens of small creeks crisscross the entire site, which ensured ample water for reactor cooling. The soil is sandy and well-drained, making it ideal for construction work. In addition, the ground for the site was not suitable for agriculture and little of the land was in use prior to the development of the Savannah River facility which made government acquisition simpler.

The climate of the Savannah River area proved favorable for nuclear operations. Temperatures are moderate for the most part, although the summers are hot. The average low in January is thirty-tree degrees; the average high in July is ninety-two degrees. The winds blow at an average speed of three and a half miles per hour from various directions, which is just higher than the ba criteria set by the AEC and Dupont. The only concern DuPont had about the Savannah River location was the high amounts of precipitation and overall very moist and humid environment, which could cause radiation to concentrate immediately around the site rather than spread out across a large area. Despite these concerns, DuPont and the AEC selected the site, because they assumed they could control radioactive releases sufficiently to avoid rainfall causing any concentrations of radioactivity material. Meteorology was only a comparative factor in the site selection process. Dupont's site report said that the Savannah River had more favorable meteorological conditions than the other sites under Dupont consideration, such as the Red River site in Texas, and therefore the AEC and Dupont could make exceptions for the higher precipitation amounts at Savannah River.[23]

The Savannah River Plant is located near Aiken, South Carolina and Augusta, Georgia. The highway and railway systems for these towns and the services found within them provided

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[22] J.B. Tinker and W.C. Kay, "Preliminary Site Survey – August 29th-Sepetember 1st." 13 September 1950, AED Records, Hagely.
[23] W. C. Kay, "Preliminary Draft of Site Report: Project 8980," 12 October 1950, AED Records, Hagley.

the infrastructure for the construction and operation of the Savannah River Plant. Many major highways actually passed through the site's land, ensuring easy transportation to and from the facility. These highways became the property of the AEC and DuPont used them for transporting goods to, from and around the site. In addition, the nearby towns provided homes for workers and a large supply of potential workers.

A third, and very important, site developed during the Cold War was the Nevada Test Site (Figure 3). Prior to 1951, all nuclear weapons testing, outside of the Trinity Test, occurred in the Pacific Ocean. With the start of the Korean War, which endangered security at the Pacific Proving Grounds, and the great expense of testing weapons in the Pacific, the AEC determined that it needed a continental test site to maintain security and provide a more convenient location for testing.[24] Therefore the AEC began a search for a suitable space to test nuclear weapons at home. Ultimately, the AEC chose the Nevada Proving Grounds, which sits about sixty-five miles north of Las Vegas. Since, the military already used the site to test non-nuclear weapons, the necessary facilities and services for weapons testing were already available and in place. The test site encompassed more than 1300 square miles, helping to keep it isolated. The closest communities to the site were Indian Springs and Cactus Springs, which were twenty-five miles southeast of the test site. This isolation was the most important aspect of the test sites physical ba, because AEC experts knew that they could never completely predict the size of a nuclear explosion, making containment difficult.

The desert climate of the site meant that testing could occur year round, as the winters were warm and mild and the summers extremely hot and dry. Unlike facilities where construction schedules were important and maintaining cool temperatures in reactors was

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[24] A. Constandina Titus, *Bombs in the Backyard: Atomic Testing and American Politics* (Las Vegas: University of Nevada Press, 1986), 55.

paramount for safety, at the Nevada Test Site the heat of the summers did not pose major operating problems at the site. The climate also meant that very little rain would fall - less than six inches of rain per year. The small amount of water naturally supplied to the site came from the multiple springs that are widely spread across the site. This created a loose and dusty soil that was easily picked up in the wind and scattered across a large area. Multiple low mountains cover most of the territory of the site, creating shifting winds that change direction frequently. These shifting winds might create difficulties for the AEC, since the winds might carry atomic particles over a wide area around the site including towns in Utah and Arizona. Despite these concerns, the AEC thought that they could predict the wind direction and therefore test safely. They believed this obvious disregard for their own ba criteria would not cause problems.[25]

Through selecting these sites based upon their ba criteria, the Manhattan District and the Atomic Energy Commission attempted to create a physical ba that would protect the American public from dangerous radiation and allow nuclear experts to work efficiently. The experts recognized the tenuous nature of their position if they were unable to stop the radioactivity from crossing outside of their 'controlled' physical ba. Unfortunately, they oversimplified their concept of physical ba and, as James Scott describes in *Seeing Like a State,* their ideas about how to define nuclear spaces could not account for the complexities both of nature and radioactivity.[26] When the nuclear experts failed to control radioactive releases they had to change plans, slow production, and face tough questions from various groups of Americans, as their intellectual ba weakened because of radiation crossing the boundaries of the physical ba.

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[25] Titus, *Bombs in the Backyard,* 57.

[26] James Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998) discusses government projects to improve human life and comfort and why they failed. He emphasizes the lack of understanding of these government experts and their oversimplification of nature.

One of the sites that suffered the greatest breakdown of the physical ba was the Hanford Nuclear Works. At the Hanford plant, radioactive materials crossed the physical ba's boundaries in three ways. First, atmospheric releases in the form of steam, smoke, and dust. Second, waterway releases into the Columbia River in the form of liquid waste and contaminated water. Finally, groundwater releases in the form of liquid wastes.[27] Each of these types of releases occurred in multiple ways, resulting in a very unstable physical ba at Hanford and this breakdown caused a variety of negative effects on the experts' intellectual ba, resulting in changed production schedules, public anger, and litigation.

The radioactive element that most often breeched the boundaries of the Hanford physical ba was radioiodine. Iodine-131 is a byproduct of processing uranium rods into plutonium. After one of Hanford's nuclear reactors processed a uranium rod, Hanford employees placed the rod in a special retention area to allow it to 'cool-off.' This period provided an opportunity for some of the radioactivity to degrade. In ideal circumstances, the rods would cool for several weeks to ensure minimum radiation hazards. Unfortunately, due to tight construction schedules that began in late 1943 and continued through 1944, General Groves ordered a shortening of the cooling time. After this order, rods were only left to cool for two to four weeks, which did not provide enough time for the radiation to decay to a 'safe' level. This practice of shortened cooling times continued throughout the Cold War.

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[27] The first to examine these three types of radioactive releases was Michele Stenehjem in the article "Pathways of Radioactive Contamination: Beginning the History, Public Enquiry, and Policy Study of the Hanford Nuclear Reservation," *Environmental Review* 13 no. 3-4 (1989): 95-112. Written shortly after the government declassified thousands of Hanford documents, this article began to document the environmental damage caused by the Hanford Nuclear Works. Exploring the amount of radiation that polluted the environment and how that radiation came to polluted the Washington area, Stenehjem argues that the Hanford plant had a large impact on American history than just as a plant that produced nuclear weapons. Stenehjem also uses the article to propose possible research questions to guide future studies into the significance of the Hanford site, encouraging historians to explore the complexities of the Hanford plant.

During the first year of operation, very little radioiodine escaped into the atmosphere, because most of the radioiodine decayed when the uranium rods cooled from the proper about of time. But, when the rods only cooled for a couple weeks, they released large amounts of radioiodine. After the cooling period, AEC workers processed uranium rods through chemical treatment vats. This process created gases that traveled through the plant's ventilation system and through the smokestacks. This gas contained radioiodine and other radioactive materials and Hanford employees spewed this gas into the atmosphere through smokestacks and vents. One specific example of radioiodine entering the atmosphere occurred during the Green Run. In this experiment constructed to see if Hanford could further reduce the cooling time for uranium rods, Hanford released 5,050 curies of radioiodine in the air.[28] While this was an intentional release, other unintentional releases of radioiodine occurred in a similar manner. Between 1944 and 1956, Hanford released approximately 530,000 curies of radioiodine into the atmosphere; some of the releases landed in towns as much as 15 miles away.[29]

These releases drastically expanded the physical ba of Hanford to include people and the environment well beyond what atomic experts had expected or intended. One of the most serious expansions of the ba was in its effects upon local cows. Radioiodine, like all iodines, is absorbed by mammalian thyroids and concentrates there. Around Hanford, cows digested large amounts of radioiodine, because the grasses they fed on trapped the radioactive materials. As the radioiodine concentrated in a bovine's thyroid, the cows' milk became highly radioactive. By 1951, scientists at Hanford, such as Parker, had begun studying the effects of radioiodine on the food chain by testing various wild animals, livestock, and cows' milk.[30]

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[28] Jerome Cramer, "'They Lied to us.' Unsafe, aging U.S. weapons plants are stirring fear and disillusion," *Time* v. 132 n. 18 (Oct 31, 1998): 60-66; "40 years of nuclear lies," *The Nation* v. 247 n. 13 (Nov 7, 1988): 441.
[29] Jerome Cramer, "They Lied to us."
[30] Gerber, *On the Home Front*, 84-85.

Despite this concern and general understanding of the dangers of radioiodine, the scientists at Hanford did not warn the surrounding population about the dangerous cows' milk. Rather, General Electric, who took over operation of the Hanford plant in 1946, issued a statement saying that the milk of the Richland area was of poorer nutritional quality than the milk found in other areas, and therefore locals should drink milk from outside sources.[31] To admit that as nuclear experts they had lost control over their physical ba would weaken their ability to continue production, because it would show that they actually did not completely understand the processes within which they worked. If the citizens of Richland, Kennewick, and Pasco knew about the AEC's failures, they would begin to question the appropriateness of trusting experts with nuclear policy, therefore challenging the AEC's intellectual ba. Therefore, General Electric released these vague statements that warned of dangers without really explaining the true risks. Because this warning did not seem serious, it was often ignored by citizens of the Richland area. Therefore, citizens of south-central Washington continued to consume the dangerous milk. Perhaps as many as 20,000 children were exposed to dangerous amounts of radiation from milk, but adults also ingested the radioactive milk.[32] These exposures to radiation occurred in amounts that could cause cancer, hyperthyroidism, and other thyroid disorders.

In addition to contaminating cows' milk, atmospheric releases of radioactive byproducts contaminated the area's wildlife. Many animals, such as deer, grazed on the same grasses and bushes as domesticated cattle. In a similar manner as the one previously mentioned, the radioactive materials concentrated in the wildlife, contaminating their meat. This posed a threat to humans, as hunting for food was popular practice around the Hanford site and eating the

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[31] Gerber, *On the Home Front,* 73-74.
[32] Cramer, "They Lied to us."

contaminated meat of the wildlife exposed humans to unsafe levels of radiation. By 1949, Hanford engineers found that game birds had extremely high levels of radioiodine in their systems. Therefore, the entire area around the Hanford project was closed for hunting season. At the time, General Electric claimed that the population growth of the area made it "too crowded" to ensure safe hunting."[33] Once again, General Electric hid their failure to control their physical ba to ensure that the locals would not question the intellectual ba and force a change in AEC goals and schedules.

Another breach of Hanford's physical ba was the release of large quantities of radioactivity into the waterways around the Hanford Engineering Works, particularly the Columbia River. Radiation entered the Columbia River through the reactor cooling systems. Pumps pulled water from the river through conduits within the reactors, helping to maintain safe operating temperatures. While going through the reactor, the Columbia River water came in contact with various reactor parts that were contaminated with radiation from the uranium rods found within the reactor. Once through the reactor cooling system, the used cooling water (effluent) was held in large tanks known as 107 Retention Basins for periods that ranged from thirty minutes to six hours. However, the longer-lived isotopes were not affected by this retention period, and thousands of curies entered the Columbia River every day.[34]

In 1942, Hanford scientists and engineers felt that the Columbia would sufficiently dilute any radioactivity that got into the river's water and therefore the radioactivity would not pose a health hazard to anyone. Small amounts of radioactivity remained in the water itself, but as scientists predicted, the contamination of the water itself did not pose any significant dangers to humans. The greater danger came from the concentration of radioactive materials in aquatic life.

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[33] Gerber, *On the Home Front*, 73.
[34] Gerber, *On the Home Front*, 115; http://www.absoluteastronomy.com/encyclopedia/H/Ha/Hanford_Site.htm (22 March 2005)

By the early 1950s, Hanford's nuclear experts had not come to understand how radioactive materials would concentrate in aquatic wildlife and therefore pose dangers for humans. First, the radioactivity concentrated in the various algae and river plants. Second, when fish, such as the plentiful salmon, ate these plants the radiation further concentrated within their bodies, making the fish, often captured for food by local citizens, a hazard to human health.

The final way radioactivity escaped the expert-constructed physical ba of Hanford was into the subterranean groundwater and soil. This contamination occurred in two ways. Radiation accumulated underground when large storage tanks, containing radioactive waste materials, leaked. Dupont and other subcontractors had designed these tanks with lead linings, double and tripled layered shells, and special vents to maintain a safe pressure inside the tanks. Hanford scientists recognized that the tanks were only a temporary solution for the large amounts of waste, but felt that the tanks could safely store radioactive materials until they could devise a permanent storage area. In intra-company correspondence, DuPont officials said that they expected the tanks to last for 30 years and then have to be replaced by another form of storage.[35] Despite the precautions, many of the tanks employed at Hanford leaked, some at the rate of dozens of gallons of radioactive materials a day. Although the ba creation criteria had recommended avoiding areas with groundwater tables, the experts did not worry as much about that aspect of the ba, especially during World War II, preferring to hasten building construction. Because of this lack of emphasis, the substantial groundwater table under Hanford was contaminated.

Also contributing to subterranean breeches of Hanford's physical ba were the waste ponds found throughout the site. In these ponds, Hanford employees dumped "low-level" wastes. Dupont created these ponds during World War II and used them extensively throughout

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[35] Correspondence for R. C. Blair, AED Records, Hagley.

the war.[36] These were wastes that Hanford scientists felt were the least dangerous of those created at the facility, because they were less radioactive and the radiation that was present decayed rapidly. These pools also contained non-radioactive materials, such as the caustic chemicals used to refine eradiated uranium into plutonium. Over time these liquid wastes seeped through the loose, sandy soil of Hanford. Eventually the wastes, like those from the leaking tanks, contaminated the large table of groundwater.[37] While this particular concentration of groundwater was not used for drinking water, it still posed a hazard. By 1949, scientists realized that if the water table shifted, particularly towards the Columbia, the high levels of radiation found in the groundwater could transfer to the Columbia River.[38] Since the concentration of radioactivity was so high in the groundwater, it was likely that the Columbia would not have the capacity to dilute the radiation to safe levels, before humans would consume the water. In all of these ways, the physical ba of Hanford broke down as radiation crossed boundaries and contaminated areas that nuclear experts had not considered endangered.

During the decades proceeding the late 1960s and 1970s, the extent of these ba-crossing radioactive releases and their dangers remained hidden from the public. Policies of secrecy pervaded the Hanford facility. While the AEC and the experts at Hanford privately acknowledged the problem, they gave no information or warnings to the locals. As Hanford's experts maintained secrecy, the AEC and General Electric could continue high levels of production and maintain normal operating procedures. The physical ba's weakness had not yet negatively affected the intellectual ba. When the citizens near Hanford and Hanford workers learned about the dangerous radiation to which the Hanford facility had exposed them, the nuclear experts' intellectual ba was affected by the ba's physical weaknesses.

[36] Gerber, *On the Home Front*, 147.
[37] Ibid., 149.
[38] Ibid.

In the 1970s, some workers began to speak out against the dangers the Hanford plant posed for the surrounding community, arguing that the experts knew about the dangers, but did not care because production was the priority.[39] This was one of the first major assaults on the experts' intellectual ba at Hanford, because workers argued that nuclear experts did not care about the American's safety and therefore should not be trusted. Ed and Cindy Bricker both worked at the Hanford plant during the 1970s. Ed discovered multiple safety failures at the plant, such as leaking tanks and a lack of warnings and barriers around radioactive materials. The Brickers blew the whistle on these dangers and faced years of badgering from plant managers and others in their community whose lives depended on the plant. In the 1980s, the Brickers contacted Tom Carpenter of the Government Accountability Project and asked him to investigate their claims.[40] Carpenter began a major investigation to show the experts at Hanford had deliberately worked to frighten Ed and his family into silence. The Bricker's case was successful in 1989. The Occupational Safety and Health Administration of the United States' government showed that the experts had worked against promoting safety at Hanford, because production held the greatest priority.[41]

The breakdown of Hanford's physical ba also required the AEC, and by extension the entire United States' government, to face litigation, questioning the nuclear experts' intentions, their values, and their legitimacy. Down winders near Hanford, particularly those who felt they had suffered from Hanford's radiation leaks, began to challenge nuclear expert's intellectual place in society. In the wake of Rachel Carson's Silent Spring (published in 1962), which

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[39] This emphasis on high production was somewhat ironic, as the United States was far ahead of the USSR in nuclear weapons development and number of weapons. As the war continued, the government always found a way to justify continuing high production, whether it was second strike capacity or simply building new, more technologically advanced weapons.
[40] Claire Safran, "We Dared to Blow the Whistle," *Good Housekeeping* (April 1992).
[41] Ibid.

focused attention on the environmental damages caused by humans, many Americans began to question the damage done to the environment and themselves by nuclear weapons production. Families, who suffered from hyperthyroidism, leukemia, and other cancers started to demand reparations for their struggles and changes in the procedures at Hanford. Some even called for the closure of the facility. Tom Bailie, the son of a farming family, was born near Hanford in 1947 and lived near the site his entire life. In the 1980s, he ran for the state legislature, in part to see that Hanford accepted responsibility for the down winders trouble and that the plant was shut down. Bailie blamed Hanford for his father and sister's colon cancers, his mother's skin cancer, and his own sterility and loss of lung capacity from lung cancer.[42] In 2000, residents near Hanford filed a 100 million dollar class-action lawsuit in Spokane. The suit accused DuPont and other AEC contractors of causing cancers in the area, particularly thyroid cancer.[43] In this direct challenge to the experts' intellectual ba, which resulted from the damages caused by the breakdown of Hanford's physical ba, the people of Washington questioned the knowledge and motives of Hanford's nuclear experts. For the citizens affected by these diseases, either the experts did not understand nuclear technology and its dangers or they did not care enough to ensure safety. In either case, these Americans no longer wanted the experts having uncontested authority on all matters nuclear.

The Nevada Test Site posed unique challenges for containing radiation within specific, well-defined physical boundaries. The inherent nature of nuclear explosions meant that radioactive materials would spread away from the actual detonation site. Testing at the site occurred above ground between 1951 and 1963, and below ground, after 1963. The site released

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[42] Cramer, "They Lied to Us."
[43] "DuPont Targeted for Hanford Radiation," *Chemical Week* v. 162 n. 30 (Aug 9, 2000): 5.

radioactive pollution both into the atmosphere in the form of fallout, dust, and radioactive clouds and into the subterranean, when deep soil was polluted.

The physical ba of the Nevada Test Site was complicated, because nuclear experts knew that the site itself and those on the site would face radiation risks, but that radiation could not contaminate the land or people outside of the site. The AEC and military assumed that they could control and understand the on-site human hazards and radiation dangers. The test site operators narrowly defined the physical ba of the Nevada Test Site, believing that these releases and radiation exposures were not a breakdown of the test site's physical space.[44] Nuclear experts only considered the expansion of nuclear materials to areas beyond the site's boundaries as a breech of the test site's physical ba. Favorable wind patterns for most explosions made it relatively simple to keep radioactive fallout within the physical boundaries of the site.

While this in theory meant that few tests breeched Nevada Test Site's physical ba and therefore the experts had contained the radiation successfully, the AEC experts' definition of the Nevada Test Site's physical ba did not completely encapsulate the complexities of radiation danger and exposure. In actuality much of the radiation, even the radiation contained on the Test Site, was out of the control of the scientists and technicians. The radiation breeched the physical ba, even though it never crossed the site's boundaries. Many involved in atomic tests received dangerous dosages of radiation, even though the AEC and nuclear experts claimed that those on the site faced no danger. Military personnel of the atomic battalion took part in war exercises, practicing invasion or tactical maneuvers after a simulated atomic attack. In addition, NTS workers took part in experiments at Ground Zero shortly after detonations. Though the military and AEC took precautions to protect these personnel by placing the soldiers in trenches and providing them with radiation badges and protective clothing, many of those who witnessed

[44] Hacker, *Elements of Controversy,* 90.

nuclear detonations received dangerously high doses of radiation. From the trenches and deployment points, soldiers inhaled and digested radioactive dust that got into their mouths during an explosion. Occasionally, workers would head towards Ground Zero just minutes after explosion, such as Ken Case, who herded cattle near nuclear explosions for experiments.[45] These types of dosages could not be washed out and often were not detectable by normal radiation methods, as internal measurements of radioactivity were often higher than external ones. The radiation sometimes had immediate effects. Often, soldiers would bleed from their eyes, mouths, ears, and noses after witnessing a test.[46] These workers received radiation dosages much higher than the safety standards regulated and therefore, while the Test Site's physical boundaries were not breeched, the physical ba had broken down.

Occasionally, adverse wind conditions caused radioactive fallout to cross over the Test Site's borders, raining dangerously high levels of radiation on surrounding communities. These incidents represented the most obvious breakdown of the Nevada Test Site's physical ba. Many test series had radiation reach the surrounding areas, but some had particularly far reaching effects. The first shot to have major radioactive fallout in uncontrolled areas was the Tumbler-Snapper Shot Easy. Wind patterns shifted and blew the debris and dirt away from the shot over nearby towns.

The shot that caused the greatest fallout beyond the site's boundaries was the Upshot-Knothole shot named Harry. The winds shifted on the day of the test in May 1953 and put several towns, such as Moab and St. George, Utah and Las Vegas, Nevada in the probable path of the fallout. Even though officials knew that the shifting winds posed a danger, they went

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[45] Carole Gallagher, *American Ground Zero: The Secret Nuclear War* (New York: Random House, 1993), 3.
[46] Ibid., xii.

ahead with the test anyway.[47] The winds caught the cloud of radioactivity, spreading radioactive materials all of the way to the East Coast, and large amounts of radioactivity fell on Utah, Nevada, and Northern Arizona (Figure 4). Within hours of the blast, AEC officials knew that dangerous amounts of radioactivity had fallen on numerous of towns.[48] AEC officials found measurements of seven roentgens, well off the scale of most radiation monitors, in the center of towns, such as St. George.[49] These two tests clearly show the inabilities of the Nevada Test Site's scientists and engineers to adequately plan and then control the physical ba of a nuclear testing location.

In response to the Limited Test Ban Treaty of 1963, which occurred at the encouragement of the broader scientific community to slow and limit the nuclear arms race, most of the testing at the NTS moved underground in attempts to better control the escaping fallout. The treaty stated that radiation from nuclear tests had to stay within the testing country's boundaries. If radiation was found beyond a country's borders, they were in violation of the treaty, which could turn world opinion against the United States. The AEC thought that underground testing would obviously contain radiation better than atmospheric testing because of the extra soil barrier. While moving tests underground often lessened the spread of radioactivity, it did not solve the problem of radiation escaping from the facility's ba.

Tests, such as Pike (detonated in March 1964) and Baneberry (December 1970), continued to project radiation to areas outside of the AEC's physical ba.[50] When the explosions occurred underground, the now radioactive soil above the test tunnels would expand rapidly and get picked up in the winds. Occasionally, as with Baneberry, the explosion forced dust up

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[47] Philip L. Fradkin, *Fallout: An American Nuclear Tragedy* (Tucson: University of Arizona Press, 1989), 3-5.
[48] Fradkin, *Fallout*, 13-14.
[49] Ibid., 13.
[50] Hacker, *Elements of Controversy,* 212.

through fissures in the ground, expelling the dust high into the air.[51] As with the above ground tests the winds did not always blow the highly radioactive particles away from neighboring towns in Utah, Nevada, and Arizona.

The escaping radioactivity at the Nevada Tests Site posed a whole variety of problems for the scientists and engineers at the site and the government that supported them. Radioactivity escaping from tests caused immediate changes in the experts' production plans. After a test spread radiation beyond site boundaries, the AEC had to stop tests temporarily to find out what went wrong. After the releases from Test Baneberry, the Nevada Test Site remained closed for several months while safety issues were considered.[52] A similar situation occurred after the dangerous releases from the Pike test.[53] During these delays, the AEC focused on ensuring proper weather patterns for nuclear testing. After a test that spread large amounts of radioactivity, the AEC always took extra care on the next shot, ensuring that all of the weather patterns were perfect. Often, waiting for perfect weather meant delaying a test for days or even weeks.[54] Since the AEC understood that environmentalists, health officials, and down winders would likely demand the site's closure if radiation accidents continued to happen, and because the scientists at Los Alamos and the Livermore laboratories emphasized that the testing of nuclear weapons was absolutely necessary to continue rapid atomic weapon development, taking time away from testing to ensure safety was a vital discussion essential to the AEC. The delays in testing because of radioactive breeches of the Test Site's physical ba, directly affected production rates, because a new weapon and mechanism could not go into full production until it had passed tests at the Nevada Test Site.

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[51] Hacker, *Elements of Controversy*, 249.
[52] Ibid.,249.
[53] Ibid., 233.
[54] Ibid., 62.

In addition, breeches of the physical ba delayed production and testing because the government had to take time to assure those living near the NTS that neither they, nor their livelihoods, had been negatively affected by the radiation. After the Harry shot (which later became known as Dirty Harry), many farmers and ranchers around the area reported odd burns and high mortality rates among their livestock. The ranchers began to question the AEC about the possibility that radiation caused the burns, even filing litigation against the AEC. Iron County sheepherders, who lost 12.1 percent of their ewes and 25.4 percent of their lambs, requested $226,000 in damages from the United States' government.[55] To ensure that testing could continue in the future, the AEC delayed weapon's testing until they had shown the farmers that radiation had not conclusively caused the deaths of their livestock. In 1956 the ranchers lost their case, but they had begun to question the authority and ability of the AEC to control nuclear tests, therefore questioning the intellectual ba of the atomic industry. If the AEC had continued testing before verifying the causes of sheep deaths and settling the litigation against them, the ranchers' outcry claiming that the atomic testing damaged their livelihood could possibly bring enough negative publicity to bring permanent stoppage to nuclear testing. Therefore, despite the delays and problems from their production plants, the AEC had to temporarily stop testing, in hopes of protecting the future of the testing program.

Just as they had to assure ranchers that radiation had not negatively affected livestock, the AEC had to face serious challenges regarding the effects of the ba-escaping radiation on the citizens of Utah, Nevada, and Arizona. After tests such as Harry, where towns accumulated significant amounts of radioactivity, the AEC faced a serious challenge to their intellectual ba at the Nevada Test Site. After Harry, the AEC mobilized emergency forces to close roads, tell

[55] Titus, *Bombs in the Backyard*, 65.

people to stay inside, and to take readings of radioactivity.[56] When they saw this strong reaction by federal experts, the people of the towns of St. George and Moab panicked, asking whether they faced any danger and even voicing anger at the carelessness of those running the site.[57] As with the farmers on their ranches, the AEC had to take time to assure those living downwind from the NTS that atomic testing posed no dangers to human health. But, unlike the livestock, the AEC faced serious concerns that perhaps the test site was a hazard to human health. Because the AEC did emphasize radiation safety, the fallout on surrounding towns forced the AEC to reconsider what constituted a safe amount of radiation. Suddenly, the AEC had to consider the effects radiation might have on humans outside of their controlled environment.[58] This led to a drawn out, hotly contested debate, in which the AEC grappled with tough questions from non-AEC scientists and doctors about what was safe, leading to a complete redefinition of the site's physical ba. These questions made the AEC realize that they could not ensure that they could control radiation and therefore further pushed them to reconsider how to protect the American people from dangerous radiation, bringing the area beyond the test site's boarders into the site's physical ba. When the physical ba of the site expanded, it resulted in a radical change in the AEC experts' intellectual ba, as the nuclear experts had to consider a wider population and environment. These delays and concerns changed the focus and schedule of the nuclear experts' intellectual ba by questioning the AEC's abilities, occurred because the AEC could not control their physical ba.

The largest shock to the AEC's Nevada Test Site's intellectual ba did not really begin until the 1970s and continues today, when down winders and soldiers of the Nevada Test Site started to fight for recognition of what they felt were radiation-induced illnesses. While

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[56] Hacker, *Elements of Controversy,* 104.
[57] Ibid., 104.
[58] Ibid.,103.

radiation can cause immediate symptoms, such as burns, often the true damage is not apparent for many years. Cancers which are caused by radiation, such as leukemia, lung, and thyroid cancers, often take several years to manifest. It was around the 1970s that soldiers who had taken part in nuclear military exercises and the citizens of nearby towns began to experience high cancer rates and deaths.[59] At this point, major challenges to the AEC, its experts, and the government that supported them began.

Beginning in the 1970s, soldiers of the atomic battalion filed lawsuits against the government for their suffering from disease, particularly with leukemia. Many men developed various illnesses, such as Larry Pray, who witnessed multiple atomic tests and developed brain cancer in his late 20s. Pray asked the government for injured veteran benefits and requested that the AEC and government admit fault for his injuries.[60] Thousands of atomic veterans filed similar suits, as they suffered abnormally high cancer rates. The nuclear experts had lied to these atomic battalion veterans about their safety and exposed the soldiers deadly amounts of radiation. These lies still breed anger and distrust towards experts. The veterans, as late as 1993, bristled with anger with their government and those who ran the site. Russell Jack Dann claimed that the government was continuing to lie about their culpability after all these years, but he felt eventually the atomic veterans would show that the government and the AEC had knowingly placed them in danger.[61]

Similarly, the people of Fredonia, Arizona and St. George, Utah, such as Esther Adair and Rose Mackelprang, along with many of their fellow townspeople, began to file lawsuits against the government, questioning the nuclear experts' integrity and knowledge.[62] In one

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[59] Hacker, *Elements of Controversy,* 259.
[60] Gallagher, *American Ground Zero*, 92.
[61] Ibid, 66.
[62] Fradkin, *Fallout*, 30.

particularly important case, *Irene Allen vs. the United States of America*, Stewart Udall represented a number of downwind families. These families and their lawyers argued that the government had acted carelessly with nuclear testing, therefore endangering the lives of those in their towns, and specifically causing the cancers that each of them faced within their family. The families came before Judge Jenkins and told their stories of cancer and loss. Almost every family had more than one member ill, dying, or dead from probable radioactivity-induced illnesses.[63] The families demanded that the Department of Energy (DOE) (the AEC's descendent agency, created in 1977) admit the government and nuclear experts fault in their illnesses. The families wanted financial reparations to cover medical expenses to provide for families who financial stability and health had been affected either by the illness or death of a family member, and reparations for their general loss of lifestyle and for suffering.

This trial represented the biggest challenge to the AEC nuclear experts' intellectual ba and was one of the first times the United States' government permitted such a challenge. The American government throughout its history had protection from lawsuits, such as the ones it now faced because of sovereign immunity. This policy stated that the United States' government and its contractors could not be held liable for damages caused while the government was acting in the best interest of the American people. It was this concept that the government initially used to protect itself from litigation regarding escaped radioactivity from nuclear weapons testing. For awhile the government was able to maintain this barrier, but the uniqueness of the situation with nuclear wastes overrode the past tradition of no government culpability. The breakdown of the Nevada Test Site's physical ba opened the door for those Americans living downwind from the site to question the AEC's authority and hold those experts accountable for their actions, thus

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[63] Fradkin, *Fallout*, 167-181.

lessening the autonomy over nuclear production and policy that the AEC's intellectual ba had created for nuclear experts.

In a landmark decision, Judge Jenkins in *Irene Allen vs. the United States of America* declared that the government was indeed responsible for the illnesses and suffering of the Americans represented in the court case.[64] Jenkins blamed the AEC for not warning the public the dangers of nuclear testing, for not taking the necessary safety precautions, and for not offering aid to those who suffered as a result of the tests.[65] This judgment further broke many Americans trust in their government, as the Vietnam War had already shaken many Americans faith in their government's agenda and policies. Down winders, in particular, thought of the AEC as an agency which thought only about the joy of solving the problem and designing the newest weapon, but who never actually considered how their actions might affect others. Many of the Americans, particularly those who lived near a nuclear facility, no longer believed AEC nuclear scientists or engineers when these experts told Americans that the nuclear program posed no danger to the American public and was a necessity for the United States' safety.[66] Now that down winders recognized that the AEC had lied to them about nuclear dangers before, the people of Arizona, Utah, Nevada, and New Mexico were less willing to allow the AEC to do things as they wish. The experts' intellectual ba, which had allowed the scientists and engineers to build atomic weapons without public oversight, shifted to an intellectual ba that had to listen to and consider the opinions of the American people. This change was caused in large part by radiation escaping the boundaries of nuclear facilities' physical ba.

The Savannah River Site offers an illustrative example of a facility where radiation safety was remarkably successful and only small amounts of radiation crossed the site's physical

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[64] Fradkin, *Fallout*, 228.
[65] Ibid., 229-230.
[66] "Energy Dept. says Nuclear Test Post No Radiation Peril to Public." *New York Times* 137 (26 Sept 1987): 10.

boundaries during most of its years of operation. Yet, despite this record of relative safety, those small amounts of escaping radioactivity created complications for the AEC experts. DuPont operated the Savannah facility where the manufactured tritium and plutonium for nuclear weapons under a policy of total containment; DuPont engineers and scientists strove to not let any radiation escape the boundaries of the site.[67] The Atomic Energy Division of DuPont, while strongly believing in this policy, recognized that actually maintaining one-hundred percent containment as impossible. Periodic releases would have to occur to maintain reactor pressures. Therefore, DuPont worked to keep these releases to a minimum and at levels that should not have posed any danger to the surrounding environment or communities.[68] The director of the manufacturing for DuPont's Atomic Energy Division, M.H. Smith, in a letter to a SRP plant manager, J.D. Ellett emphasized safety first in his plant objectives. He said, "Protection against nuclear incidents ... should continue to receive top priority."[69]

Nonetheless, breeches of the physical ba occurred at the Savannah River in the same manner as at other facilities. Atmospheric contamination occurred in the form of gaseous releases from the five reactors on the site. These releases were intentionally performed to avoid excessive pressure levels in the reactor. The gases purged typically contained small amounts of plutonium, uranium, and tritium, all of which posed health hazards in large enough amounts. In theory, atmospheric dispersion would lessen the radioactivity to completely benign levels before coming in contact with those living near the Savannah facility. F.E. Kruesi, who operated the Savannah facility for DuPont, said in an August 1978 memo that there were traces of radioactive cesium in the swamps near the SRP effluent streams. Kruesi concluded that the releases were well under safety standards for radioactivity concentrations since DuPont knew the extent of the

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[67] M.H. Smith, "General Objectives – Savannah River Plant", 3 January 1961, AED Records, Hagley, 2.
[68] F.E. Kruesi, Correspondence to J.F. Proctor, "Containment," 31 January 1983, AED Records, Hagley.
[69] Smith, "General Objectives -- Savannah River Plant", 3 January 1961, AED Records, Hagley.

releases and could account for them, in Kruesi's view physical bad had been maintained and thus the safety of the surrounding area.[70] For the most part this was true. However, occasionally rain from the frequent showers would cause dangerous levels of radioactive materials to land near the site, contaminating fields, swamps, and communities.

The larger breakdown of Savannah River's physical ba occurred with the subterranean releases of radioactivity. The major cause of this contamination was underground storage tanks. These tanks, which were very similar to those used at Hanford, stored the waste from the various reactors. And like the Hanford tanks, these underground tanks leaked. At Savannah River, four of nineteen tanks had leaks in 1962.[71] The liquid waste contaminated the ground water found beneath the site. The true danger from this contamination came when the contamination from the ground water began to seep into the multiple surface streams that crisscrossed the site, which in turn contaminated the Savannah River itself and the surrounding swamplands.

The Savannah River Site's intellectual ba also faced early challenges to the authority and abilities of its experts. In 1957, a local farmer, C.L. Dunbar, filed charges against the site for damaging the surrounding environment and Dunbar's crops. Dunbar's lawyer, Albert Butler, asked the managers to recognize the dangers the plant posed to the area and to provide compensation to Dunbar for his loss of crops and trees.[72] While the letters between Butler and DuPont's Atomic Energy Division representative remained cordial, the lawyer was certainly challenging the knowledge and the abilities of the experts to adequately control nuclear products. He argued that many sudden illnesses and deaths in the area to the east of the Savannah River Plant could only be caused by the facility, therefore arguing that the experts did not fully control

[70] Correspondence between F.E. Kruesi and E.B. Yelton, 26 August 1974, AED Records, Hagley.
[71] Correspondence for R. C. Blair, AED Records, Hagley.
[72] Albert E. Butler, Correspondence to Professor Eugene Odom, 29 May 1957, AED Records, Hagley.

their radioactive emissions.[73] DuPont had to settle Dunbar's claim and take a good deal of time proving that the facility had not caused any damage. Though DuPont had set up multiple remote monitoring stations around the perimeter of the site – some as far as 25 miles from the site's borders - they realized more fully that they could not account for all radioactivity that crossed site borders all of the time. Tritium with its low radiation readings was particularly problematic, forcing the DuPont engineers to reconsider how to maintain control over radioactive waste.[74] As with the Nevada Test Site, the physical ba expanded to include areas further from the site, forcing a change in the intellectual ba, as nuclear experts had to consider new environments and their own inability to completely control nuclear waste.

Though the physical ba at Savannah River had more stability than the physical ba at Hanford or the Nevada Test Site and the levels of contamination were much lower, the intellectual ba suffered negative effects. First, as with Hanford, the leaking storage tanks meant taking time away from refining production procedures to focus large numbers of personnel on fixing the tanks. DuPont had to commit an entire team to this task. The team took time away from working at the Savannah River plant to travel to Hanford to discuss the problems of the storage tanks. Kruesi said that an additional complement of tankage would have to be completed, as the put tanks into operation in 1971, were failing.[75] Once again, the original plans and schedule of the intellectual ba changed because of physical leaks.

Ultimately, as the public learned even more about the extent of the leaks and releases of radioactive materials from Hanford, the Nevada Test Site, and Savannah River, complaints, concerns, ideas, and demands for change grew more common. Environmentalists, members of

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[73] Albert E. Butler, Correspondence to Louis A. Young, AED Records, Hagley.
[74] C.M. Patterson, "Trip Report I: Meeting with AEC Instrument Branch II Savannah Site Survey, 15 February 1951, AED Records, Hagley.
[75] F.E. Kruesi , Correspondence to N. Stetson, 26 August 1974, AED Records, Hagley.

the surrounding communities, and journalists began to express anger at the dangers they had faced (and were often still facing) as a result of the country's attempt to build nuclear weapons as quickly as possible. Journalists for the *New York Times* described the failures of the government. Fox Butterfield, an investigative reporter for the *New York Times* said that a Congress obsessed with secrecy missed warning signs of danger and did not bother to ask the opinions of experts outside of the AEC/DOE. Butterfield argued that these failures to contact outside experts allowed the government and corporate internal experts to dictate everything, including what was acceptable risk for the American public.[76] An earlier article claimed that the experts had operated free of Nuclear Regulatory Commission oversight, and therefore had gotten away with dangerous activities.[77] Still a third article argued that the AEC knew and understood the dangers from radiation, but chose to proceed anyway.[78] DuPont, General Electric, all other AEC subcontractors, and the AEC/DOE itself had to consider how they were going to manage cleaning up all of the escaped radioactive materials and how to continue to protect the environment from the continuing legacy of nuclear weapons production, namely radioactive waste.

These discussions about the suitability of experts to manage nuclear policy still continue today and the expert's authority and right to make decision on all matters atomic are still challenged and made difficult by the previous releases of radioactivity. Because many Americans now understood that the government had controlled dispersion of information during the Cold War about accidental releases of radioactivity, many Americans strongly distrusted any and all government plans for nuclear wastes over the long term. The DOE had had attempted

[76] Fox Butterfield, "Trouble at atomic bomb plants: How lawmakers missed the signs." *New York Times* 138 (28 Nov 1988): A1

[77] "The Bomb Makers' Complacency." *New York Times* 136 (27 Dec 1986): 14.

[78] Philip J. Hilts. "Fallout Risk Near Atom Tests Was Known, Documents Show." *The New York Times* 144 (15 March 1995): A15

through the 1970s, 1980s, and 1990s to find a suitable location in which to store the millions of pounds of radioactive wastes. One of the major prospects was the Waste Isolation Pilot Plant (WIPP) site near Carlsbad, New Mexico (Figure 5).[79] At this site, buried deep within a mountain, the DOE wanted and still wants to store the nation's nuclear waste. The experts have claimed over and over again that WIPP could safely store almost all of the nation's nuclear waste for thousands of years. Despite these claims and the experts' assurances, the citizens of New Mexico and various environmental groups, which had grown quickly during the 1970s in response to *Silent Spring,* have fought the idea of having nuclear waste in their backyard. In 1991, several states demanded that the DOE receive Congressional support for WIPP.[80] No longer did the American people accept what the experts said about safety. Increasingly, various groups challenged the experts' role and knowledge, imposing their own will on issues involving nuclear activities.[81] Because of protest, WIPP fell years behind its construction schedule. The site was supposed to open in the mid-1980s, but instead did not open until 1999.[82] WIPP provides an ongoing example of the ways physical ba-crossing radioactivity affected not only production schedules of nuclear weapons, but also Americans' faith and trust in their experts.

Each of these case studies, including the brief discussion of WIPP, provide insight into how the experts' ba or place was changed and molded by escaping radioactivity. Sometimes the consequences were mundane annoyances, such as briefly having to delay production until a

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[79] For a detailed study of the selection, construction, and politics surrounding the WIPP site, see: Chuck McCutcheon's, *Nuclear Reactions: The Politics of Opening a Radioactive Waste Disposal Site* (Albuquerque: University of New Mexico Press, 2002). McCutcheon traces the entire history of the WIPP site from the search for a site, starting in 1974 to the opening of WIPP in 1999. He discusses how the site was chosen over other possible locations and Americans reacted to the idea of a permanent waste disposal site. McCutcheon is particularly interested in the protests and conflict that occurred around the site, from public protests in New Mexico near the WIPP location, to broader national discussions, such as Idaho governor Cecil Andrus' refusal to allow radioactive materials travel through or be temporarily stored in Idaho.
[80] Chuck McCutcheon, *Nuclear Reactions: The Politics of Opening a Radioactive Waste Disposal Site,* (Albuquerque: University of New Mexico Press, 2002), x.
[81] Hacker, *Elements of Controversy,* 278.
[82] McCutcheon, *Nuclear Reactions*, xi.

process was confirmed safe; other times the problems led to direct challenges the experts' role in society through litigation and protest. Down winders, environmentalists, doctors, and non-AEC scientists began to ask if experts - in this case the government agencies of the AEC/DOE and their nuclear scientists and engineers - could be trusted. If the AEC could not see beyond solving the scientific problem and did not completely understand the danger of nuclear materials, then these groups felt they needed to force their views and ideas on the experts. This took away the autonomy the experts had enjoyed for years after World War II.

The organization of the AEC and its dozens of nuclear facilities, including Hanford, the Nevada Test Site, Savannah River, and WIPP, show the importance of maintaining tight control over both the physical and intellectual aspects of a complex technological system. For the AEC, it proved initially easier to control the intellectual space of the atomic industrial complex through classification of all materials and great secrecy. However, the physical ba proved nearly impossible to control. Almost immediately, radioactive wastes and byproducts broke physical boundaries. These wastes poisoned the American environment and people throughout the Cold War. Just as the concept of ba suggests, this loss of control over the physical aspect of nuclear facilities occurred and affected the intellectual space, which included the experts, production processes, information, knowledge, and further research. The experts could no longer constantly maintain high rates of production without interruption, nor would most Americans accept that the experts knew and understand nuclear processes and only wanted to protect America. Now they had to change production or even worse be told that the American public wanted a say in their affairs. The penetration radioactivity beyond physical boundaries changed the face of the experts' jobs and roles.

The story of atomic ba exposes how experts cannot simply control a body of knowledge and maintain authority in society. They must also control the environment in which they work and must maintain a strict separation between their working environment and the outside environment. This does not negate the necessity of experts being the only ones with access to a particular body of knowledge to ensure their place in society, but rather complicates and expands the requirements for maintaining expert status.

In addition, the breakdown of atomic ba shows that a tightly closed ba, such as the one created by the AEC and the United States' government, is nearly impossible to maintain. The article about ba does not really address the issue of the risks and problems of a closed ba system, but the AEC example suggests that such a system is difficult to operate and any mistakes completely destroy the position of the experts within the system. This does not propose that all closed systems are doomed to failure – Los Alamos during World War II was a closed system that successfully completed its mission and elevated the position of experts in many American minds – but rather suggests that these systems have less room for error than other systems. It is difficult to know whether the AEC could have prevented these breakdowns with the knowledge and resources available that the time, but one can say that radioactivity escaping the atomic ba and the dangers it posed to the American environment and people caused a change in the organization of the AEC and the position of experts in American society.