DOE Workforce Pipelines in Northern New Mexico

Frontline worker recruitment in the US nuclear weapons complex
Funding, siting, impacts, and alternatives

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INTRODUCTION

This paper examines the growing involvement of New Mexico institutions of higher education in frontline worker recruitment in the DOE nuclear weapons complex. Under pressure from major DOE contractors and various state and local officials, a number of community colleges in Northern New Mexico have established DOE "workforce pipelines" over the last several years. These pipelines are designed to quickly train local residents for hazardous frontline positions at DOE's nearby Los Alamos National Laboratory.

Officials expect these accelerated, 10-week to two-year programs to train the hundreds or thousands of frontline workers who will be needed to fulfill current DOE missions at LANL. These missions include: (a) the round-the-clock production of plutonium "pits" that is being undertaken as part of the modernization of the US nuclear arsenal (a plutonium pit is a precision-machined component that is used to trigger the detonation of a nuclear weapon); and (b) the remediation and disposal of the immense volume of radioactive and hazardous waste that is the legacy of decades of nuclear weapons activity at LANL. A substantial quantity of new radioactive and hazardous waste will be created during the production of plutonium pits. This new waste will also require treatment, characterization, packaging, and transport to an underground repository.

DOE pipelines are also being established in the vicinity of DOE's Savannah River Site near Aiken, South Carolina. In response to growing public concern regarding DOE pipelines (and DOE labor practices more generally), this paper presents a critical examination of DOE workforce pipeline initiatives in Northern New Mexico. As of this writing, three community colleges in the region—Santa Fe Community College, Northern New Mexico College, and UNM-Los Alamos—have initiated training programs for frontline DOE workers as part of their curricula.[1] [2] [3] All three of these institutions have an explicit mission to serve Hispanic, Native American, and/or low-income students in the region. The discussion below focuses on recent DOE workforce pipeline initiatives at UNM-LA.

BACKGROUND

Since 2019, when DOE workforce pipeline initiatives at Northern New Mexico community colleges were first announced to the public, DOE and other officials have worked to highlight the benefits of these training programs to local communities. Yet official accounts, which invariably emphasize job creation and short-term economic benefits while overlooking other impacts altogether, are neither balanced nor objective.

Arriving at a deeper understanding of DOE pipelines and their true impact in the region requires: (a) careful examination of the harms associated with these training programs; and (b) consideration of whether those harms fall on certain communities more than others. As context for a more objective and historically-grounded analysis of DOE workforce pipeline initiatives in Northern New Mexico, we ask readers to consider the points that follow.

1. Frontline positions at DOE weapons facilities are among the most hazardous in US industry

The DOE nuclear weapons complex currently comprises nine major facilities across seven US states. At these sites, federal contractors overseen by DOE and the National Nuclear Security Agency (NNSA) conduct a variety of activities involving the US nuclear arsenal. Other contractors overseen by DOE's Office of Environmental Management (DOE-EM) work to address the vast legacy of environmental contamination that was created during five decades of US nuclear weapons development, production, and testing. As of 2022, operations at Los Alamos National Laboratory (LANL) are managed by DOE contractor Triad National Security. Legacy waste cleanup activities at the site are managed by DOE-EM contractor N3B-Los Alamos (Newport News Nuclear-BWXT).

Frontline workers at US nuclear weapons facilities perform a wide variety of tasks that support current DOE activities, including weapons production, facilities decontamination and decommissioning, and legacy waste remediation. Due to the nature of these activities, frontline workers at DOE sites face on-the-job risks that far exceed those in conventional industry in number, kind, and severity. In addition to the physical risks present in conventional industrial settings (e.g., falls, burns, electrocution, and amputation), frontline workers at nuclear weapons facilities face extraordinary occupational exposures unique to this setting alone.[4] [5]

Frontline activities at nuclear weapons facilities involve frequent exposure to radioactive materials, toxic metals, organic solvents, and chemicals. LANL radiation control technicians, for example, must be present at "all Laboratory activities above a certain hazard level" and so move continuously from one very high-risk setting to another. Personnel who work on site at DOE facilities, yet are not involved in weapons production or cleanup directly—e.g., craft and construction workers, security guards, maintenance workers, and emergency personnel—suffer significant exposure to radioactive and hazardous materials as well. Unusual materials of considerable toxicity are routinely used at DOE sites. Safe levels of exposure to these materials (if they even exist) are unknown.[6]

The large-scale production of plutonium pits that is scheduled to begin soon at LANL will be especially hazardous to frontline DOE workers. Pit production involves routine handling of acutely hazardous materials such as beryllium and plutonium, frequent exposure to solvents, and ongoing risks from both chronic low- and high-dose radiation exposure. These substantial occupational hazards will only be compounded by the pressures of intensive, round-the-clock operations.

Occupational exposures suffered at DOE facilities may cause acute injury, and may also induce serious chronic illnesses with long latency periods, including chronic beryllium disease, asbestos-related lung disease, neurological disorders, leukemias, lymphomas, and cancers.[6] Some affected workers may be disabled early in their lives, be unable to support their families, and, after enduring years of medical screening and treatment, suffer prolonged or painful deaths.

Forty-five year old Bill Evans, Jr., for example, did cleanup work at the Plutonium Finishing Plant at DOE's Hanford site before being disabled by seizures. The physical and emotional suffering he now endures was profiled in an investigation by the *Seattle Times* in 2020. The short video that accompanies the article movingly conveys the dismal reality of occupational illness at DOE weapons facilities.[7] We ask readers (and all who make policy around DOE workforce pipelines) to please take a moment to view it.

According to the most recent study of DOE occupational radiation exposure, LANL had the highest collective radiation dose among all DOE facilities. LANL was also unique among DOE facilities in being the *only* site where collective radiation dose increased during the period of study. Round-the-clock plutonium pit production will increase collective radiation doses at LANL significantly.

To comprehend the hazards associated with plutonium pit production at LANL, it is helpful to consider the waste that will be generated by this activity. It is estimated that the "30–80 PPY [pits per year] mission" at LANL will produce the following types and volumes of waste per year: radioactive waste, approximately 1,000 to 2,800 cubic yards per year (the equivalent of 3,700 to 10,360 55-gallon drums); chemical waste, 150,000 to 399,000 pounds per year; and liquid radioactive waste requiring treatment, 1.7 million gallons per year.[8]

Workers will be exposed to these materials, not only during the activities that generate them, but also during the many steps involved in their disposal, including waste characterization, packaging, transport, and storage.

2. DOE pipelines in context: minority-serving institutions in Northern New Mexico

To appreciate the complexities of DOE workforce pipelines in Northern New Mexico and their impacts in the region, it is useful to examine student demographic data from local community colleges that have undertaken DOE pipeline initiatives. These data provide a glimpse of the primary populations served by these institutions—and thus of the populations that are most likely to be recruited into DOE workforce pipelines.

In brief, these colleges chiefly serve Hispanic, Native American, rural, and low-income students, many of whom have not been adequately prepared for college-level coursework. For critical context on academic preparedness in Northern New Mexico, including the 2018 ruling in *Yazzie and Martínez v. State of New Mexico*, please see footnote 9. Briefly, the case revealed that New Mexico's public schools were insufficiently funded, and therefore failing to provide an adequate K-12 education to English-language learning, Native American, and low-income students in particular.[9]

Santa Fe Community College. "While Santa Fe shares a rich multicultural history," officials at Santa Fe Community College wrote in their 2019 application for federal funding for Hispanic-Serving Institutions, "it struggles with multigenerational poverty and low educational attainment rates." Recent student enrollment statistics at SFCC show that about two thirds of full-time students identify as Hispanic. About 60 percent are low-income, and about 80 percent are first-generation. Many students have not been adequately prepared for college-level coursework.[10]

Northern New Mexico College. Located in Rio Arriba County, Northern New Mexico College "primarily serves rural communities within a 40-mile radius of its campus in Española, New Mexico, within one of the most underserved regions of the state." Students at Northern New Mexico College are mostly first-generation; more than ten percent identify as Native American, and about three-quarters as Hispanic. Low-income students comprise about three-quarters of the student body. Virtually all have been inadequately prepared for college-level coursework. Recently, 94 percent tested into remedial classes.[10] [11]

UNM-Los Alamos. According to the application UNM-LA officials submitted in 2020 for funding for Hispanic-Serving Institutions, the college "has long provided a solid educational foundation and career development opportunities to Hispanic and lower-income students." Of the students enrolled at UNM-LA in Spring 2020, almost 50 percent identified as Hispanic and seven percent as Native American; the percentage of minority students overall was 62 percent. Approximately 70 percent of students had been inadequately prepared for college coursework.[10] [11]

Note that the student body at UNM-LA, with its many Hispanic, Native American, and low-income students, is far more representative of the demographics of the communities surrounding Los Alamos County than of Los Alamos County itself. In 2019, the median household income in Los Alamos County was $121,324—one of the highest in the nation—and the proportion of residents identifying as Hispanic, Latino, or Native American was less than 20 percent. In contrast, more than 90 percent of residents in adjoining Rio Arriba County were Hispanic, Latino, or Native American, and the median household income was $22,911. [12]

The preceding statistics give the reader a sense of the primary populations served by institutions that have established DOE pipelines—and also of the broader political economy in the region.

Long-time residents of rural Northern New Mexico use the word querencia (love of place and home) to describe feelings of deep attachment to, and longing for the land and local culture.

3. Siting of DOE pipelines targets vulnerable communities and individuals for the most hazardous work

All who are familiar with LANL's operations will recognize the informal occupational segregation within the institution—a fact little-discussed by officials, yet relevant to occupational risk at the Laboratory. A recent report revealed that in 2015, only about ten percent of LANL scientists and R&D engineers and seven percent of postdocs identified as Hispanic or Native American—while fully two-thirds of LANL technical workers did so.[13]

This informal partitioning of LANL occupational roles by race and ethnicity contributes in turn to wide racial and ethnic variation in on-the-job risk, including exposure to the vast array of radioactive materials, solvents, and chemicals present at LANL facilities. In general, LANL administrators, engineers, and scientists enjoy very low occupational exposures to hazardous materials, while the exposures of technicians, subcontractors, and frontline workers (including craft, security, and maintenance workers) are higher. Data on the racial and ethnic identities of the workers who suffer the very highest (i.e. life-threatening) occupational exposures at LANL are conspicuously hard to come by, but it is likely that Hispanic and Native American individuals fill the vast majority of these positions.

Established at institutions of higher education serving Hispanic, Native American, and low-income communities specifically, DOE pipelines target members of vulnerable communities for the most hazardous frontline work at LANL.

Many of the adverse health effects that result from exposure to radioactive and other hazardous materials are stochastic in nature, meaning that their occurrence can only be predicted statistically. While the development of adverse effects among *a group* of exposed persons is certain, the particular *individuals* who will be affected cannot be predicted with accuracy. Nevertheless, the racial and ethnic segregation of occupational risk, such as that at LANL described above, implies that the *communities* in which adverse health effects will occur can readily be identified.

In a step that is part of a broader agenda that formalizes and legitimizes this unofficial hierarchy of occupational risk, DOE contractors have recently pushed for the establishment of frontline worker training programs at schools and colleges that have an explicit, publicly-stated, and federally-funded mission to serve Hispanic, Native American, and/or low-income students in the region. In anticipation of a hiring surge associated with intensive production of plutonium pits, LANL's in-house recruitment efforts have deliberately targeted local minority and underprivileged students when promoting these "pipeline educational opportunities." [14]

Because the most hazardous positions at LANL have for decades been filled by minority and low-income residents of nearby communities, these groups have already borne a disproportionate share of the most dangerous work involving the nuclear arsenal. Thus, the new DOE pipeline programs—although cast as higher education—merely perpetuate an entrenched pattern of socioeconomic exploitation in Northern New Mexico. Established at regional institutions serving Hispanic, Native American, and/or low-income individuals specifically, these pipeline programs effectively single out historically-impacted and marginalized communities for further illness and injury.

4. DOE's indefensible record on worker protection and safety

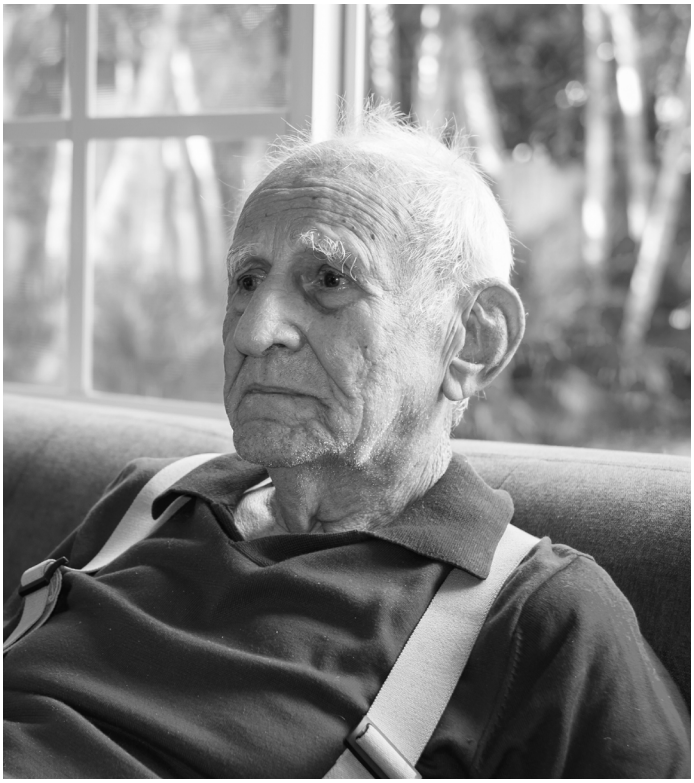
The Department of Energy has long denied the substantial occupational hazards at its nuclear weapons facilities. For decades, DOE and its contractors have (a) concealed their knowledge of these hazards from workers; (b) attempted to minimize or dismiss workers' concerns about occupational risks; (c) falsified and destroyed the medical records needed to substantiate workers' claims of occupational illness and injury; and (d) used federal funds to litigate against sick and injured workers who sought workers' compensation.[15] [16] [17]

DOE's Office of Environment, Safety, and Health was established in 1985, after it became clear that "the Department's emphasis on production [came] at the expense of workers' health and safety." [4] A related Congressional investigation observed that DOE "was an institution not accustomed to oversight." The DOE weapons production culture, the investigators said, "was one of secrecy and environmental recklessness," where "the paramount goal to manufacture the nuclear arsenal overrode all other considerations." [18]

Former DOE workers, including former LANL mechanical technician Ben Ortiz of Nambé, fought for years for federal legislation to secure compensation for workers who develop work-related illnesses at DOE facilities. (Ortiz himself struggled for decades to win compensation for the neurological disability he developed as a result of occupational exposures at LANL.)[19] In 2000, Congress finally passed the Energy Employees Occupational Illness Compensation Program Act (EEOICPA), providing financial compensation and medical coverage to the many nuclear workers who, due to their employers' "fears of adverse publicity, liability, and employee demands for hazardous duty pay," had been put at serious occupational risk without their knowledge or consent. Congress learned during related testimony that many nuclear workers had been "deliberately misled, [and] in some cases...intimidated by the formidable legal resources of the US government." [5] [15]

As of December 2022, approximately 137,000 US nuclear workers have filed occupational illness claims under EEOICPA. About three-quarters of these claimants have received some compensation under the program, which has paid out more than $22 billion in benefits to date.[20] Sadly, a large group of mobile service workers—firefighters, security guards, laborers, craft workers, custodians, and radiation control technicians—who routinely rotated between worksites at LANL has not been designated as a "Special Exposure Cohort" under EEOICPA. These workers are thus unlikely to be compensated for any exposure-related illness they have sustained.[21]

During the hearings that led to the establishment of EEOICPA two decades ago, Congress noted that DOE and its predecessor agencies had since World War II been "self-regulating" with respect to nuclear and occupational safety. "No other hazardous Federal activity," they said, "has been permitted to be carried out under such sweeping powers of self-regulation." [5] Despite numerous ongoing deficiencies related to worker protection and safety, however, DOE facilities remain unregulated by any independent external occupational safety board, such as OSHA. (The Defense Nuclear Facilities Safety Board, which oversees worker and public safety at US nuclear weapons facilities, functions in an advisory, rather than a true regulatory capacity.) The lack of regulatory oversight at DOE facilities enables the senseless continuation of avoidable occupational hazards.



5. “Dirty work”: moral injury of frontline workers and frontline communities

Finally, there exists a significant, yet far-less recognized form of injury suffered by frontline workers at DOE nuclear weapons facilities. In a recent essay, Eyal Press describes the phenomenon of “dirty work” in America—work that “undergirds the prevailing social order,” which people in positions of privilege rarely have to perform.[22] Dirty work occurs in settings such as prisons, mines, and slaughterhouses; it is generally performed in isolated locations or in institutions that are not open to the public view. In America, says Press, dirty work “is not randomly distributed.”

> It falls disproportionately to people with fewer choices and opportunities such as high-school graduates from depressed rural areas, undocumented immigrants, women and people of color.

Many people employed in dirty work, Press continues, are susceptible “not only to exploitation and physical injury—as is true of so many people in low-status occupations—but also to another, less familiar set of hazards,” owing to the nature of the jobs they do. In 1973, he notes, sociologists Richard Sennet and Jonathan Cobb called for a new emphasis in class analysis on “the moral burdens and the emotional hardships” borne by certain workers:

> For dirty workers, these burdens include stigma, self-reproach, corroded dignity and shattered self-esteem. In some cases, they include “moral injury,” a term that military psychologists have used to describe the suffering that some soldiers endure after they carry out orders that transgress the values at the core of their identity. [...] Though more difficult to quantify, the moral and emotional wounds that many dirty workers experience can be as debilitating as material disadvantage.

These wounds shape dirty workers’ “sense of self-worth, their place in the social order and their capacity to hold on to their dignity and pride.” The result, Press observes, is “a form of moral inequality that mirrors the economic kind.”

There has been little acknowledgment or discussion of the moral and emotional harms suffered by frontline workers at DOE nuclear facilities—although this work too constitutes a form of dirty work that people in positions of privilege rarely have to perform. Despite the substantial impacts of work-related psychological injury on the lives of frontline workers, it is at present unthinkable that such harms will be compensated under occupational injury programs such as EEOICPA. In the special case where many individuals in a particular geographic region or setting are compelled to do dirty work—not as a matter of choice, but as a question of survival—the collective moral and emotional harm that results may be substantial, and indeed may blight the vitality of entire communities.

While workers are often blamed for their participation in dirty activities, this scapegoating can “obscure the power dynamics and the layers of complicity” that structure and constrain workers’ choices. The responsibility for the emotional and moral harms associated with dirty work, Press observes, extends to local institutional leaders and elected officials, and to the voters who elect and support them.

DOE PIPELINES IN NORTHERN NEW MEXICO

1. Case study: DOE/NNSA workforce training initiatives at UNM-Los Alamos

Since 2019, UNM-LA has implemented three DOE workforce training programs for frontline nuclear workers. The first, a 10-week "bootcamp" in Radiation Control Technology, prepares students for entry-level work in radiation monitoring, decontamination, and emergency response; the second, a 10-week bootcamp in Nuclear Waste Operations, trains students to prepare the radioactive and hazardous waste that has accumulated at DOE nuclear weapons facilities for decades for shipment to an off-site repository.

The newest program at UNM-LA, launched in January 2021, is an AAS in Nuclear Enterprise Science and Technology (NEST). The program, designed for current LANL employees, trains students in "fissionable material handling and glovebox operation," i.e., protocols for handling and processing radioactive materials such as plutonium, which if improperly handled can expose workers to extremely high, even fatal doses of radiation. Workers will need skills in plutonium handling to participate in the production of plutonium pits, a new NNSA mission set to begin soon at LANL.[14]

Finally, the welding program at UNM-LA has recently undergone a major expansion in order to accommodate surging demand at LANL, a major employer of welders in Northern New Mexico. Welders play a critical role in the production of plutonium pits.[23]

A hands-on plutonium glovebox training facility at UNM-LA?

As part of the effort to train another generation of young workers for positions in the US nuclear weapons complex, officials at UNM-LA recently proposed to renovate several buildings on the campus to create a "hands-on glovebox laboratory." (A radiological glovebox is a stainless steel enclosure, typically fitted with lead-lined gloves and a radiation-shielding viewing window, which is used to confine operations involving acutely radioactive and toxic materials such as plutonium and beryllium. Gloveboxes reduce, but do not eliminate the hazards these materials pose to workers.) Students in the NEST program will train in the simulated glovebox environment to prepare for work manufacturing plutonium pits at LANL's plutonium facility, TA-55. [23]

To finance construction of the glovebox training facility on its campus, UNM-LA submitted a proposal in July 2019 to the New Mexico Higher Education Department (NMHED), requesting $1.875 million in public funding through the state's 2020 General Obligation (GO) Bond for Higher Education.[24] (General obligation bonds, which typically fund repairs and safety upgrades to senior centers, libraries, and institutions of higher education, are financed through residents' property taxes.) After reviewing UNM-LA's funding

request during its 2019 Summer Hearing process, however, the Higher Education Department declined to recommend the glovebox training facility for funding.[25]

The basis for NMHED's rejection of the glovebox training facility is not a matter of public record. However, the Department is required by New Mexico law (5.3.9.8 NMAC) to give preference to capital projects for which there is "no other available or more appropriate" source of funding. Furthermore, total legislative appropriations for New Mexico GO bonds are roughly stable from one funding cycle to the next, in order to avoid the need for an increase in property taxes and the bond's possible rejection by voters. Because adding a new project to a bond package will likely require cuts to others, NMHED's funding recommendations are very carefully considered.

Despite the Education Department's rejection of the glovebox facility at UNM-LA, $1.7 million in funding for the project found its way into the 2020 Capital Projects GO Bond Act (SB 207), which was introduced into the legislature in January. The bill described the plutonium glovebox project in only the most indirect of terms.[26] Following its passage by the legislature in February, SB 207 became the basis for GO Bond Issue C. The bond passed by a large margin during the November 2020 election.[27]

At the same time that funding for the glovebox facility was written into SB 207, substantial cuts were made to capital projects at other New Mexico institutions of higher education. Appropriations to three institutions that serve predominantly Native American students—UNM-Gallup, the Institute of American Indian Arts (IAIA), and Diné College—as well as the Junior College at Hobbs, were reduced 30 to 50 percent relative to NMHED's recommended funding levels.[28] Were cuts to legitimate state higher education needs made to fund UNM-LA's subsidization of DOE/NNSA workplace training instead?

DISCUSSION

1. UNM-LA: Local community college, or DOE/NNSA training center?

UNM-LA's 2020 capital project is highly irregular, first, for its appropriation of public funds to construct a training facility for the handling of fissile and other high-risk nuclear materials, when that burden should clearly fall on the DOE; and second, for officials' lack of transparency around the nature of the proposed renovations at UNM-LA. New Mexico voters, for example, were not likely to grasp the intended use of campus upgrades referred to simply as "Workforce Development Career Technical Education Classroom Renovations," nor to recognize that the objective was to use state education funds to create a DOE/NNSA training facility on the UNM-LA campus.

The project is currently listed on a UNM web page describing the University's general obligation bonds for 2020. However, detailed descriptions of the various branch campus projects, including the glovebox project at UNM-LA, may not have been posted by the University until several weeks *after* the November 2020 election.[29] For UNM-LA's GO Bond request for 2022, "UNM-LA Campuswide Improvements," see footnote 29.

a. A troubling pattern of non-transparency

The aura of secrecy surrounding GO Bond funding of the glovebox project reflects UNM-LA's troubling lack of transparency around its DOE workforce development activities more generally. Although UNM-LA has launched three DOE pipeline programs since 2019 (RCT, NWO, and NEST), the programs (although listed in the course catalog) cannot be found on the "Areas of Study" or "Degrees & Certificates" pages of the UNM-LA website.[30]

Furthermore, neither former UNM-LA Chancellor Cynthia Rooney nor members of the UNM-LA Advisory Board have responded to requests for the information about occupational risks the college distributes to students who are considering its RCT, NWO, and NEST programs, prior to their enrollment in these programs. It thus remains in doubt that prospective students are being informed of the substantial occupational hazards they will inevitably face as frontline workers at LANL and other nuclear weapons facilities.

Finally, UNM-LA leadership has been evasive when confronted with questions regarding the school's recent award of $2.3 million in federal Title V funding for Hispanic-Serving Institutions.[31] These questions included: Will Title V funds be used to support the planned DOE glovebox training laboratory? Does UNM-LA believe that supporting DOE workforce training programs constitutes an appropriate use of Title V funds? Given DOE's history of exploitation of Hispanic communities in Northern New Mexico, does UNM-LA consider DOE workforce training programs to be "Hispanic-serving"? Does UNM-LA leadership believe DOE pipelines constitute progress in Hispanic higher education?

b. A distorted notion of community

A notable feature of official discourse around DOE workforce development initiatives in Northern New Mexico is the portrayal of LANL—a federally-funded national security laboratory—as "local community." UNM-LA, for example, uses this rhetoric to justify its role in implementing DOE pipeline programs as "being responsive to community needs." [32] Multibillion-dollar national defense contractors, however, cannot credibly be construed as local business—and DOE pipeline programs are clearly established to fulfill national security missions, not to serve local communities.

It is also clear that DOE workforce training programs, which aim to prepare hundreds or thousands workers for a single DOE contractor operating at a single (or a few) DOE facilities, are fundamentally different from traditional community college degree programs, such as LPN, auto mechanic, or solar installer.

Nevertheless, substantial benefits accrue to DOE contractors that site workforce pipelines and other training programs at local community colleges. By (a) portraying federally-required employee training and continuing education as "higher education"; and (b) shifting related expenses such as real estate, overhead, and facility construction, renovation, and maintenance costs onto nearby colleges, DOE contractors can reduce or even eliminate some of the burdens associated with their operations.

As an example, consider the radiation control technician (RCT) program that N3B-Los Alamos runs in collaboration with Northern New Mexico College. Launched in 2019, the program is run as a paid apprenticeship, with students owing three or more years of service as an RCT to LANL upon graduation.[33] LANL and NNSA funded the paid apprenticeships of ten of the forty students in the initial RCT cohort. The New Mexico Department of Workforce Solutions, however, covered tuition for the remaining thirty students, using public workforce program (WIOA) funds.[34]

2. Triad: "Community commitment" — or perpetuating historic patterns of exploitation?

The same distorted notion of community that DOE and its contractors have used to legitimize the shifting of in-house training costs onto local colleges has also been used to put a veneer on LANL's ongoing exploitation of regional inequalities. LANL press releases are full of references to community: "community initiatives", "community engagement", "community benefit", "Office of Community Partnerships", and "investing in the community." LANL's public relations department has made much of Triad's "Community Commitment" initiative since Triad assumed the contract for LANL management and operations in 2018.[35] Yet Triad's Community Commitment program is not just about charitable giving. The Española-based Regional Development Corporation—which is pursuing a major initiative to establish DOE pipeline programs in Northern New Mexico—has been a key beneficiary of Triad's Community Commitment program, winning $700,000 of $2.5 million in available funding in 2021.[36] [37]

LANL's legacy waste cleanup contractor, N3B-Los Alamos, has a Community Commitment program as well. In 2020, fully half of N3B's $543,000 in Community Commitment funds went to regional workforce development initiatives.[38] In a recent presentation to the now-defunct Regional Coalition of LANL Communities, N3B said it "gives back to Northern New Mexico communities by supporting local...workforce development activities." [39]

Yet DOE-related workforce development activities, rather than "giving back," may in fact *shift costs onto local communities*. In establishing a DOE pipeline program—a nuclear waste operator training program, for example—a publicly-funded institution such as NNMC assumes the primary burdens of housing, operating, promoting, and even soliciting outside funding for nuclear waste-worker training. Yet the legacy waste contractor, for its part, may offset the burdens placed on the college only partially—its much-publicized contributions to local community programs notwithstanding.

In a 2019 letter to the UNM Board of Regents, for example, UNM-LA officials noted the considerable resources the college had expended in establishing DOE workforce pipelines during the previous year. With LANL and N3B workforce needs continuing to escalate, the college was "stretching [its] resources significantly beyond capacity." UNM-LA officials were therefore seeking the Board's approval to solicit $92,000 in appropriations from the New Mexico Department of Higher Education to fund its DOE pipeline activities in the following year.[40]

The case of DOE workforce development initiatives at minority-serving institutions in Northern New Mexico supports prior observations that LANL's activities impose additional burdens on an already disadvantaged system and region. These burdens, little known to the public, are rarely disclosed or discussed by local officials. In the final accounting, DOE contractors secure both opportunities for positive public relations and a net reduction in workplace training costs—while New Mexico's public institutions are left holding the bill.

DOE workforce pipelines in Northern New Mexico institutionalize the informal racial and ethnic partitioning of occupational risk that has long been active at LANL. DOE frontline workforce recruitment is also underway in the vicinity of the Savannah River Site (SRS) in Aiken, South Carolina, in anticipation of plutonium pit production at the site. The majority of residents living in the counties adjacent to SRS are Black, and one in five lives in poverty.

a. A long history of exploiting regional inequalities

LANL has long exploited social inequalities in Northern New Mexico to support nuclear weapons development, testing, and production. A recent LANL news feature, for example, described the WWII-era development of the "bridge-wire" detonators used to trigger the bombs at the Trinity test site and Nagasaki. According to the article, physicists Lawrence Johnston and Luis Alvarez were "the brains behind the detonators." Yet the explosive devices they designed were assembled mostly by women, because of the "dexterity" required for detonator construction:

> "Women were brought in from nearby pueblos to do the assembling and loading," Johnston explained. [With soldiers] in charge..."those women got real good at soldering the bridge-wires on the entrance plugs and loading the explosives." [41]

This account illustrates attitudes long typical at LANL: the assumed roles of individuals living "on the Hill" (in Los Alamos) and in the Española Valley, the divide between intellect and manual labor. Making only the briefest of references to the possibility of injury to the workers involved in detonator assembly, the account scarcely considers the individuals whose lives were put at risk.

Similarly troubling attitudes and practices have been evident throughout LANL's history. Recently, a former LANL employee publicly dismissed the legitimate concerns of nearby Pueblo residents regarding a planned release of radioactive tritium at LANL. Tritiated water, he said, is rapidly excreted from the body. In the early 1970s, he added, LANL workers who inadvertently ingested tritium in the course of their work were simply "given a six-pack of beer and sent home." [42] (The ingestion of tritium, a beta-emitting radioisotope of hydrogen, does in fact pose hazards to health, see footnote 42).

Arte Romero y Carver is co-founder and former policy director of YUCCA, a Santa Fe-based youth organization that examines climate change from the perspective of justice and civil rights. The group is especially interested in looking at the ways that climate change disproportionately impacts certain populations.

At a recent conference, Romero y Carver noted that, like climate change, nuclear weapons production and cleanup activities impact people of color and poor people disproportionately. Yet these activities don't merely harm certain communities *by chance*. Indeed, the US nuclear industry has developed in the way that it has precisely *because* its harms fall on certain communities—and *because* people in power have long regarded certain communities as being more expendable than their own.[43]

The social and economic effects of occupational illness, disability, and death among LANL frontline workers ripple across families and communities in Northern New Mexico.

b. Promoting the pipelines

Today, LANL contractors and local community colleges use incentives such as free tuition, paid internships, and the promise of "challenging, well-paying jobs" to draw young New Mexicans—many of whom are living in poverty—into DOE training pipelines. Yet the wages graduates are offered—which may be above average for the region and level of education involved—are no good fortune, or sign of generosity on the part of LANL or N3B. They may in fact reflect a certain measure of hazard pay—silent testimony to the many unique hazards at nuclear weapons facilities, and associated risks of premature disability and death.

DOE contractors are using other tactics and channels to promote their pipeline programs as well. In June 2021, LANL legacy waste contractor N3B released a video promoting the Nuclear Operator Apprenticeship program that it runs in collaboration with Northern New Mexico College.[44] Drawing on values such as reverence for land and water, civic virtue, and love of family, the video seeks to resonate with deeply-held values in Northern New Mexico—especially those held by rural and land-based people in the region. Due to their physical proximity to LANL, these communities feel the impacts of legacy waste contamination most acutely. The N3B video campaign consciously exploits local values and concerns to bolster N3B waste operator recruitment.

Emily Arasim, a young farmer who lives in the Española Valley, serves as a youth representative for Communities for Clean Water, a coalition of local organizations that work to protect community waters impacted by LANL. During a recent webinar, Arasim movingly described her feelings around LANL's role in perpetuating long-standing injustices in Northern New Mexico. The young people in the region, she said, especially those in rural communities, have come to believe that frontline positions at LANL are the only good-paying jobs they can hope for. "I just want to share the grief that I feel as a young person," she said, "who has to watch my friends and neighbors have to turn to jobs at LANL" because "they feel like it's the only way they're going to be able...to support their families."

Once, during an official tour of LANL, Arasim witnessed a heart-wrenching scene in the badge office, where hundreds of young people her age were streaming in to begin their workdays. These young people, "my peers, people I grew up with" had positions in construction, maintenance, and other frontline work at LANL, and were not being informed about "what they're doing, or what they're being exposed to." It's very upsetting, she said, "to see our young people pushed into a corner, feeling like they can't survive economically" unless they take jobs that may do harm to their bodies, lands, and families.

"There are no easy answers," she said, "but this is a deep issue of economic and social injustice facing our rural communities in Northern New Mexico." Arasim is working to build a better future for the next generation—a future where young people in the region have real choices, and can pursue work in their own communities that is safe, culturally-rooted, and dignified.[45]

Acequia farming traditions are intimately tied to history, culture, and community in Northern New Mexico. For LANL's adverse impacts on these traditions, see footnote 45.

c. Targeted initiatives lead to disproportionate exposures

As mentioned above, LANL is intentionally targeting minority and low-income students in its frontline workforce recruitment efforts. During a recent presentation to the New Mexico Legislature, Dr. Carol Burns, Executive Officer of LANL's Office for Science, Technology, and Engineering, described the Lab's current efforts to develop its radiation protection workforce. A targeted LANL workforce initiative, she said, is offering tours for "minority, underprivileged, STEM, and high-achieving high school students," to increase their "exposure to [the] RCT field and pipeline educational opportunities." [14]

Minority communities are also being targeted in DOE pipeline initiatives designed to train workers for acutely hazardous positions producing plutonium pits.[46] NNSA is making preparations to begin intensive pit manufacturing both at LANL and at DOE's Savannah River Site in Aiken, South Carolina. This decades-long mission, if fulfilled, will put several thousand frontline plutonium workers (machinists, welders, RCTs, and others) at serious occupational risk.

To begin training workers for these positions, the Subcommittee on Energy and Water Development wrote millions of dollars of funding into the House appropriations bills for FY2021, FY2022, and FY2023 to support the establishment of plutonium-worker training pipelines in New Mexico and South Carolina. What is more, the bills called for the establishment of these "training partnerships" with HBCUs, Hispanic-Serving Institutions, and Tribal Colleges specifically.[47]

Note that the FY2021-23 appropriations bills described above (which call for funding for plutonium-worker pipelines at minority-serving institutions specifically), also contain provisions that place statutory restrictions on the use of appropriated funds. One of these provisions specifically prohibits the use of appropriated funds "in contravention of Executive Order No. 12898." Enacted in 1994, Executive Order No. 12898 requires federal agencies—including the Department of Energy—to identify and address "any disproportionately high and adverse human health effects of its programs, policies, and activities on minority and low-income populations." [48] The obvious contradiction between the FY2021-23 appropriations bills and Executive Order 12898 calls into question the legal standing of Congressionally-funded plutonium-worker training pipelines at minority-serving institutions in the US.

In recent years, many federal agencies have placed an emphasis on promoting equity and justice through their policies, programs, and activities. The DOE, for example, is instituting reforms to ensure that the benefits of its new clean energy initiatives are felt in low-income, minority, and other historically marginalized communities.[49]

DOE's workforce development initiatives, too, are being advanced to the supposed advantage of marginalized communities, with officials citing economic benefits in these communities as a key rationale for establishing workforce pipelines. The LANL Office of Partnerships and Pipelines, for example, speaks of its commitment to creating "a thriving local economy." Former NNMC President Rick Bailey has remarked on the ability of workforce pipelines to "lift up entire communities." [50] LANL Director Thomas Mason defends local workforce pipelines, stating that they ensure that "the economic benefits associated with our activity flow to communities around the region." [32]

LANL and other authorities continue to issue statements emphasizing the benefits of DOE workforce pipelines to local communities. Yet these officials' lack of candor (and indeed, of concern for the young people of New Mexico) here must be recognized, for their relentlessly positive accounts of DOE pipelines show an utter disregard for the extraordinary occupational hazards new pipeline graduates face.

As discussed above, frontline workers at nuclear weapons facilities—including the radiation control technicians, nuclear waste operators, plutonium machinists, and fissile material handlers who are the focus of recent pipeline programs—face unique hazards that put them at greatly elevated risk of serious occupational illness, disability, and death. Yet in their many remarks on DOE pipelines, authorities never mention these extraordinary hazards.

Recent US wage statistics show that the average nuclear waste operator at N3B earns $21.40 an hour—five to ten percent less than the average solar technician in the region, and about 25 percent less nationally.[51] Do officials believe this sort of opportunity somehow offsets the deadly hazards nuclear weapons waste workers face?

d. Race, class, and educational opportunity in Northern New Mexico

Rather than protecting vulnerable Hispanic, Native American, and low-income communities from harm, officials have chosen to target them for the highest-risk roles at US nuclear weapons facilities. Graduates of the apprenticeship programs recently established in association with LANL and N3B, for example, are bound to several years of frontline work upon completion of their training (see footnotes 1-2). During this time, they may endure significant exposure to hazardous materials, and be pushed to the DOE limit (5 rem) for radiation exposure each year. (Note that the exposure limit for the general public is 0.1 rem, see footnote 67). Students must simply accept the possibility of serious occupational injury as a condition of program enrollment. DOE and university officials, for their part, never touch on these realities, and aggressively promote the benefits of DOE pipelines to targeted communities. Such one-sided presentations verge on the criminal when officials fail to inform prospective students of relevant occupational hazards.

e. Disproportionate environmental and occupational exposures are frequently linked

Environmental justice rightfully concerns itself with the significant and disproportionate exposure of vulnerable communities to industrial and other contaminants. And indeed, it is difficult to overstate the magnitude of the injustice suffered by the mostly poor and marginalized individuals who live their lives in close proximity to hazardous industry.

Yet proximity to hazardous industry may result not only in elevated and disproportionate *environmental exposures*, but also in serious and disproportionate *occupational harms*, if many in the community are drawn into frontline positions in the nearby industry. Residents of marginalized communities may suffer adverse health effects, not only from contact with air, water, and land that has been contaminated by nearby industries, but also from occupational exposures they sustain as frontline workers in the same industries.

Vulnerable communities are only further disadvantaged when risks of occupational illness and injury are layered onto existing stresses and exposures. This observation is relevant not only to worker recruitment initiatives targeting communities near DOE weapons facilities, such as N3B's workforce pipelines, but also to EPA environmental cleanup initiatives at Superfund sites throughout the US. To recruit workers to remediate these most highly-contaminated of industrial sites, EPA's SuperJTI (Job Training Initiative) offers "free training and employment opportunities" to people living in heavily-impacted local communities.[52] There are many troubling parallels between EPA's SuperJTI and DOE workforce development initiatives.

3. N3B-Los Alamos: engineered controls, or continued worker exposures?

As noted previously, LANL was the DOE site having the highest collective radiation dose in 2020, and was also the *only* DOE site where the collective radiation dose was increasing. A recent survey showed that DOE's Office of Environmental Management (DOE-EM), which manages legacy waste cleanup activities, had the highest total workforce radiation dose across all DOE programs, accounting for 54 percent of DOE's total dose in 2016. [53] It follows that radiation exposures of cleanup workers at LANL are among the highest in the DOE complex.

a. Eliminating worker exposures during legacy waste cleanup

For decades, DOE-EM has worked to develop systems to eliminate hazardous exposures during DOE cleanup activities. Many of these systems are based on the simple yet effective principle of putting distance between workers and radioactive, hazardous, and explosive materials. Workers then use robotic tools to grasp and manipulate the materials remotely.[54]

"Many current and projected EM tasks present unique hazards to the workforce," DOE investigators said in 2018, "including chemical, biological, and radiological contamination, [and] ergonomic issues." In these settings, remote and robotic systems "can reduce acute and chronic injury rates, reduce radiation exposure, and remove workers from the immediate proximity of the most hazardous materials and areas." [54] DOE-EM investigators urged DOE to (a) prioritize the development of remote and robotic cleanup technologies, including radiation-tolerant and decontaminable robots; and (b) to offer contract and workforce-training incentives to DOE-EM contractors who integrate robotic technologies into their cleanup operations.[53]

Savannah River Site. Remote and robotic technologies have already been implemented during cleanup operations at several DOE facilities.[55] [56] [57] At the Savannah River Site (SRS), for example, cleanup contractor Savannah River Remediation (SRR) has significantly reduced workers' exposure to radioactive, hazardous, and explosive materials through the use of robotic technology. "Robots are essential to reducing the risk of radioactive waste to SRR workers," said SRR President and Project Manager Tom Foster in 2017. Using remotely-controlled devices to accomplish work such as removing debris, retrieving samples, and repairing leaking vessels greatly reduces human exposure, "keeping our people safe," he said. "SRNL's mission is to deliver advanced technologies that can accelerate Cold War legacy cleanup across the DOE complex," said Savannah River National Laboratory Director Terry A. Michalske. "We are proud to support SRR's ability to use robotic technology to help keep workers safe and get the job done." [58]

Portsmouth. Robotics are also being used in cleanup activities at the Portsmouth Gaseous Diffusion Plant in Piketon, Ohio. According to a 2017 news release, the PipeDream remote system in development there "offers a significant reduction in potential hazards to workers, which is the essence of EM's Science of Safety." Workplace training at Portsmouth is evolving as well, with workers undergoing training in simulation modeling, robotics, and virtual reality to prepare for deactivation work in a former uranium enrichment processing facility at the site. These new technologies "will provide increased efficiency and safety for workers" at Portsmouth.[59]

Idaho National Laboratory. Finally, cleanup crews at the Advanced Mixed Waste Treatment Project (AMWTP) at Idaho National Laboratory use state-of-the-art robotic arms to handle legacy waste more safely. Positioned outside concrete and metal chambers ("hot cells") that shield them from the radioactive and hazardous materials inside, waste operators at AMWTP use the robotic arms to open radioactive waste containers, reduce the size of the items within, and sort and package the waste into 55-gallon drums for later compaction.

A 2019 news release from DOE-EM described a recent collaboration at AMWTP to develop a new robotic arm attachment known as the "super clam." The super clam "easily reduces the size of waste boxes, drums, concrete, and metal containing transuranic (TRU) constituents." It is "so powerful and dexterous that operators can crunch a 55-gallon drum into the size of a basketball, reduce solid concrete slabs into small chunks, and quickly crush waste boxes and metal debris." Operators at AMWTP "have become so proficient using the super clam that they can even gently turn the pages of magazines they occasionally find in the waste." [60]

b. Exposure-reducing technologies not adopted at LANL?

New cleanup technologies, then, have been adopted during cleanup operations in at least three sites in the DOE complex: SRS, Portsmouth, and Idaho National Laboratory. Yet these technologies—despite their demonstrated ability to reduce or eliminate hazardous worker exposures—do not appear to be in use at LANL. Searches of technical documents, RFPs, legacy waste cleanup contracts, contractor fee scorecards, and LANL and N3B news releases have found no evidence that (a) exposure-reducing technologies (ERTs) are being adopted to any significant degree in LANL's legacy cleanup activities; or (b) that training in the use of these technologies—or even better, in the *development* of these technologies—has been integrated into N3B pipelines or applicable degree programs (e.g., robotics) in the region.[61]

Current students in the Nuclear Operator Apprenticeship program at Northern New Mexico College, for example, support N3B cleanup operations by opening containers of radioactive and hazardous waste, removing the materials inside, and documenting the containers' contents.[62] Rather than using robotic tools to manipulate these materials from a distance, students apparently perform these activities directly, relying on "appropriate Personal Protective Equipment (PPE)" to reduce associated exposures.

Nuclear Operator apprentices at N3B apparently enjoy none of the benefits of exposure-reducing technologies such as the robotic "super clam" used by waste operators at the AMWTP. This despite the fact that N3B's parent entity BWXT has been involved in cleanup operations at SRS, Portsmouth, and Idaho—and is therefore clearly aware of the importance of ERTs during legacy waste handling activities.[63] Even operations involving nominally "contact-handled" waste present substantial hazards to cleanup workers.[64] [65]

When exposure-reducing technologies (ERTs) are implemented in legacy waste cleanup settings, significantly lower occupational doses are reasonably and consistently achievable.

c. Strengthening state and federal regulations and standards for occupational radiation exposure

As of this writing, the Consent Order for LANL contains no provisions requiring the use of ERTs by DOE contractors engaged in legacy waste cleanup or remediation activities at LANL. (It is possible that such a directive is beyond the scope of its powers.) The Consent Order, last updated in 2016, is a legal agreement between the New Mexico Environment Department (NMED) and DOE that establishes enforceable parameters for the remediation of hazardous and mixed legacy waste at LANL. Based on lifetime excess risks for cancer and other diseases, this regulatory document establishes target risk-levels for various hazardous contaminants, in order to evaluate whether a given site at LANL poses an unacceptable risk to human health, and thus requires remediation.

The Consent Order is justifiably concerned with risks to human health involving the public, the environment, and workers involved in legacy waste remediation.[66] Yet despite the availability of technology that can significantly reduce, or even eliminate worker exposures during legacy cleanup activities, the 2016 Consent Order neither mandates the use of such technology by DOE and its contractors, nor limits the use of direct human labor in cleanup activities more generally (see glossary entry for *highly-exposed human labor*).

We urge relevant authorities (a) to enforce the rapid adoption of best-available ERTs at legacy waste cleanup sites; and (b) to reject prevailing yet obsolete occupational dose limits for radiation and hazardous materials (many of which were established decades before these technologies were available) in favor of more stringent standards. When exposure-reducing technologies are implemented in legacy waste cleanup settings, significantly lower occupational doses become reasonably and consistently achievable.[67] Obsolete regulatory standards only enable N3B's anachronistic reliance on direct human labor—a practice all too evident in its recent workforce pipeline initiatives.

d. Centering and protecting the most vulnerable individuals in the community

Technological considerations aside, advocates have long called for the adoption of more stringent standards for exposure to radioactive and hazardous materials, in order to better protect workers, nearby communities, and the environment. Beata Tsosie-Peña of Santa Clara Pueblo, a Tewa-speaking community located downstream and downwind of LANL, is former program coordinator for the Environmental Health and Justice Program at Tewa Women United. Tsosie-Peña notes that the current standard for exposure to ionizing radiation takes a healthy adult white male living in an urban setting as its reference.

Yet this standard is too permissive to adequately protect more vulnerable members of the community—infants, children, pregnant people, and those suffering from illness, for example—and those who live off the land, hunting, fishing, and harvesting seasonally. Tsosie-Peña advocates for the adoption of a more just and protective measure, *Nava To'I Jiya* (Tewa for 'Land Worker Mother'). Taking into consideration the possibility of harm from long-term, cumulative exposures, *Nava To'I Jiya* holds the pregnant Indigenous person as the universal standard for environmental protection.[68] When the most vulnerable among us are adequately protected, Tsosie-Peña says, all community members are safer. "If they are protected, everyone is protected." [45]

Rather than condemning yet another generation of legacy waste cleanup workers to serious illness and injury, officials must demand the rapid adoption of methods that greatly reduce or eliminate hazardous worker exposures.

e. Historical context: Navajo uranium miners

On a final note, it is important to place N3B's apparent failure to adopt exposure-reducing technologies into historical context. In the 1950s, mechanical ventilation that would have protected Navajo uranium miners from known radiation hazards was available, yet was rarely implemented. The government failed to require reduction of inhalation hazards by ventilation; as a result, many miners suffered needless and life-threatening exposures.[69] [70] Navajo workers, who were paid a fraction of the wages paid to others, were viewed as a cheap and expendable source of labor.[71]

Today, technology that can protect young New Mexicans from the known hazards of legacy waste remediation is available, yet does not appear to be in use at LANL. Compared to investments in remote and robotic technology, do N3B officials merely view Nuclear Operator Apprentices as the least costly alternative?

CONCLUDING REMARKS

Jobs in the DOE nuclear weapons complex are not the "leading-edge careers" or the "jobs of the future" their promoters have depicted.[3 14] Instead, they are a continuation of a WWII- and Cold War-era mindset that places DOE interests and agendas above all other concerns.[72] DOE workforce pipelines, even if well-intentioned, merely lend new legitimacy to old practices and prejudices. They are only the most recent manifestation of a pattern—here expressed through the higher education system—of socioeconomic exploitation in Northern New Mexico.[73]

It is regrettable that DOE/NNSA and its contractors have compelled institutions of higher education in the region to use their limited resources (time, personnel, and funding) to fulfill national security agendas—and that, in establishing, operating, funding, and promoting DOE workforce pipelines, these schools are made to play a significant role in perpetuating injustice in the region. Yet it is also disappointing that local institutions of higher education have not more effectively resisted this role—especially in light of the recent surge of concern around socioeconomic inequality in this country.

Note that a new degree requirement, "U.S. Global Diversity and Inclusion," has recently been adopted as part of the undergraduate curriculum at UNM. The goal is to promote broader understanding of the culture, history, and current circumstances of individuals and groups who, in either historical or contemporary contexts, have been targets of systemic discrimination. As individuals who believe in the transformative power of education, we argue that mastery of this subject area should be mandatory for any position of leadership at UNM and UNM-LA moving forward.[74]

DOE workforce pipelines capitalize on regional vulnerabilities far more than they alleviate them. They draw on beliefs—far too prevalent in the region—that the young people of Northern New Mexico should count themselves fortunate to find any good-paying work, no matter how hazardous. Do DOE and UNM senior officials wish for their *own* children or grandchildren to fill the most hazardous positions in the nuclear weapons industry? If not, then the establishment of DOE pipelines in minority-serving institutions in Northern New Mexico is no reflection of community partnership or community commitment. Rather, it is yet another expression of the view that some lives are less valuable than others.

FINAL RECOMMENDATION

The Department of Energy has long siphoned workers from Northern New Mexico communities to carry out its most hazardous activities. Despite the steady refinement of exposure-reducing technology, DOE continues to rely on direct human labor, and so continues to compel vulnerable workers to endure needless and life-threatening exposures. This practice is inexcusable.

Legislators and policy advisers should scrutinize DOE workforce development activities in Northern New Mexico, not only in regard to their funding and siting (i.e., their possible targeting of vulnerable communities), but also in light of technological alternatives. Precedence should be given to approaches that move away from the social injustices of the past and eliminate needless hazards to workers.[75] [76]

The Manhattan Project and the Cold War left New Mexico with a heavy burden of radioactive and hazardous waste. Rather than supporting the continued use of direct human labor in cleanup activities, the state should be a leader in the application of methods that address this toxic legacy without further harm to vulnerable workers and communities.

Reducing hazardous exposures during DOE cleanup activities is urgently necessary, yet must be understood as only one element of the whole. To fully eliminate the suffering of US nuclear workers, their families, and communities, all activities supporting the further production, maintenance, and modernization of the US nuclear arsenal must quickly and decisively be brought to an end.[77]

ACTION ITEMS

DOE pipeline initiatives

1. Recognize the disproportionate impacts of DOE workforce pipelines in Northern New Mexico; convey these concerns to state and federal law and policy makers.

2. Request copies of the materials local community colleges are providing to prospective students in their DOE pipeline programs in order to fully disclose the hazards of frontline positions at nuclear weapons facilities *prior* to students' enrollment.

3. Scrutinize current and proposed DOE workforce training initiatives with respect to their funding, siting, and possible alternatives. Are vulnerable communities being targeted? Can technology be used to reduce or eliminate reliance on direct human labor, and needless exposure of workers?

End the cycle of worker injury and exploitation

1. Demand an end to the reckless endangerment of frontline nuclear workers by Triad, N3B, and DOE. Call for state and federal legislation that imposes substantial penalties on DOE contractors whose labor practices (e.g., reliance on highly-exposed human labor) results in the needless exposure of frontline workers to radioactive and hazardous materials (see *Carlos' Law* on p. 38).

2. Reject current occupational radiation dose limits in favor of more stringent standards.

3. Call for federal funding to implement exposure-reducing technologies (ERTs) at LANL and other DOE facilities, and, in consultation with Indigenous and other impacted communities, at contaminated sites such as abandoned uranium mines.

As a start, all state and federal funds currently appropriated for conventional DOE waste worker pipelines should be redirected towards educational initiatives, including R&D, degree, and vocational programs, that further the rapid adoption of ERTs (see footnote 75). Any workforce initiatives associated with the new Justice40 pilot project at EM-LA, for example, should be eligible for federal funding *if and only if* they focus on training in the use of, or development of ERTs (see glossary entry for *Justice40 Initiative*). Workforce development initiatives that put residents of impacted and marginalized communities at serious occupational risk are not deserving of Justice40 (or any other) federal recognition or funding.

This action item is in alignment with the recommendations made by the National Academy of Sciences in 2019 (see p. 42) following their review of science and technology use and development within DOE-EM.

4. Revise and strengthen the current Consent Order for LANL to require the use of ERTs during legacy waste clean-up operations.

5. Strengthen educational and other programs in Northern New Mexico to support safe, culturally-rooted, and dignified alternatives to work in DOE weapons facilities.

6. Advocate for nuclear disarmament and the global elimination of nuclear weapons. Ending nuclear weapons development, testing, production, and possession is essential to ending the suffering of frontline nuclear workers.

ENDNOTES AND REFERENCES

1. DOE pipeline programs at Santa Fe Community College include a certificate and an Associate of Applied Science (AAS) degree in Engineering Machining Technology. See: "Engineering Machining Technology Program." (Section: "LANL cohort"). Santa Fe Community College. Accessed 1 Dec 2022.

During a presentation to the Science, Technology, and Telecommunications Committee of the New Mexico Legislature in October 2020, LANL Executive Officer for Science, Technology, and Engineering, Dr. Carol Burns announced LANL's new collaboration with SFCC to "revamp [the college's] machinist program for LANL's manufacturing mission," i.e., the intensive, round-the-clock production of plutonium pits (see footnote 14). Students in the engineering machining LANL cohort at SFCC are bound to at least three years of employment at LANL upon completion of the training program.

2. DOE pipeline programs at Northern New Mexico College include a certificate and an AAS degree in Radiation Control and Protection, and an AAS degree in Nuclear Operations Technology. See: Northern New Mexico College Fall 2022–Summer 2023 Catalog (pp. 86-7, 88). For the RCT apprenticeship at LANL, see: "Radiation Control and Protection: In Partnership with Los Alamos National Laboratory." Northern New Mexico College. Accessed 1 Dec 2022. For the Nuclear Operator apprenticeship at N3B, see: "Nuclear Operator Apprenticeship Program." N3B-Los Alamos. Accessed 1 Dec 2022; and "Nuclear Operator/Waste Handler Apprenticeship Program." New Mexico Department of Workforce Solutions. Accessed 1 Dec 2022. Students in the RCT apprenticeship program are bound to at least three years of employment at LANL upon completion of the program; students in the NWO apprenticeship program are bound to one year of employment at N3B-Los Alamos, or two years if they accept a sign-on bonus.

3. DOE pipeline programs at UNM-Los Alamos include a certificate and an AAS degree in Nuclear Enterprise Science and Technology, a Nuclear Waste Operator certificate, a Welding certificate, and a Radiation Control Technology certificate. See: "UNM-LA 2021-2022 Academic Catalog." (pp. 89, 105, 107, 110, 112).

The NWO and RCT certificates were designed as 12-week, 10-credit-hour "boot camps" requiring nine credit hours of coursework and one credit hour of lab/field experience, with a minimum grade of C+/B- for completion. The NEST certificate requires a minimum grade of C+, with a minimum of C in each technical core course. According to the UNM-LA course catalog, the nuclear waste operator program was "designed in partnership with local agencies to fulfill a local workforce need." (p. 105, 107, 110)

4. Active nuclear weapons facilities in the US are located in New Mexico, California, Nevada, Texas, Missouri, South Carolina, and Tennessee. New Mexico is the only state that is home to two weapons facilities, Los Alamos and Sandia. The Waste Isolation Pilot Plant (WIPP), the nation's only permanent repository for the transuranic waste that is generated during the production of nuclear weapons, is located in New Mexico as well.

The phrase "frontline worker" is used here to denote individuals whose work involves frequent exposure to ionizing radiation, chemicals, or other hazardous materials. In the nuclear power industry in France, individuals performing tasks that require routine exposure to ionizing radiation, known as DATR (*directement affectés à des travaux sous rayonnements*) workers, are recognized

as a discrete class and are subject to regular medical examinations. See: *Nuclear Servitude: Subcontracting and Health in the French Nuclear Industry*. Thébaud-Mony, A., transl. Jacobs-Colas, A. Baywood Publishing Co. Amityville, New York. 2011.

5. "Opening Statement of Honorable James H. Scheuer. Hearing on Department of Energy's Epidemiology Program." DOE's Epidemiology Program: Hearing before the Subcommittee on Natural Resources, Agriculture Research, and Environment of the Committee on Science, Space, and Technology. US House of Representatives. 101st Congress, 2nd Session. 28 Mar 1990. (p. 5)
"Title XXXVI, Energy Employees Occupational Illness Compensation Program." Sec. 3602. Enactment of Provisions of H.R. 5408, the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001: Conference Report to Accompany H.R. 4205. United States Congress. Washington: US GPO. 2000. (pp. 515-6)

6. For radiation control technicians at LANL, see: "Los Alamos, Northern New Mexico College launch radiation protection course to help fill high-demand jobs." LANL News Release. 19 Mar 2019.

For adverse health outcomes associated with exposure to ionizing radiation, see: "BEIR VII: Health Risks from Exposure to Low Levels of Ionizing Radiation. Report in Brief." National Research Council. 2006.

For beryllium hazards in DOE nuclear weapons facilities, see: 10 CFR § 850. Chronic Beryllium Disease Prevention Program. Federal Register. Vol. 64, No. 235. 8 Dec 1999, especially the "Background" and "Health Effects" sections (pp. 68854-6).

Many workers in the DOE nuclear weapons complex have developed chronic beryllium disease, a progressively debilitating and often fatal lung disorder. A recent study estimated the risk of chronic beryllium disease among DOE machinists as 94 in 1000—nearly one in ten. The disease is considered incurable; lung transplant may relieve symptoms in the most severe cases. No safe level of exposure to machined beryllium dust exists. See: Beryllium's public relations problem: protecting workers when there is no safe exposure level. Michaels D, Monforton C. Public Health Rep. 2008 Jan-Feb;123(1):79-88 (pp. 79, 85). See also: Screening for beryllium disease among construction trade workers at Department of Energy nuclear sites. Welch L et al. Am J Ind Med. 2004 Sep;46(3):207-18; Beryllium disease among construction trade workers at Department of Energy nuclear sites. Welch L et al. Am J Ind Med. 2013 Oct;56(10):1125-36; Beryllium disease among construction trade workers at Department of Energy nuclear sites: A follow-up. Cloeren M et al. Am J Ind Med. 2022 Sep;65(9):708-720; "Chronic Beryllium Disease: Clinical Overview." National Institute for Occupational Safety and Health. Accessed 1 Dec 2022; and: "Beryllium-Associated Worker Registry (BAWR)." US Department of Energy. Accessed 1 Dec 2022.

Workers at DOE weapons facilities are also at risk for (1) asbestos-related conditions and cancers (COPD, pneumoconiosis, asbestosis, and mesothelioma); and (2) neurological disorders resulting from chronic exposure to chemicals, solvents, and heavy metals (e.g., toxic encephalopathy involving diminished cognitive function, memory loss, tremor, seizures, and dementia). These risks also apply to workers at DOE sites who are not directly engaged in weapons production or cleanup activities, such as craft, maintenance, construction, and security personnel. See: "Mortality of older construction and craft workers employed at Department of Energy (DOE) nuclear sites: follow-up through 2011." Ringen K et al. Am J Ind Med. 2015 Feb;58(2):152-167; and "Mortality of older construction and craft workers employed at Department of Energy nuclear sites: follow-up through 2016." Ringen K et al. Am J Ind Med. 2019 Sep;62(9):742-54.

The extraordinary hazards encountered by construction and trade workers at DOE sites (e.g., ionizing radiation, beryllium, asbestos, solvents, chemicals, and heavy metals) call into question LANL's recruitment of young craft and construction workers at public high schools in Northern New Mexico. LANL recently announced that it had partnered with Taos High School to create a building trades course that qualifies students for direct entry into a paid apprenticeship at LANL at age 18. "Building the regional workforce," says LANL Director Thomas Mason, "benefits both Northern New Mexico and the Laboratory while supporting our communities." LANL expects to hire more than 1,200 craft workers in the next five years. See: "Los Alamos National Laboratory, New Mexico Building and Construction Trades Council, and Taos Municipal Schools announce new job-training collaboration." LANL News Release. 2 June 2020.

For more on the staggering array of radioactive, toxic, and hazardous materials encountered at US nuclear weapons facilities, including LANL, see footnote 13.

7. "Hanford workers were given leaky respirators at contaminated job site, contractor's documents reveal." Malone, Patrick and Hal Bernton. *Seattle Times*. 22 Mar 2020. Links to the article can also be found in the news release: "Senators Murray and Manchin, Representative Smith Reintroduce Legislation to Expand Worker's Compensation for Toxic Exposure at Hanford and Other Nuclear Sites." United States Senator Patty Murray. 25 Mar 2021.

Senator Murray (D-WA) co-sponsored H.R. 2257, Toxic Exposure Safety Act of 2021, to make it easier for workers who had been exposed to toxic substances (e.g., organic solvents and chemicals) at DOE facilities and cleanup sites to receive benefits through the Energy Employees Occupational Illness Compensation Program (EEOICPA). The Act also called for epidemiological research investigating the associations between exposure to toxic substances at DOE facilities and the subsequent development of disease.

Although New Mexico Senators Ben Ray Luján and Martin Heinrich were among the co-sponsors of S.1025 (the Senate version of Senator Murray's bill), they have also played active roles in promoting DOE pipeline initiatives in Northern New Mexico. See: "SFCC and LANL announce collaboration in SFCC's Machining Engineering Technologies certificate." (video). Santa Fe Community College. 16 Apr 2020, for Senator Luján; and: "Nuclear Operator Apprenticeship Program." (video). N3B-Los Alamos. Accessed 1 Dec 2022, for Senator Heinrich. The video featuring Senator Luján accompanies the article: "LANL, SFCC partner on Machining Engineering Technologies training, expand job opportunities." Inside SFCC. Vol. 2. 2020.

Speaking alongside DOE and NNSA senior officials during a LANL event in September 2022, Senator Heinrich said he would continue to support "productive partnerships" between LANL, Sandia, and communities across the state, including DOE pipeline initiatives at community colleges in Northern New Mexico. Later that month, Senator Luján made an amendment to the FY2023 National Defense Authorization Act to allow management and operations (M&O) contractors at LANL and SRS to create and fund "workforce development and training partnership programs" for their employees and "prospective employees," to support the production of plutonium pits. See: "Sen. Martin Heinrich Speaks At 50th Anniversary Event For LANL's Neutron Science Center (LANSCE)." *Los Alamos Reporter*. 10 Sept 2022; and:

"S. Amdt. 6338 to S. Amdt. 5499 to H.R. 7900 - 117th Congress (2021-2022)." Library of Congress. 29 Sept 2022.

Workers at the DOE Hanford site near Richland, WA produced weapons-grade plutonium for use in the US nuclear weapons program during WWII and the Cold War. For information on occupational illness incurred at the Hanford site, and the gross injustices of the DOE-managed workers' compensation program there, see: "Sick and denied care at Hanford: 'We want our lives back.'" Frame, Susannah. *King5News*. 3 Feb 2017.

In 2018, the Washington state legislature passed a law, HB 1723, which helped federal contract workers at Hanford obtain compensation for illnesses resulting from their work at the site. The new law asserted that the Hanford workers' illnesses—including heart, lung, and neurological disorders, beryllium disease, and certain leukemias and cancers—could reasonably be attributed to occupational exposures (radiation, beryllium, heavy metals, solvents, or chemicals) sustained during their work at the site. The injured workers (or their survivors) were therefore eligible for federal workers' compensation benefits. The new law, which was challenged by DOE and later by the US Department of Justice, was upheld by both the US District Court and the US Court of Appeals in 2019. The federal government subsequently petitioned the Supreme Court to review the lower court's ruling. The Supreme Court overturned HB 1723 in June 2022.

As of this writing, the Supreme Court's decision on HB 1723 has not adversely impacted workers at Hanford. The state of Washington passed SB 5890, an amended version of HB 1723, in March 2022, in anticipation of the Supreme Court's ruling. The amended bill applies to all workers at the Hanford site, rather than to federal contract workers only.

According to a recent analysis, the cleanup at the Hanford site "is expected to continue over the next six decades and involve roughly 400 department employees and 10,000 contractors and subcontractors." The final outcome in this series of workers' compensation cases is therefore of great significance to current and future cleanup workers at Hanford.

Sources: Text of HB 1723, *Creating a presumption of occupational disease for certain employees at the United States Department of Energy Hanford Site*. Washington State Legislature, 2017-2018. For the 2019 US Court of Appeals decision, see: "Federal judges uphold state law aimed at helping sick Hanford workers." Frame, Susannah. *King5News*. 19 Aug 2019. For background on the Supreme Court case (United States v. Washington [Docket 21-404]) and Hanford cleanup statistics, see: "High court takes up nuclear site workers' compensation case." Mulvaney, Eric. Bloomberg Law. 10 Jan 2022. For the 2022 Supreme Court decision, see "Justices overturn Washington workers' compensation law on a strict reading of intergovernmental immunity." Duff, Michael C. SCOTUSblog. 22 June 2022; and: "Attorney General Ferguson statement on US Supreme Court ruling on Hanford." Washington State Office of the Attorney General. 21 June 2022. Text of SB 5890, *Clarifying eligibility for the presumption of workers' compensation for all personnel working at a radiological hazardous waste facility*. Washington State Legislature, 2021-22.

8. "U.S. Department of Energy Occupational Radiation Exposure Report for Calendar Year 2020." DOE Office of Environment, Health, Safety, and Security. Feb 2022. Exhibits 3-12, 3-13, 3-14, B-5. In 2020, the collective total effective dose (TED) at LANL was 232.7 person-rem, by far the highest in the US nuclear weapons complex. LANL is also uniquely high among DOE facilities in the fraction of the TED that is attributable to neutron radiation, a densely-ionizing type of radiation that is much more damaging to biological tissues than the X, β, and γ forms. Although human exposure data are lacking, neutron radiation is strongly associated with the induction of leukemias and lymphomas in laboratory animals. Activities contributing to radiation doses at LANL in 2020 included: weapons manufacturing and related work at the TA-55 plutonium facility; plutonium-238 work; retrieval, repackaging, and shipping of radioactive waste; and infrastructure support for radiological work and facility maintenance.

Sources: For LANL neutron radiation doses and associated hazards, see: "Top Contributors: Los Alamos National Laboratory." A Decade of REMS: 10-year Summary of Occupational Exposures. DOE. Accessed 1 Dec 2022; and Relative biological effectiveness (RBE), quality factor (Q), and radiation weighting factors (W_R): ICRP Publication 92. Valentin J, ed. Annals of the ICRP. 1 Oct 2003. (pp. 1-4, 40-1). For radioactive and hazardous waste generation associated with pit production at LANL, see: Final Supplement Analysis of the 2008 Site-Wide Environmental Impact Statement for the Continued Operation of Los Alamos National Laboratory for Plutonium Operations. NNSA. Aug 2020. (pp. 57, 75-81)

9. Central to any discussion of higher education in Northern New Mexico is the 2018 ruling in *Yazzie and Martínez v. State of New Mexico*. The lawsuit was brought on behalf of low-income, English-language-learning, Native American, and disabled students in public school districts across the state (including Santa Fe and Española, the two largest districts adjacent to LANL). The ruling found that the state of New Mexico had not provided adequate funding for educational programs and services, and, in violation of the state constitution, was failing to provide a sufficient public education to children in these at-risk groups in particular. Sarah M. Singleton, the District Court judge who presided over the case, described the education being provided to these at-risk children as "dismal."

In showing that certain students—mostly low-income students of color—were being placed at grave disadvantage in schools across New Mexico, *Yazzie/Martínez* provided unequivocal evidence of a failed K-12 educational system. Nonetheless, some postsecondary educators and officials in the state have continued to cling uncritically to outdated and discriminatory "deficit models" of student achievement. In seeking to explain differences in academic performance between privileged (mostly white) and socioeconomically-marginalized groups, deficit models downplay or ignore (a) the under-performance or failure of educational systems themselves; and (b) the adverse effects on student outcomes of external economic forces and players. Deficit models instead emphasize perceived shortcomings of individual students, and attribute poor academic performance to personal factors such as lack of motivation, effort, or ability. In deficit-based frameworks, such factors are often implicitly tied to non-white racial and ethnic identities.

In recent years, scholars of educational theory have strongly critiqued deficit-based frameworks, noting the role that entrenched class, racial, and other biases have played in creating negative perceptions of low-income students and students of color. These negative attitudes in turn fuel further negative stereotyping, cultural pathologization, and marginalization of vulnerable individuals within educational systems.

Indeed, deficit-based frameworks may underlie the view that pipelines to hazardous industry constitute appropriate, even self-evident, educational models for members of socioeconomically-disadvantaged communities. Sadly, this model is rapidly becoming a dominant (and well-funded) higher education paradigm in low-income, rural, Hispanic, and Native American communities in Northern New Mexico.

Fortunately, community colleges in the region have many alternatives from which to choose when developing programming that serves local communities, for recent years have seen the robust development of postsecondary curricula that empower Hispanic, Native, rural, and land-based student populations. For an example of culturally-responsive pedagogy at a federally-designated Hispanic-Serving Institution, we can look to Lehman College in the Bronx, NY. In response to recent Latinx student advocacy, the College recently replaced its British-centric literature curriculum—which marginalized BIPOC and postcolonial writings—with one that centers Latinx and African-American courses instead.

The college's push to transform its outdated curriculum, writes Melissa Castillo Planas of the Latinx Project at NYU, speaks both to "the special responsibility that Hispanic-serving and majority-minority institutions have to their students," and to the important role these institutions can play in driving academic innovation. Castillo Planas highlights the work of education scholar Gina Ann Garcia on notions of "service" to Hispanic communities at Hispanic-Serving Institutions. "In her expansive work on HSIs," Castillo Planas writes, Garcia raises an important question: "What does it mean, at an organizational level, to serve Latinx [and] other racially minoritized, low-income, and first-generation students?"

For a model of postsecondary education that centers Indigenous cultures, see e.g., the programs in mathematics and Indigenous Liberal Studies at the Institute of American Indian Arts (IAIA) in Santa Fe, NM. For organizations working to prepare a new generation of scholars in Indigenous Education, see the Institute for American Indian Education at the University of New Mexico, and the student-led Future Indigenous Educators Resisting Colonial Education (FIERCE) at the Harvard Graduate School of Education.

Finally, the Land Grant and Acequia curriculum under development at New Mexico Highlands University, the New Mexico Acequia Association's acequia curriculum, and the Indian Pueblo Cultural Center's Indigenous Wisdom Curriculum Project are examples of innovative postsecondary and K-12 curricula that center the knowledge of rural and traditional land-based peoples in Northern New Mexico.

Sources: "Judge Rules New Mexico Violates Public School Students' Constitutional Right to Sufficient Educational Opportunities." New Mexico Center on Law and Poverty. 20 July 2018; "Yazzie/Martínez Decision & Order." Singleton, Sarah M. First Judicial District, State of New Mexico. July 2018. (p. 45); "Serving Students of Color at Hispanic-Serving Institutions and Beyond." Planas, Melissa Castillo. The Latinx Project at NYU. 12 Jan 2022; Garcia, Gina Ann. *Becoming Hispanic-Serving Institutions: Opportunities for Colleges and Universities*. Baltimore: Johns Hopkins University Press. 2019; Program in Indigenous Liberal Studies at IAIA: Liberal Arts from a Native Perspective. Guiding Statement from the 2021-2022 College Catalog; "IAIA Decolonizes Their Mathematics Curriculum." 12 Jan 2022; "Mission and Guiding Principles," Institute for American Indian Education at UNM; "A FIERCE Commitment to Native Education." Harvard Graduate School of Education. 21 Nov 2016; "Reclaiming Our Past, Sustaining Our Future: Envisioning a New Mexico Land Grant and Acequia Curriculum." Valdez, Elena V. Center for the Education and Study of Diverse Populations at New Mexico Highlands University. 16 May 2021.

10. For Santa Fe Community College, see: FY 2019 Awards. Developing Hispanic-Serving Institutions Program—Title V. U.S. Department of Education. (p. 30). For Northern New Mexico College and UNM-Los Alamos, see: FY 2020 Awards. Developing Hispanic-Serving Institutions Program—Title V. U.S. Department of Education. (NNMC, p. 50; UNM-LA, p. 87).

11. "Collaboration, Communication Key to N3B Apprenticeship Programs Through UNM-LA and NNMC." *Los Alamos Reporter*. 8 Nov 2020; for NNMC, also see ref. in footnote 6.

12. "Quick Facts: Los Alamos County, New Mexico; United States." United States Census Bureau; "Quick Facts: Rio Arriba County, New Mexico; United States." United States Census Bureau. Population estimates: 1 July 2019 (V2019).

13. "Los Alamos National Laboratory Update." Presentation to the Science, Technology, and Telecommunications Committee. New Mexico State Legislature. Márquez, Richard A. LA-UR-15-28374. LANL. 3 Nov 2015. (pp. 13, 21). The data in this report are unsurprising, for Hispanic and Native American individuals have rarely gained entry into upper-level professional, management, and scientific positions at LANL. See, for example: *Los Alamos Revisited: a Workers' History*. Malmgren, Peter and Kay Matthews. Wink Books. 2017; and: *The Nuclear Borderlands: The Manhattan Project in Post-Cold War New Mexico*. Masco, Joseph. Princeton University Press. 2006.

To appreciate the extreme variation in occupational risk among LANL employees and contractors, the reader may refer to the site exposure matrix (SEM) data maintained by the US Department of Labor. The site exposure matrices detail the radioactive and hazardous materials present at all DOE sites by technical area, work process, labor category, disease association, and other variables. These data are used by the Department of Labor in evaluating claims of DOE-related occupational illness payable under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA), including beryllium disease, cancer, and neurological disorders.

According to the current site exposure matrices for LANL, only a single hazardous material is found at the Main Administration Building at LANL: the asbestos that was used in the construction of the building. In contrast, nearly 50 radioactive and hazardous materials are (or have been) in use at TA-50-69, the Waste Characterization, Reduction, and Reprocessing Facility (WCRRF); more than 170 at the Plutonium Processing Facility (PF-4/TA-55-4), including asbestos, beryllium, carbon tetrachloride, toluene, uranium, and plutonium; almost 250 at TA-55, the Plutonium Facility site as whole; and more than 300 at TA-50 (a site used in the management of radioactive, mixed, and hazardous waste at LANL). Note that the latter three facilities (TA-50-69, PF-4, and TA-50) are among the primary worksites for nuclear waste operators and plutonium machinists at LANL.

The site exposure matrices organized by LANL labor category are also revealing. The data for LANL administrative, managerial, support, and legal staff suggest that these classes of "Energy Employees" are quite unlikely to be exposed to radioactive or hazardous materials in the workplace. LANL frontline workers, however, are another matter altogether. LANL radiation control (health physics) technicians, for example, face exposure to almost 150 radioactive and hazardous materials in the course of their work, and LANL machinists and cleanup workers, almost 200. Note that the group of individuals in very-low-risk positions at LANL includes senior administrative officials in LANL's Office of Community Partnerships—the same officials who have pushed to establish DOE pipeline programs in Northern New Mexico, and promoted them relentlessly.

LANL's TA-54 is a 130-acre site used to manage hazardous and mixed waste generated during LANL activities. The SEMs show that the number of radioactive and hazardous materials present at the various Material Disposal Areas (MDAs) at TA-54 ranges from three (americium, fission products, and plutonium) at MDA-C to a staggering 326 at MDA-L. Students in the Nuclear

Operator Apprenticeship program at Northern New Mexico College have recently received on-the-job training at TA-54.

Source: "DOE Facilities and RECA Site Data." DEEOIC Site Exposure Matrices. US Department of Labor. Updated 16 May 2022. For on-the-job training at TA-54, see: "LANL Legacy Waste Contractor Committed To Growing Diversity Through Workforce Development Programs." Los Alamos Reporter. 27 Feb 2020.

14. For LANL's targeting of minority and underprivileged students, see: "Los Alamos National Laboratory Status Update." Presentation to the Science, Technology, and Telecommunications Committee, New Mexico Legislature. Dr. Carol Burns, Executive Officer, Office for Science, Technology, and Engineering, LANL. 26 Oct 2020. (slides 4, 5)

N3B news releases regularly feature pipeline program students and graduates with Hispanic surnames. See, for example: "Apprenticeship program in environmental cleanup offering associate's degree." N3B-Los Alamos News. 24 June 2021; "Local students earn associate degrees through N3B Los Alamos apprenticeship program." N3B-Los Alamos News. 18 Aug 2022. The photo of N3B officials and pipeline training program graduates that accompanies the latter article stands as silent testimony to the profound occupational segregation within the DOE nuclear weapons complex, and the seemingly natural divisions between "the Hill" (Los Alamos) and the Española Valley. These social relations are of such long standing as to have become nearly invisible.

For the hiring surge associated with pit production at LANL, see: "Connecting community members with college and career pathways." LANL Community Connections. 5 July 2022. To meet its escalating need for frontline nuclear workers, says the article, LANL has pushed for the establishment of accelerated training programs at community colleges in the region. "Often, the solution is short-term credentials and programs" with participants receiving free tuition, books, and wages. The radiation control technician (RCT) pipeline program established at Northern New Mexico College in 2019 boasts more than three dozen students and graduates to date. "That success," according to the article, "is paving the way for more," with the paid apprenticeship model used at NNMC now being applied in the recruitment of engineering (i.e., plutonium and beryllium) machinists in collaboration with Santa Fe Community College.

Note that RCTs and machinists working in plutonium facilities suffer some of the highest occupational exposures in the entire US nuclear weapons complex. RCTs regularly work in very high-hazard environments in DOE facilities, putting them at risk for exposure to numerous radioactive and hazardous materials. A recent study of DOE machinists suggested that the incidence of chronic beryllium disease—a progressively disabling and incurable condition that results from the inhalation of beryllium particles and associated scarring of the lungs—was nearly one in ten (see footnote 6). For an account of the occupational illness and disability suffered by 38-year-old LANL radiation control technician Gilbert Mondragón, see: "Billions paid to sickened workers at nuke research labs." Grey, Jamie and Lee Zurik. *The Tribune-Democrat*. 27 Dec 2018.

The push to establish DOE pipeline programs in Northern New Mexico is part of a broader national agenda that formalizes long-standing hierarchies of occupational risk at US nuclear weapons facilities. Parallel efforts to establish pipeline training programs for frontline nuclear workers are also underway at community colleges in the vicinity of the DOE Savannah River Site (SRS) in Aiken, South Carolina—where, as in Northern New Mexico, the majority of local residents are socioeconomically disadvantaged. In neighboring Barnwell, Orangeburg, and Bamberg counties, for example, approximately 60 percent of residents identify as Black, the median household income is about $37,600, and one in five residents lives in poverty. One in ten is medically uninsured (U.S. Census QuickFacts: Barnwell, Orangeburg, and Bamberg counties, South Carolina). See: "Students graduate from SRNS/Aiken Tech nuclear apprenticeship program." ANS Nuclear Cafe. 12 Aug 2022. Plutonium pit production in association with the modernization of the nuclear arsenal is scheduled to begin within the next several years at SRS.

The pipeline programs being established in conjunction with the nuclear weapons facilities at LANL and SRS effectively confine the heaviest burden of DOE-associated occupational exposure within a few, historically-disadvantaged communities; these local communities will therefore continue to suffer the greatest burden of DOE-associated occupational disease.

Nevertheless, DOE and elected officials celebrate these pipeline programs, portraying them as wins for "diversity and inclusion," for example, or as a means of "uplifting" local communities. Lost in this rhetoric, however, is the way these pipeline programs and the "short-term credentials" they offer fit within a broader pattern of economic exploitation and coercion. They are in fact only one facet of a cynical and self-serving strategy, which—in the context of DOE's inadequate disclosure of extreme occupational risks and near-continuous failures of worker protection—constitute an unconscionable (and frankly predatory) assault on vulnerable populations and individuals.

DOE's new emphasis on diversity and inclusion amid surging demand for frontline weapons production and cleanup workers brings to mind Keeanga-Yamahtta Taylor's theory of "predatory inclusion." See *Race for Profit*, her award-winning analysis of mortgage lending practices in the post-redlining era, when buyers in Black communities—who had previously been excluded from mortgage lending programs—became newly eligible for loans. The government's new policy of guaranteeing mortgage loans in these communities led predatory lenders to target poor Black people (especially poor Black women) with the full expectation that they would lose their homes to foreclosure. Lenders' profits soared through these intentionally "inclusive" practices, which only contributed to the further immiseration of poor Black communities. See: Taylor, Keeanga-Yamahtta. *Race for Profit: How Blacks and the Real Estate Industry Undermined Black Homeownership*. UNC Press. 2019.

For further context for DOE pipeline programs in Northern New Mexico, including the profound failures of the state's K-12 educational system revealed by the *Yazzie/Martínez* lawsuit, see footnote 9. For many years, New Mexico's K-12 public education system has left many students (especially English-language-learning, Native American, and low-income students) lacking basic math, reading, and other skills, and fundamentally unprepared for college coursework. At Northern New Mexico College, for example, 94 percent of incoming students recently tested into remedial classes. More than four years after the *Yazzie/Martínez* ruling, there has been no appreciable improvement in the state of K-12 education in New Mexico, and the state consistently ranks among the lowest in the nation on education indicators. Yet state and federal resources continue to pour into DOE pipeline programs.

15. Paducah Gaseous Diffusion Plant: Hearing before a Subcommittee of the Committee on Appropriations, United States Senate, 106th Congress, First Session. 26 Oct 1999. (pp. 16, 23-4)

In 1999, Congress conducted an investigation of safety practices at the Paducah Gaseous Diffusion Plant near Paducah, Kentucky—a DOE facility that produced enriched uranium for nuclear weapons and power plants from 1952 to 2013. The investigation revealed that DOE contractor Union Carbide had neglected to monitor hundreds of Paducah workers for exposure to neptunium-237, in hopes of avoiding "unfavorable public relations." (Neptunium-237 is a toxic, highly radioactive metal with a half-life of 2.14 million years, which if taken into the body is sequestered in the liver and bones.) Union Carbide had also failed to obtain postmortem tissue and urine samples from deceased workers who were likely to have suffered neptunium-237 exposures. "Apparently, management was reluctant to test the deceased for uptakes of neptunium, much less the living," said David Fuller, President of the Paper, Allied-Industrial, Chemical, and Energy Workers Union, Local 5-550 at Paducah.

Many workers at Paducah were completely unaware of the substantial occupational hazards at the plant until the *Washington Post* led an investigation of safety practices there in 1999 (See: "In Harm's Way, But in the Dark." Warruck, Joby. *Washington Post*. 8 Aug 1999.) Paducah officials' failure to disclose neptunium-237 and plutonium hazards and to monitor workers' exposures, Fuller said, "was not a happenstance thing. It was a calculated decision." The US Government, he said, is "not just any employer," but an institution that has an obligation to protect human welfare. Faced with a choice between money and Paducah workers' lives, officials made a cynical choice. "The only thing more cynical would be for government to find a way to turn away from this today, now that the facts have come out, and to just do nothing."

16. Paducah Gaseous Diffusion Plant: Hearing before a Subcommittee of the Committee on Appropriations, United States Senate, 106th Congress, First Session, Special Hearing. 26 Oct 1999. During the 1999 hearing on the Paducah Gaseous Diffusion Plant, Congress heard the testimony of Dr. Steven B. Markowitz, MD, a physician who was studying occupational illness at Paducah at the time. Dr. Markowitz identified two core problems at the plant: (a) workers' lack of access to occupational health care that was expert, independent, and objective; and (b) management's failure to accurately characterize worker exposures there. (pp. 31-6)

17. "Half-Life." Moss, Rebecca. ProPublica/*Santa Fe New Mexican*. 26 Oct 2018.

18. FY 1992 Budget Request for the DOE's Environment, Safety, and Health Program: Hearing before the Subcommittee on Environment of the Committee on Science, Space, and Technology. House of Representatives. 102nd Congress, 1st session. 7 Mar 1991. (p. 1)

19. "Ben Ortiz, 1937-2015: Lab Worker's Advocacy Helped Launch Federal Compensation Act." Wright, Margaret. *Santa Fe New Mexican*. 24 July 2015.

20. Office of Workers' Compensation Programs (OWCP). EEOICP Program Statistics. United States Department of Labor. Accessed 1 Dec 2022.

21. "Los Alamos National Laboratory (LANL). Petition 109 (Jan 1, 1976 to Dec 31, 2005)." NIOSH Dose Reconstruction Program. Centers for Disease Control and Prevention. Accessed 1 Dec 2022. Monetary compensation under EEOICPA is capped at $150,000 or $250,000, depending on the nature and timing of the illness. These limits are in effect even in instances where workers are incapacitated early in life and are no longer able to work, or die prematurely.

22. "America Runs on 'Dirty Work' and Moral Inequality." Press, Eyal. *The New York Times*. 13 Aug 2021.

For LANL's presence in Northern New Mexico as a cause of cultural dispossession and declining mental health in the region, see Angela Garcia's *The Pastoral Clinic: Addiction and Dispossession Along the Rio Grande*. The process of "mobilization and concentration of resources in the name of national security" in Los Alamos, writes Garcia, "came at great cost, materially and psychologically, to the communities in the valley below." Some locals, she says, "view Los Alamos as '*una herida*,' a wound." (pp. 96-102, 186).

For the profound alienation experienced by the Northern New Mexican farmers and ranchers who were forcibly evicted from their land on the Pajarito Plateau during the early years of the Manhattan Project, see Myrriah Gómez' *Nuclear Nuevo México: Colonialism and the Effects of the Nuclear Industrial Complex on Nuevomexicanos*. Severed from their livelihoods, many of these homesteaders and their relatives subsequently found work as laborers at Los Alamos. For decades they and others from neighboring communities in the Española Valley performed many of the most hazardous jobs at the site. Alejandro Gonzáles, a Valley resident who did construction and demolition work at the Lab, described the need to shower two, three, or four times with an abrasive cleaner in order to remove radioactive contaminants at the end of the workday. His family had owned a ranch on the Pajarito Plateau before their removal by the government.

23. In December 2018, UNM-LA officials petitioned the UNM Board of Regents for approval of its planned RCT, NEST, and NWO pipeline training programs. The petition process required the submission of a variety of supporting documentation, e.g., a statement of academic rationale for each training program. Here, UNM-LA's responses are noteworthy.

For the nuclear waste operator program, for example, UNM-LA officials did not provide a meaningful academic justification for the program to the Board of Regents. Instead, University records suggest that the driving force behind the program's establishment was an "urgent need to fill entry-level positions for nuclear waste operators" in the region.

Indeed, UNM-LA officials attached a letter of support from LANL legacy waste contractor N3B to UNM-LA Dean of Instruction Sharon Hurley. To meet commitments associated with its [10-year, $1.3 billion] cleanup contract, wrote an N3B official, the company was in urgent need of a "fast-track method to qualify waste processing operators." N3B's primary focus was on "candidates" from local communities. The company needed a "repeatable, sustainable" means of turning out new nuclear processing operators on a regular basis.

N3B's letter did not advance an academic rationale for the NWO training program, nor did it describe any associated educational gains for students. Nonetheless, the Board of Regents approved the program, giving N3B the "fast-track method" of certifying workers it had asked for. N3B's burden of maintaining an active in-house employee training program, moreover, was quietly handed off to the state (and New Mexico taxpayers) in the process.

N3B Training Officer Mark Russell was hired to design and implement nuclear worker training programs for the company in 2018. "Boot camps are the way to go," he said in a recent interview. "They are the most efficient way to answer job force needs in the most rapid, consolidated fashion." (For required coursework and minimum academic standards for the NWO, RCT, and NEST "bootcamp" certificate programs at UNM-LA, see footnote 3.)

Bootcamp training programs undoubtedly benefit DOE con-

tractors by rapidly credentialing a large number of workers. Yet these "fast-track" programs do not (and cannot) give students the level of academic preparation needed to understand, evaluate, interpret, and effectively act upon the variety of hazards routinely faced by frontline workers at DOE weapons facilities. During even a limited period of employment, a frontline nuclear worker may suffer radioactive and toxic exposures that have serious, irreversible, and potentially lifelong impacts on health. If students' best interests were foremost at UNM and N3B, the depth and intensity of their academic preparation would be commensurate with these serious occupational hazards.

While the bootcamp training model has been successfully implemented in the state in fields where occupational risks are negligible (e.g., 3D printing, fiber optics, healthcare administrative support, prep cooking, and retail food service), the model is wholly inadequate for the preparation of frontline nuclear workers. In high-hazard environments such as nuclear weapons production and waste-handling facilities, inadequate academic preparation and training puts both workers and the public at risk. Given that frontline occupational hazards at LANL are almost unparalleled in number and severity (see footnote 13), it is unclear why University leadership—including the Board of Regents, the University Provost, and branch campus officials—have enthusiastically supported the establishment of "fast-track" DOE bootcamp certificate programs at UNM-LA.

Sources: For UNM-LA's petition to the UNM Board of Regents, see: UNM Board of Regents Agenda Book [BOR e-Book] for 10 Dec 2019. (See: Justification for Adding Certificate in Nuclear Waste Operator, UNM-Los Alamos Campus, pp. 74-79 of 498; N3B letter of support for NWO certificate, p. 80 of 498). For Mark Russell, see: "N3B Employment Boot Camps Thrive in Los Alamos to Support Environmental Cleanup." N3B News. 18 Apr 2022. For successful implementations of the bootcamp training model, see: "Leadership Los Alamos Class of 2022 Holds Session on Education." *Los Alamos Reporter*. 24 Jan 2022. For UNM-LA's newly-approved Nuclear Enterprise Science and Technology (NEST) program for current LANL employees, see: "Plutonium workers get a new level of education in the actinide mission." LANL News. 2 Mar 2021. For the welding program, see: "UNM-LA now offering welding certificate program." Coombs, Nancy. UNM Newsroom. 3 May 2019.

24. "New Mexico Department of Higher Education. 2019 Summer Hearing–Five Year Capital Project Funding Request–All Institutions." New Mexico Higher Education Department. 23 Aug 2019. (Document available upon request from NMHED.)

25. "2019-FY21 - General Obligation Bond Recommendations." O'Neill, Kate M. New Mexico Higher Education Department. 3 Oct 2019.

26. For New Mexico statute regarding NMHED's review of higher education capital project funding requests, see: NMAC 5.3.9.8, Review Criteria. For the text of SB 207, see: "SB 207 – 2020 Capital Projects GO Bond Act." New Mexico Legislature. 11 Mar 2020.

27. New Mexico Bond Question C, Public Education Bond Issue (2020). Ballotopedia. Accessed 1 Dec 2022.

28. The 2019/FY21 capital projects for higher education that saw the greatest percentage reductions in their funding, relative to NMHED recommendations, were: IAIA Academic and Museum Collections Renovation: −53% ($1.5 million recommended by NMHED; reduced to $0.7 million in SB 207); UNM-Gallup Center for Career Technologies Education: −50% ($6 million recommended; reduced to $3 million); Diné College Shiprock Agricultural Multipurpose Center: −35% ($2 million recommended; reduced to $1.3 million); NM Junior College Hobbs Safety & Security: −34% ($3.05 million recommended; reduced to $2 million). A full analysis of all 2019/FY21 Capital Projects for higher education, showing the percent increase or reduction in project funding in SB 207 relative to NMHED's recommendations, is available from the authors upon request.

29. "Los Alamos Branch: Work Force Development Career Technical Education Classroom Renovations." University of New Mexico General Obligation Bonds 2020. Bond C. According to the description on the site, the GO Bond-funded project at UNM-LA would convert existing campus facilities into a simulated training environment for pit production. Campus lab and support space would be equipped for new programs developed for "plutonium initiates."

UNM's GO Bond request for the November 2022 ballot included support for a capital project entitled "UNM-LA Campuswide Improvements." Although few details are given in the public description of the project, the proposed improvements are said to be important in providing "degree programs that meet the needs of the local workforce." Increased enrollment and "degree production" are expected at UNM-LA in the future, as a result of "recent additions of degrees in Nuclear Enterprise Science and Technology (NEST) and new certificate programs in welding, radiation control technology, and waste operations." Requested funds for UNM-LA total $1.3 million.

Needless to say, the proposed campuswide improvements at UNM-Los Alamos do nothing to address real educational needs in Northern New Mexico, including critical shortages of early childhood educators, K-12 teachers, and nursing and other health professionals (see below). The goal of the project, by the University's own admission, is to upgrade campus facilities to better serve DOE/NNSA missions and objectives.

UNM officials are thus again attempting to divert state higher education funding towards national security activities. This bid, which places the interests of multibillion-dollar defense contractors over local concerns, is both unworthy of university leadership, and an insult to New Mexico taxpayers.

Of interest here are comments made by UNM Provost, Executive Vice President for Academic Affairs, and Professor of Nuclear Engineering Dr. James Holloway (see footnote 32). At a recent meeting of the UNM-LA Advisory Board, Dr. Holloway expressed his appreciation for the UNM branch campuses as "locally-rooted" educational institutions that "can be responsive to the needs of communities." In what sort of world is training plutonium machinists understood as meeting community needs? The university's evident capitulation to outside interests begs the question: Is higher education funding in the state of New Mexico increasingly being manipulated to benefit DOE/NNSA and its contractors?

For the critical shortage of nursing and other health care professionals in Northern New Mexico, see, for example: "Presbyterian's shift to for-profit ER firm to fill shortfall raises concerns." Todd, Marianne. *Santa Fe New Mexican*. 16 Oct 2022. A nursing shortage at Santa Fe's Presbyterian Medical Center forced the closure of the hospital's intensive care unit in July 2022, and now threatens operations in the hospital's emergency department. A recent report from the UNM Health Sciences Center documented a shortage of more than 3,000 EMTs and nearly 5,900 registered nurses in the state of New Mexico in 2022. See: "New Mexico Health Care Workforce Committee: 2022 Annual Report." University of New Mexico Health Sciences Center. 1 Oct 2022.

30. "Areas of Study." UNM-Los Alamos. Accessed 1 Dec 2022; "Degrees & Certificates." UNM-Los Alamos. Accessed 1 Dec 2022.

31. "UNM Los Alamos awarded Title V grant." UNM Newsroom. 22 Sep 2020.

32. UNM-LA Advisory Board meeting, 11 Jan 2021. During a meeting of the UNM-LA Advisory Board in January 2021, LANL Director Dr. Thomas Mason described the new Nuclear Enterprise Science and Technology (NEST) training program at UNM-LA. The NEST program, he said, is "a training program for current employees who work in nuclear facilities." The curriculum was designed by LANL employees, who were given special faculty appointments at UNM for the purpose. Later, UNM Provost Dr. James Holloway voiced his support for the "workforce training mission" of the UNM branch campuses. "We very much appreciate having...locally-rooted educational institutions that can be responsive to the needs of the communities in which they're placed," he said. "We think that the...structure of branch campuses, as responsive to community needs, is critical." The NEST program described by Dr. Mason, Holloway said, "is a great example of that."

During the August 2021 NMHED Summer Hearings, UNM-LA Chancellor Cynthia Rooney described the school's ongoing efforts to "focus on serving our community." UNM-LA, in conjunction with Triad National Security, had recently developed several new training programs, including the program in Nuclear Enterprise Science and Technology. The new programs, she said, were "specifically designed to educate the incumbents at LANL." NMHED Capital Outlay Summer Hearings, Day 1. 11 Aug 2021.

33. "Earn while you learn! Become a radiation control technician." Flyer: Northern New Mexico College. In partnership with Los Alamos National Laboratory. Northern New Mexico College. Fall 2021.

34. "Partnering on training programs for high-demand jobs." LANL Community Connections. 13 Aug 2019.

35. "Triad's Community Commitment Plan." LANL. Accessed 1 Dec 2022; "Economic and Workforce Development." LANL. Accessed 1 Dec 2022.

36. "$2.5 million grant benefits students, communities." LANL News Release. 1 Feb 2021.

37. "Workforce & Education. Higher Education Workforce Project." Regional Development Corporation. Accessed 1 Dec 2022.

38. "2020 Community Commitment Annual Report." N3B-Los Alamos. 2021. (p. 1). During 2019, one third of N3B's Community Commitment funds went towards the apprenticeship program at Northern New Mexico College. See: "N3B Community Contributions Program." Presentation to the Regional Coalition of LANL Communities. N3B-Los Alamos. 27 June 2019. (slides 10-11)

39. "LANL Legacy Cleanup Overview for Regional Coalition of LANL Communities." Henderson, Kristin A. N3B-Los Alamos. 16 Apr 2021. (slide 12). In 2017, the RCLC pressured contractors vying for the new LANL management and operations (M&O) contract to make their financial commitments to regional workforce development initiatives explicit in their proposals to the NNSA. See: "Northern New Mexico Community Relationship Priorities." NNSA Part 1 & 2 Responses to Draft Solicitation for LANL M&O Contract Competition. Regional Coalition of LANL Communities. Aug 2017. (p. 2)

From its inception in 2011, the RCLC had close ties to the Energy Communities Alliance (ECA), a Washington DC-based lobbying organization that seeks to define values, priorities, and policy positions in multiple DOE "host communities" across the US. As an organization that shapes policy at many DOE facilities, including LANL, the ECA's values and attitudes around frontline nuclear workers are troubling. In a recent webinar, "ECA Advancing Alliances Webinar: Building Nuclear Workforce Development Initiatives in the Community," presenters celebrated their success in recruiting frontline workers from impoverished rural Appalachia. Such attitudes reflect an organizational worldview that regards the socially and economically vulnerable as fodder for hazardous industry. See: "ECA Advancing Alliances Webinar: Building Nuclear Workforce Development Initiatives in the Community." (video). Energy Communities Alliance. 28 Jan 2021.

40. "UNM-Los Alamos RPSP Request: Workforce Development Initiative." See: UNM Board of Regents Finance and Facilities Committee e-book for 10 Sept 2019. 10 Sept 2019 (p. 56 of 96); and: UNM Board of Regents e-book for 17 Sept 2019 (updated). 17 Sept 2019. (p. 79 of 220)

41. "Devils in the details: the tricky business of making detonators." Spivey, Whitney. The Explosives Issue. *National Security Science*. Winter 2019.

42. "Tritium venting operation is safe, and the right thing to do." Reilly, T. Douglas. *Los Alamos Monitor Online*. 14 Apr 2020.

The health hazards associated with the ingestion of tritium, a beta-emitting radioisotope of hydrogen, depend on its biochemical form. While the majority of any volume of tritiated water (HTO) that is ingested into the human body will be excreted within several weeks, some fraction will be incorporated into metabolically-active cells and tissues, and thus become organically-bound tritium (OBT). OBT is retained in the body for a much longer period than is HTO, and because tritium has a half-life of 12.3 years, may continue to damage adjacent cells and tissues for years.

When tritium is released into the environment, some fraction will be retained as OBT by wild and domestic plants and animals. This OBT can harm both the tritium-exposed plants and animals, and any living being, including humans, that subsequently consumes them.

Sources: Estimation of radiation dose from ingested tritium in humans by administration of deuterium-labelled compounds and food. Masuda T, Yoshioka T. Sci Rep. 2021 Feb 2;11(1):2816; Organically bound tritium. Diabaté S, Strack S. Health Phys. 1993 Dec;65(6):698-712; Current understanding of organically bound tritium (OBT) in the environment. Kim SB, Baglan N, Davis PA. J Environ Radioact. 2013 Dec;126:83-91.

43. "Climate Change and Social Justice." Arte Romero y Carver. Taos Environmental Film Festival. Day 3, Session 6. 25 Apr 2021.

44. "Nuclear Operator Apprenticeship Program." (video). N3B-Los Alamos. Accessed 1 Dec 2022.

In December 2021, DOE's Office of Environmental Management (DOE-EM), together with the Energy Facilities Contractors Group and the Energy Communities Alliance (see footnote 39), hosted the National Cleanup Workshop, "Capitalizing on a New Era of Cleanup Success" in Alexandria, VA. The workshop was sponsored and attended by dozens of major defense environmental contractors, including Bechtel, BWXT, Energy Solutions, Fluor, Holtec, Huntington Ingalls Industries, Waste Control Specialists,

Westinghouse, and others.

During one panel session, "The Future of the EM Workforce," senior officials discussed the challenges of recruiting sufficient manpower to meet DOE-EM's cleanup goals in the decades to come. "People aren't going to school in middle school thinking 'I'm going to grow up and clean up nuclear waste,'" said Rebecca Casper, Vice Chair of the ECA. During the workshop's plenary session, however, DOE-EM Senior Adviser Ike White offered a solution, emphasizing to corporate representatives and others in attendance the importance of "partnering with local communities." DOE-EM, he said, is "very fortunate" to be "surrounded by diverse communities" that aid EM in its mission.

Other panelists also shared their perspectives on surmounting the challenges of frontline nuclear worker recruitment, with many of the speakers' comments aligning with the new emphasis on diversity and inclusion within DOE. Mary Kruger, Deputy Assistant Secretary of Resource Management at DOE-EM, said "we have been really successful" with pipeline program recruitment at "our Minority-Serving Institutions." The ECA's Rebecca Casper spoke to the favorable effects of a policy of student loan forgiveness. Repaying student loans, she said, "may indirectly bring you into contact with that more diverse set of students," adding, "We still live in a society where a great many of those who are economically forced to rely on their student loans might be coming from that minority background."

Kim Lebak, President of N3B-Los Alamos, described her experiences developing a recruitment strategy to support the company's legacy waste cleanup activities at LANL. Because Northern New Mexico is "very diverse," diversity outreach requires little effort on N3B's part. "We just, you know, put out the requisitions," she said. "For our challenges on recruiting," she said, "one thing we did was work with local community colleges and set up boot camps and apprentice programs" in order to rapidly expand the pool of frontline nuclear workers in the area. N3B worked closely with UNM-LA and Northern New Mexico College to establish the pipeline programs, she said.

One significant challenge N3B does face, Lebak said, is hiring competition with LANL. Nevertheless, the company "is finding success in talking to some of the junior folks" about cleaning up radioactive and hazardous waste. Residents of local communities, she noted, are very concerned about LANL's impacts on local land, water, and air. "They want to clean up the environment," she emphasized. N3B's corporate spotlight highlights frontline workers from nearby communities. "One hundred percent of them say that they want to clean up the environment," Lebak said. "If they have New Mexico roots," she explained, "they want to keep the area clean for their children and family."

In closing, Lebak said that N3B's recruitment strategy—which both recognizes and exploits local anxieties about contamination of the environment—really "resonates" with Northern New Mexicans. "So we are going to continue to pursue that," she concluded. "That is working for us."

Sources: "Capitalizing on a New Era of Cleanup Success." National Cleanup Workshop 2021. Alexandria, VA. 7-9 Dec 2021. "The Future of the EM Workforce." 2021 National Cleanup Workshop (Day 2). 9 Dec 2021. [1:40:00]; "A New Era for EM Cleanup." 2021 National Cleanup Workshop (Day 1). 8 Dec 2021. [0:40:00].

45. For Emily Arasim, see: "Radiation Contamination in New Mexico." New Mexico Environmental Law Center Environmental Justice Series. 24 June 2021.

(*Photo*) Acequia farming traditions are intimately tied to history, culture, and community in Northern New Mexico. Acequias are networks of gravity-fed earthen channels that deliver stream water originating in high mountain snow to distant pastures, orchards, and fields. Acequias are in use in arid regions throughout the world, and have enabled farming communities to withstand variable precipitation for thousands of years.

During a recent study, *parciantes* (acequia members) in Northern New Mexico were asked about closely-held values in their communities. Respondents overwhelmingly described acequias as "part of our culture." The Upper Rio Grande watershed, which encompasses north-central New Mexico and southern Colorado's San Luis Valley, is home to the most extensive traditional acequia communities remaining in North America.

Cooperative social practices are as much a part of traditional acequia communities as are the slender earthen channels that bring water to the fields. The principle of *mutualismo*, writes Emily Arasim, or working in a spirit of trust and reciprocity towards the common good, "has kept acequias flowing for hundreds of years." Traditions that bind acequia communities together include collective labor, annual ditch cleaning rituals, respect for elders, and celebration of the Spanish language. An acequia community stands united in its desire to preserve its land base, water rights, and unique way of life. Researchers see the values of mutuality, reciprocity, and trust that are characteristic of acequia communities in Northern New Mexico as a distinct form of moral economy.

According to investigators who led a recent five-year, NSF-funded study of traditional acequia practices in the Southwestern US, acequias are complex systems that work to preserve community identity and cohesion, promote economic stability, enhance floodplain hydrological function, and provide essential habitat for wildlife. The investigators found that traditional acequia practices "create and sustain intrinsic linkages between human and natural systems," increasing both community and ecosystem resilience to external stressors.

Yet Northern New Mexico's traditional acequia communities are increasingly under threat. The climate crisis is bringing warmer winters with diminished precipitation and earlier spring snowmelt. Population growth, gentrification, and urbanization in the region are driving the conversion of historic farmland and water rights to residential and commercial uses.

And perhaps most significantly, the gradual loss of *parciantes* from farming to conventional wage-work, often far from rural communities, is steadily eroding participation in vital acequia activities. Researchers say this steady attrition, which weakens community ties and places heavy burdens upon remaining *parciantes*, increasingly threatens the survival of traditional acequia communities in Northern New Mexico.

A new state workforce training program that offers $5,000 apprenticeships to beginning farmers, however, could help to sustain these centuries-old traditions by encouraging the transmission of acequia knowledge, culture, and governance to a new generation of Northern New Mexicans. Yet in stark contrast to the funding flowing into DOE pipelines in the region, the farmer apprenticeship program received appropriations of only $50,000 in for 2021, most of which went to large agricultural producers in the southern half of the state.

Sources: "NMSU Publishes New Research on NM Acequias." Arasim, Emily. New Mexico Acequia Association. 21 Oct 2021.
For the NSF-funded study, see: "Acequias of the Southwestern United States: Elements of Resilience in a Coupled Natural and Human System." Agricultural Experiment Station. Research Report 796. Rosenberg, Adrienne, ed. NMSU College of Agricultural, Consumer, and Environmental Sciences. Nov 2020; and: "CNH: Acequia Water Systems. Linking Culture & Nature." NMSU College of Agricultural, Consumer, and Environmental Sciences. Accessed 1 Dec 2022. For apprenticeships for beginning farmers,

see: "Agricultural Workforce Development Program." New Mexico Department of Agriculture. Accessed 1 Dec 2022. For the Land Grant and Acequia curriculum under development at New Mexico Highlands University, see: "Reclaiming Our Past, Sustaining Our Future: Envisioning a New Mexico Land Grant and Acequia Curriculum." Valdez, Elena V. Center for the Education and Study of Diverse Populations at New Mexico Highlands University. 16 May 2021. The New Mexico Acequia Association works to educate young people about acequia cultural heritage in Northern New Mexico, and offers acequia farming apprenticeships through the Los Sembradores Farmer Training Project.

46. "LANL's Science, Technology, Engineering and Mathematics Outreach and Pipeline Programs." Presentation to the Science, Technology, and Telecommunications Committee, New Mexico Legislature. Nan Sauer, Senior Director, Partnerships and Pipeline Office, LANL, and Kathy Keith, Director, Community Partnerships Office, LANL. 22 July 2021. (slide 8)

47. H. Rept. 116-449 (Accompanies H.R. 7613. Energy and Water Development and Related Agencies Appropriations Act, 2021). 15 July 2020. (p. 139-40); H. Rept. 117-98 (Accompanies H.R. 4549. Energy and Water Development and Related Agencies Appropriations Act, 2022). 20 July 2021. (p. 161); H. Rept. 117-394 (Accompanies H.R. 8255. Energy and Water Development and Related Agencies Appropriations Act, 2023). 30 June 2022. (p. 166). The relevant passage in Report 116-449 (for FY21) reads: "*Plutonium Modernization.*—Within funds provided, not less than $7,000,000 shall be for workforce development and training partnerships with Historically Black Colleges and Universities, Hispanic-Serving Institutions, and Tribal Colleges and Universities in South Carolina and New Mexico to support plutonium pit production." Identical passages appear in Reports 117-98 and 117-394 for FY22 and FY23; appropriations for the workforce development initiatives and partnerships increased from $7 million to $10 million dollars for FY22 and FY23.

The Explanatory Statement for the FY21 enrolled bill (H.R. 133. Consolidated Appropriations Act, 2021) reads: "*Plutonium Pit Production.*— [...] The NNSA is directed...to include in future budget requests a breakdown of manpower needs for pit production and all support functions. The agreement includes not less than $7,000,000 for workforce development and training for Historically Black Colleges and Universities, Hispanic Serving Institutions and Tribal Colleges in South Carolina and New Mexico." Congressional Record. Book IV. 21 Dec 2020. (p. H8375)

48. For passages in House Committee Reports and related Appropriations Bills regarding Executive Order 12898, see: H. Rept. 116-449 (pp. 202, 215) and H.R. 7613 (p. 63) for FY2021; H. Rept. 117-98 (pp. 222, 235) and H.R. 4549 (p. 62) for FY2022; H. Rept. 117-394 (pp. 232, 255) and H.R. 8255 (pp. 64-5) for FY2023. The prohibition on the use of appropriated funds in contravention of Executive Order 12898 also appears in the enrolled bills for FY2021 (H.R. 133. Consolidated Appropriations Act, 2021. General Provision Sec. 503, p. 198); and FY2022 (H.R. 2471, Consolidated Appropriations Act, 2022. General Provision Sec. 503, p. 190).

For the text of Executive Order 12898, see Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. Executive Order 12898. Federal Register. Vol. 59, No. 32. 16 Feb 1994.

49. H. Rept. 117-98. 20 July 2021. (p. 99). For the House Appropriations Committee's views on legacy waste cleanup activities at DOE sites and relevant appropriations, see pp. 166-168.

50. For the LANL Office of Community Partnerships, see: "Building a workforce pipeline: Long-term education project helps the Laboratory and the region." LANL Community Connections. 11 Apr 2019. For former NNMC President Rick Bailey, see: "'Earn While You Learn' Collaboration Involving Area Colleges, LANL, N3B and State Celebrated." *Los Alamos Reporter*. 31 July 2019.

51. For the average earnings of nuclear operators at N3B, see: "Nuclear Operator/Waste Handler." New Mexico Department of Workforce Solutions. Accessed 1 Dec 2022. For solar installers and technicians, see: "Solar Thermal Installers and Technicians. 47-2152.04." O*NET OnLine. Accessed 1 Dec 2022. Despite strong demand for workers in the solar installation field, both UNM-Los Alamos and Santa Fe Community College have eliminated their long-running programs in Solar Technology since 2020. See footnote 73 and: "Solar Winds." *Santa Fe Reporter*. Melhado, William. 11 May 2021.

52. "Superfund Job Training Initiative." US Environmental Protection Agency. Accessed 1 Dec 2022. The SuperJTI program offers little in the way of training: the core elements are a standard 40-hour HAZWOPER course and instruction in CPR. It is unlikely that workers recruited through the program are monitored for any short- or long-term adverse health effects that might result from on-the-job exposures incurred at former uranium mines.

In the Four Corners region, the Navajo Nation SuperJTI recruited under- and unemployed people living on and near the Navajo Nation in 2012 to remediate contaminated uranium mining sites on Navajo lands. Many hundreds of abandoned uranium mines (AUMs) in the region still await remediation.

Sources: "Making a Difference in the Community: the Superfund Job Training Initiative on Navajo Nation Lands." Navajo Lands Superfund JTI Fact Sheet. US Environmental Protection Agency. Accessed 1 Dec 2022; "Navajo Nation: Cleanup Up Abandoned Uranium Mines." US Environmental Protection Agency. Accessed 1 Dec 2022.

53. "DOE-EM Research and Technology Roadmap: Robotics and Remote Systems for Nuclear Cleanup." DOE Office of Environmental Management. 2018. (Total workforce radiation dose, p. 9; reduction of injury rates, p. 4; DOE-EM's recommendations, p. 5.) The report states that DOE "continues to work diligently to keep occupation[al] exposure to ionizing radiation and other workplace hazards as low as reasonably achievable; however, the nature of nuclear cleanup and radioactive waste management exposes the atomic energy workforce to ionizing radiation. As such, EM remains the DOE program retaining the highest workforce personnel radiation dose." (p. 9)

54. Interest in developing methods for handling radioactive materials more safely began in the early twentieth century, with increasing recognition of the damage done to living cells and tissues by ionizing radiation. This interest doubtless grew during the WWII-era, with the increased processing and handling of nuclear materials associated with the development of nuclear weapons.

Scientists knew that radioactive materials could be manipulated more safely by simply increasing the distance between the operator and the materials. The underlying principle (the *inverse square law*) is that intensity of radiation (and thus the magnitude of the radiation dose) is inversely proportional to the square of the distance from the source. If the distance is doubled, the dose is reduced by a factor of four. Remote handling methods might increase the distance from the source by a factor of ten, twenty, or more, and reduce doses correspondingly by factors of 100, 400, or more. Remote handling methods would therefore allow workers to manipulate radioactive materials much more safely.

To encourage the development of methods for remote handling of radioactive materials, the Atomic Energy Commission (DOE's predecessor) established the Remote Control Engineering Division at Argonne National Laboratory in 1947. In 1948, Argonne researcher Dr. Raymond Goertz gave a paper entitled "Remote Control Apparatus" at a symposium concerning the design of radiochemistry laboratories. Goertz had developed a number of devices for handling radioactive materials remotely, his designs ranging in sophistication from unusually long-handled tongs ("used when distance and small amounts of shielding are adequate protection") to intricate remote-controlled gauges, drills, and synchro-operated syringes.

A year later, Goertz announced the first of his many, increasingly-refined mechanical systems that enabled an operator to manipulate radioactive materials while positioned "behind a shielding barrier." Goertz referred to his new prototype as a "Master-slave manipulator," because "the slave tongs move in exact correspondence with a master handle." The test model, he wrote, "is entirely mechanical."

The refinement of methods for the remote handling of radioactive materials continued in the twentieth century. In the early 1990s, researchers at the Savannah River Site in Aiken, SC used a more sophisticated version of Goertz' master-slave manipulator to do remote maintenance on the robotic tools (gantry manipulator) under development at the Transuranic Waste Test Facility (TWTF) at SRS. The goal of the TWTF, which opened in 1987, was to explore the possibility of using robotic manipulators to open, process, and repackage the bulky transuranic waste that is generated during the production of nuclear weapons. By 1994, TWTF researchers had confirmed that, by implementing remote handling technology, DOE waste facilities could process transuranic waste more safely, rapidly, and cost-effectively.

Sources: "Inverse square law." Radiopaedia. Accessed 1 Dec 2022. For Raymond Goertz' post-WWII work at Argonne National Laboratory, see: "Remote Control Apparatus." Goertz RC. Argonne National Laboratory. 12 Apr 1948; "Master-Slave Manipulator." Goertz RC. ANL-4311. Remote Control Engineering Laboratory, Argonne National Laboratory. 7 Mar 1949. For the Transuranic Waste Test Facility at the Savannah River Site, see: "Telerobot tool maintenance using master-slave manipulators." Kriikku EM. WSRC-TR-92-428. Westinghouse Savannah River Company. Savannah River Site. Aiken, SC. 1992; and: "FY94 Office of Technology Development Mixed Waste Operations Robotics Demonstration." Kriikku EM. WSRC-RP-9401140. Westinghouse Savannah River Company, Savannah River Site. Aiken, SC. 30 Aug 1994.

55. "Robotics Challenge Aims to Enhance Worker Safety, Improve EM Cleanup - Other EM Events Set for September Focus on Safety, Technology Development." DOE Office of Management. 31 Aug 2016.

56. "EM, Contractors Collaborate on U.K. 'Snake Arm' Robot Demonstration." DOE Office of Environmental Management. 28 June 2017.

57. "Robotics Institute Delivers Pipe-Crawling Robot To DOE." Spice, Byron. Carnegie Mellon University School of Computer Science. 9 Aug 2018. Accessed 1 Dec 2022.

58. "SRS Relies on Array of Robots for Liquid-Waste Cleanup." DOE Office of Environmental Management. 31 Aug 2017. Accessed 1 Dec 2022. See also: "Facts from the Savannah River Site: Robotic Technology." US Department of Energy. Dec 2020.

59. "EM Looks to Bring PipeDream Robot to Life in Portsmouth Site Cleanup." DOE Office of Environmental Management. 17 Aug 2017. According to the news release, DOE's Science of Safety Initiative "aims to deploy enhanced technologies throughout the DOE complex, including supporting worker safety in high-hazard operations." For workplace training at Portsmouth, see: Fact Sheet: "Major Projects at PORTS: High Tech Robotics Used for Worker Safety." DOE Office of Environmental Management. 2017. Fluor-BWXT Portsmouth. Accessed 1 Dec 2022.

60. "Robotic Arms, Supercomputer Slice and Squash Challenging Waste." DOE Office of Environmental Management. 15 Oct 2019. See also: "Advanced Mixed Waste Treatment Project." Fluor-Idaho. Accessed 1 Dec 2022.

61. For DOE-EM's draft and final RFPs for management of the Los Alamos Legacy Cleanup Contract (LLCC), see: "Los Alamos Legacy Cleanup Contract (LLCC) - Draft Request for Proposal." DOE Office of Environmental Management. 26 May 2016; and: "Final Request for Proposal DE-SOL-0008109 for Los Alamos Legacy Cleanup Contract (LLCC)." DOE Office of Environmental Management. 21 Sept 2016. For N3B's contract, see: "89303318CEM000007 - Through Modification 0001." Los Alamos Legacy Cleanup Contract (LLCC) [v.1]. Newport News Nuclear-BWXT (N3B-Los Alamos, LLC). DOE Environmental Management Los Alamos Field Office. 14 Feb 2018.

For N3B's award fee (performance) scorecards for 2018-22, see: "Fiscal Year 2018 N3B Award Fee Determination Scorecard." 8 Jan 2018; "Fiscal Year 2019 N3B Award Fee Determination Scorecard." [undated]; "Fiscal Year 2020 N3B Award Fee Determination Scorecard." [undated]. "Fiscal Year 2021 N3B Award Fee Determination Scorecard." 22 Feb 2022. "Fiscal Year 2022 N3B Award Fee Determination Scorecard." 22 Dec 2022. The scorecard for FY2020 notes that workers' lack of understanding of the risks associated with 480-volt electrical sources revealed "significant deficiencies in training and safety oversight" on N3B's part, with potentially life-threatening consequences. The scorecards for FY2021 and FY2022 also note deficiencies in the workplace safety culture at N3B.

For the past several years, DOE-EM's annual "Strategic Vision" statements have emphasized the agency's interest in recruiting a "next-generation workforce" to execute current and future EM missions. The Strategic Vision statements for 2021 and 2022, for example, highlight EM contractors' use of "regional partnerships" to assure "a consistent workforce pipeline." The new bootcamp and apprenticeship programs run by N3B-Los Alamos in collaboration with Northern New Mexico College are spotlighted here, as is a new DOE Justice40 Pilot Program with EM-Los Alamos (see glossary entry for *Justice40 Initiative*). Recruitment strategies that reflect EM's recent emphasis on diversity and inclusion, such as its Minority Serving Institutions Partnership Program (MSIPP), are also featured.

The 2021 and 2022 Strategic Vision statements also describe current EM activities at various DOE sites, including remediation efforts involving remote handling of waste at Idaho National Laboratory. New EM investments in exposure-reducing technology (e.g., remote and robotic handling methods) are scarcely mentioned in the Strategic Vision statements, however, and there is no description of recent initiatives or progress in this area. See: "New EM Program Plan Guides Progress, Opportunities to Accelerate Cleanup." DOE Office of Environmental Management. 22 Sept 2022; "EM Strategic Vision: 2021-2031." DOE Office of Environmental Management. 2021; "EM Strategic Vision: 2022–2032." DOE Office of Environmental Management. 8 Mar 2022. "Justice40 Initiative." DOE Office of Environmental Manage-

ment. Accessed 1 Dec 2022. The Justice40 Initiative is a "federal effort to deliver at least 40 percent of the overall benefits from certain federal investments to disadvantaged communities" (see *Justice40 Initiative* glossary entry).

A document released by DOE-EM's Los Alamos Field Office (EM-LA) in 2021 does briefly mention the possibility of remote handling of legacy waste at LANL. The document recommends methods to be used in the remediation of waste buried at LANL's 11-acre Material Disposal Area C (MDA-C). An attached waste inventory for MDA-C, generated by EM-LA using old (1943-1974) records from the site, shows that buried waste there includes americium-241, beryllium, fission products, polonium-beryllium-fluorine compounds, strontium, and plutonium. An underground vapor plume of trichloroethylene (TCE), a known carcinogen and CNS toxin, is also present at the site. Despite these documented hazards, EM-LA recommended that excavation of the hundred-plus waste-filled pits and shafts at MDA-C should be accomplished using standard excavation methods, "unless potential or real hazards dictate remote handling."

Sources: "Corrective Measures Evaluation Report for Material Disposal Area C, Solid Waste Management Unit 50-009 at Technical Area 50, Revision 1." EM2021-0177. N3B-Los Alamos. June 2021. (pp. 48, 70). (This document is a revision of a 2012 version; both versions acknowledge the possibility of remote handling at MDA-C.) EM-LA Report (2012): "Corrective Measures Evaluation Report for Material Disposal Area C, Solid Waste Management Unit 50-009 at Technical Area 50." LA-UR-12-24944. Los Alamos National Laboratory. Sept 2012. (pp. 41, 63); "Material Disposal Area: MDA-C." N3B-Los Alamos. Accessed 1 Dec 2022; "Fact Sheet on Trichloroethylene (TCE)." US EPA. Accessed 1 Dec 2022.

Finally, neither UNM's Manufacturing Engineering Program, nor New Mexico State University's program in Robotics & Controls appears to be involved in efforts to develop improved methods for handling of radioactive and hazardous waste. At one point, a group of faculty at UNM were actively involved in the University Research Program in Robotics (URPR), a DOE-funded consortium of five universities working to develop robotic systems for use in the remediation of hazardous waste sites. The last publication from the group at UNM, however, was in 2002, and associated faculty have long since retired.

Currently, the only undergraduate degree program in robotics offered in the state of New Mexico is the associate of applied science (AAS) program at UNM-Los Alamos. Although the program is "designed to develop skills that will assist students in gaining employment in various robotics career fields," there is no evidence that any training in remote and robotic waste handling methods—a field experience at N3B, for example—constitutes any part of the curriculum.

Given New Mexico's extraordinary burden of Manhattan Project- and Cold War-era radioactive and hazardous waste, it is surprising that New Mexico's institutions of higher education are not established leaders in the development of legacy waste-handling technology. Legacy waste is a grave problem of public health in the state, and sadly, any advances that might be made in the area of remote remediation technology would also be in great demand in the US and globally.

Sources: "UNM Manufacturing Engineering Program." University of New Mexico. Accessed 1 Dec 2022; "Robotics & Controls." New Mexico State University. Accessed 1 Dec 2022; "DOE University Research Program in Robotics." University of New Mexico. Accessed 1 Dec 2022; "Robotics." UNM-Los Alamos. "UNM-LA Robotics program prepares students for employment." Olds, Christina. UNM Newsroom. 1 Dec 2015.

62. For the work activities of students enrolled in N3B's Nuclear Operator Apprenticeship program at Northern New Mexico College, see: "Nuclear Operator Apprentice I. Newport News Nuclear BWXT Los Alamos LLC." Salary.com. Accessed 1 Dec 2022. (Identical listing at: "Nuclear Operator Apprentice 1." GrabJobs. Accessed 18 Sept 2022.) The job description reads, "The Nuclear Operator...document[s] waste that exhibits chemical and radiological hazards. Specifically, the Apprentice provides technical support while wearing the appropriate Personal Protective Equipment (PPE). Technical support includes opening waste containers, removing waste items if possible, describing the waste items and recording the results."

63. N3B's parent entity BWXT is currently involved in cleanup operations both at SRS (as part of Savannah River Remediation, with Bechtel National and Jacobs), and at Portsmouth (as part of Fluor-BWXT). Exposure-reducing technologies (ERTs) are in use in cleanup operations at both of these sites. BWXT also played a central role in operations at Idaho National Laboratory's Advanced Mixed Waste Treatment Project (AMWTP), see: "A commitment to safely clean up radioactive waste." Bechtel Corporation. Accessed 1 Dec 2022. According to the article, Bechtel and partner BWXT managed and operated the AMWTP ("the DOE's most advanced radioactive waste treatment facility at the time") from 2005 to 2011.

64. The federal government classifies packaged transuranic waste into two categories based on the intensity of the radiation (dose rate) at the surface of the waste container. Contact-handled TRU (CH-TRU) waste has a surface radiation dose rate of ≤200 millirem/hr, and remote-handled TRU (RH-TRU) waste, of >200 millirem/hr. Because CH-TRU has a lower surface dose rate than RH-TRU, workers in the DOE complex may be required to handle it directly, without the benefit of remote handling technology. Hence, the designation of this waste as "contact-handled."

The contact- and remote-handled designations are made solely on the basis of the radiological characteristics of the waste. Other characteristics of the waste, such as the co-occurrence of hazardous, yet non-radioactive materials, are not reflected in the designation. When radioactive waste also contains hazardous materials (i.e., those with ignitable, corrosive, reactive, or toxic characteristics) it is classified as *mixed waste*. (See glossary entry for *hazardous waste*).

Despite the lower surface radiation doses involved, CH-TRU handling operations (e.g., waste excavation, packaging, and repackaging) pose substantial risks to workers when hazardous materials are present. Hazardous materials frequently encountered in *mixed TRU waste* include corrosive and explosive compounds, VOCs, and heavy metals. Workers may encounter hazardous materials during *non-mixed TRU waste* handling operations as well, because the contents of individual waste containers, pits, and shafts are never known with certainty. Finally, damaged and breached CH-TRU waste containers pose continual risks to workers, including exposure to corrosive materials and the inhalation of radioactive particles and VOCs.

Hazards associated with CH-TRU repackaging specifically include: (a) non-compliant prior packaging of containers, including packaging that unlawfully attempts to reduce the container surface dose rate below the 200 millirem/hr limit by shielding highly radioactive items within the waste; (b) the unexpected presence of ignitable, corrosive, or reactive materials within previously packaged containers, leading to fires, chemical burns, and explosions; and (c) the unexpected presence of toxic materials such

as PCBs, beryllium, and beryllium oxides that, even in minute quantities, are extremely hazardous to human health. Individual waste containers may have been improperly closed, or may have become damaged during storage or handling. Damaged waste containers may show evidence of container pressurization, bulging, cracks, punctures, or outright leakage. Hazardous materials and conditions may also be encountered during the manual excavation of buried CH-TRU from underground waste dumps, pits, and shafts.

Finally, CH-TRU surface radiation dose rates, while lower than those for RH-TRU, are still exceptional, and of a magnitude never encountered in other radiation-handling or conventional industrial settings. Legacy waste workers who regularly work in close proximity to containers with surface dose rates of 200 millirem/hr inevitably suffer substantial cumulative radiation exposure. To put a 200 millirem/hr radiation dose into perspective, consider average doses associated with these common medical diagnostic procedures: arm or leg X-ray, 0.1 millirem; panoramic dental X-ray, 1 millirem; chest X-ray, 10 millirem—and the steps taken to protect patients and medical personnel from unnecessary exposure during these procedures.

Clearly, legacy waste workers who are tasked with handling CH-TRU waste directly (without the benefit of remote handling technology) suffer substantial risks of exposure to radiation and hazardous materials—risks that are never encountered in typical industrial settings. The adverse health effects resulting from long-term, cumulative exposures of this nature may be substantial.

Sources: For TRU classification, see: "S.1671 - Waste Isolation Pilot Plant Land Withdrawal Act." 102nd Congress. Library of Congress. 30 Oct 1992. For TRU characteristics and hazards, see: "DOE Notice N 435.1, Contact-Handled and Remote-Handled Transuranic Waste Packaging." DOE. 9 Aug 2011; and Characterization of Remote-Handled Transuranic Waste for the Waste Isolation Pilot Plant: Interim Report. National Academies of Sciences, Engineering, and Medicine. 2001. (p. 9)

65. In 1993, DOE promulgated a rule, 10 CFR § 835, *Occupational Radiation Protection*, with the goal of more effectively protecting workers from the hazards of ionizing radiation during DOE activities. Among other topics, 10 CFR § 835 sets limits on the radiation exposure of workers, establishes radiation monitoring requirements for DOE facilities (§ 835.401), and requires individuals to complete safety training prior to entry into high-radiation areas (§ 835.901).

Section 835.1001 of the rule, "Design and Control," draws on knowledge of the effectiveness of various exposure-reducing methods to specify the order in which these methods should be implemented at DOE facilities. So-called "engineered controls" are very effective in reducing exposures, and therefore should be the primary methods employed at DOE facilities. Engineered controls (which include the design of facilities and equipment and the use of remote methods to put distance between workers and unavoidable hazards) are also highly reliable, because they require little or no input on the part of the worker.

So-called "administrative controls," in contrast, aim to reduce the duration, frequency, or intensity of radiation exposure by modifying the behavior of workers themselves. These controls, which include work-process training, job rotation, and restricted access to hazardous materials and areas, are less effective than engineered controls, and according to § 835.1001, should be used only as an accessory to the latter. Least effective of all—and recommended only when engineered and administrative methods cannot reduce hazards to acceptable levels—are various forms of personal protective equipment (PPE), including gloves, safety goggles, hazmat suits, and air-purifying respirators.

The text of 10 CFR § 835.1001, "Design and Control," states:

> (a) Measures shall be taken to maintain radiation exposure in controlled areas ALARA through engineered and administrative controls. The primary methods used shall be physical design features (e.g., confinement, ventilation, remote handling, and shielding). Administrative controls shall be employed only as supplemental methods to control radiation exposure.

The rule expresses a clear preference for engineered controls in preventing occupational radiation exposures, with administrative controls applied only secondarily. Finally, section 10 CFR § 835.1003, "Workplace Controls," specifies that any anticipated exposure of workers must be within established occupational dose limits, and must be as low as reasonably achievable (ALARA, see footnote 67).

Beryllium hazards. In 1999, DOE promulgated the rule 10 CFR § 850, *Chronic Beryllium Disease Prevention Program*, to address the hazards of beryllium exposure at DOE facilities. Section 4.2.5.2, "Hierarchy of Controls," of this rule states:

> Title 10 CFR 850.25(c) mandates the conventional hierarchy of industrial hygiene controls; material substitution and engineering controls must be accomplished first if practicable, followed by administrative and work practice controls, followed by PPE.

Section 4.2.8 of the rule, "Respiratory Protection," addresses the use of PPE in beryllium environments specifically:

> Respiratory protection programs are required when employers have implemented all practicable engineering and administrative controls and the action level is still exceeded.

Defining a hierarchy of controls to effectively guide the reduction of workplace hazards is established practice in the field of occupational safety. The National Institute for Occupational Safety and Health (NIOSH), for example, also promulgates a hierarchy of safety controls. When it is impossible to eliminate a particular hazard altogether, this hierarchy (like DOE's radiation and beryllium directives) prioritizes the use of engineered controls such as facility and equipment design, and discourages the reliance on administrative controls and PPE. The latter two methods, according to NIOSH, "require significant and ongoing effort by workers and their supervisors," and should be implemented only when (a) primary controls cannot reduce hazards to acceptable levels; or (b) they are the only control options available. "PPE might seem to be less expensive than other controls," NIOSH concludes, "but can be costly over time."

Despite clear guidance regarding the reduction of occupational exposure to ionizing radiation and beryllium, there are likely instances at DOE facilities where PPE is a primary (if not the only) method used to reduce these exposures. When this is the case, workers are at significant risk of contact and inhalation exposures if the PPE fits poorly, is worn inconsistently, or is technically defective.

Note that inhalation exposures pose particularly grave hazards to frontline workers at nuclear weapons production facilities. During the machining of plutonium metal (an activity that is central to the production of plutonium pits), ultra-fine particles of alpha-emitting plutonium radioisotopes are continuously generated. If this plutonium metal dust bypasses a machinist's or waste worker's PPE and is inhaled, some fraction will be sequestered in the lungs, liver, and bones, and will remain to irradiate surrounding tissue over a lifetime. The machining of metallic beryllium (another activity that is central to the production of plutonium

pits) likewise generates ultra-fine beryllium dust. Inhalation of this dust into the lungs may lead to chronic beryllium disease, a progressively debilitating and often fatal lung disorder (see footnote 6). No safe levels of exposure to machined plutonium or beryllium dust exist. Sources: For 10 CFR § 835 *Occupational Radiation Protection*, see footnote 67. For 10 CFR § 850, *Chronic Beryllium Disease Prevention Program*, see footnote 6.

Bill Evans, Jr., the ailing Hanford worker mentioned earlier in the text, was one of an estimated 560 workers at the Plutonium Finishing Plant at Hanford who were provided with faulty respirator cartridges between 2012 and 2016, putting them at risk of internal radioactive and chemical contamination. For more on Bill Evans and occupational illness at DOE's Hanford Site, see footnote 7, the glossary entry for *safety equipment breaches and failures*, and the article: "Hanford workers were given leaky respirators at contaminated job site, contractors' documents reveal." Malone, Patrick and Hal Bernton. *Seattle Times*. 22 Mar 2020.

Sources: For the beryllium rule and beryllium hazards in DOE nuclear weapons facilities, see: 10 CFR § 850. Chronic Beryllium Disease Prevention Program. Federal Register. Vol. 64, No. 235. 8 Dec 1999, especially the "Background" and "Health Effects" sections (pp. 68854-6). For NIOSH, see: "Hierarchy of Controls." The National Institute for Occupational Safety and Health (NIOSH). Centers for Disease Control and Prevention. Accessed 1 Dec 2022.

Decades of federal investment in the development of remote methods for handling radioactive and hazardous materials have made DOE's goal of eliminating radiation exposures during legacy waste cleanup activities "reasonably achievable." (As Low As Reasonably Achievable is a tenet of DOE's radiation protection program that requires reduction of exposures to the lowest reasonably achievable level, see footnote 67.) The ability of remote handling technology to significantly reduce cleanup worker exposures has been demonstrated at multiple sites in the DOE nuclear weapons complex, including the Savannah River Site, Portsmouth, and Idaho National Laboratory. DOE-sponsored research has shown that these techniques greatly increase the safety of workers, and also enable DOE-EM to meet cleanup goals in a more rapid and cost-effective manner. See, for example, the use of remote handling methods to open, process, and repackage bulky TRU waste at SRS (footnote 54).

Despite the substantial advantages associated with the use of remote handling methods, legacy waste contractor N3B-Los Alamos does not appear to have implemented them in its operations at LANL. The company's plan to rely on direct human labor in the future, moreover, is all too evident in its recent pipeline initiatives.

Carlos' Law. In 2015, 22-year old Ecuadorean immigrant Carlos Moncayo died at a Manhattan construction site when the 13-foot trench in which he had been ordered to work suddenly collapsed, burying him alive. The trench had not been properly reinforced, and Harco Construction, the general contractor at the site, had been cited for the violation by safety inspectors. A police official who responded to the accident called the unreinforced trench "a ticking time bomb."

Although prosecutions for injuries and deaths at construction sites are exceedingly rare nationwide, Manhattan District Attorney Cyrus Vance, Jr. pursued charges in the incident. Harco Construction was subsequently found guilty on counts of reckless endangerment, manslaughter, and criminally negligent homicide. Yet the company received a fine of only $10,000, the maximum penalty in cases of negligence under OSHA. Vance characterized the $10,000 fine as mere "Monopoly money" for Harco.

The case led to the introduction of a bill into the New York Legislature in 2017. Now known as Carlos' Law, the bill establishes penalties of $300,000 to $500,000 (beyond those imposed by OSHA) on general contractors whose recklessness or negligence leads to the injury or death of workers. "Corporations must be held accountable when a worker is injured or killed due to unsafe conditions," said current Manhattan District Attorney Alvin Bragg. Passed in December 2022, the law makes contractors criminally liable for avoidable worker injuries at construction sites in New York state. Its protections extend to historically-exploited groups such as subcontractors, day laborers, and immigrant and non-union workers. New York Assemblymember Rodneyse Bichotte Hermelyn (Flatbush/Brooklyn) hopes the new law will prevent unscrupulous firms from taking advantage of the working-class and immigrant workers in her district.

Conditions at the New York construction site that led to Carlos Moncayo's death can shed light on preventable hazards in legacy waste handling settings. Harco Construction, Carlos Moncayo's employer, had a clear obligation to reinforce the 13-foot trench in which he would be working. Ordinary structural reinforcements would have greatly reduced the risks of working in the trench, by preventing its collapse altogether. Yet Harco Construction failed to implement this basic engineering protection. As a result, Carlos Moncayo had nothing more than a hard hat to protect him as thousands of pounds of construction debris collapsed upon around him.

DOE contractors have a corresponding obligation to implement engineered controls in legacy waste handling settings. Currently-available remote handling methods significantly reduce the risks of working with hazardous (radioactive, toxic, and explosive) materials, by removing workers from proximity to these materials altogether. When legacy waste contractors fail to implement these basic engineering protections, however, workers have little more than PPE to protect them. Even the best-fitting respirator is of little value when a 55-gallon drum of hazardous waste unexpectedly explodes in nearby workers' faces.

Harco Construction was found guilty of reckless endangerment in the Moncayo case because the company's wrongful actions created a significant risk of bodily injury or death to other persons. Although Harco may not have *intended* the resulting harm to Carlos Moncayo, it acted in a way that showed a *disregard for the foreseeable consequences* of its actions.

The foreseeable consequences of working in close proximity to DOE legacy waste are numerous, and include physical injury (crush injury, dismemberment, and chemical burns), fire, explosion, inhalation of toxic particles and vapors, and acute and long-term exposure to ionizing radiation. Does a DOE contractor's failure to implement engineered controls to avert these foreseeable consequences constitute reckless endangerment of legacy waste workers? If not, why not? Are DOE contractors somehow indemnified from liability in cases of personal injury, incentivizing them to allow unnecessary worker exposures to continue? What steps can be taken to ensure DOE contractors are held accountable for their actions (whether their negligence leads to acute physical injury, or contributes to the development of occupational illness many years later)?

Sources: "How a long-sought bill could make construction work less deadly." Zraick, Karen. *The New York Times*. 7 July 2022; "Senate Bill S621B. Enacts Carlos' law; relates to crimes involving the death or injury of a worker." 2021-2022 Legislative Session, New York State Senate. 6 Jan 2021. "Reckless Endangerment Law and Legal Definition." USLegal.com. Accessed 1 Dec 2022; "Governor Hochul Signs Legislation Establishing Carlos' Law."

Governor, New York State. 23 Dec 2022.

66. Compliance Order on Consent. US Department of Energy: Los Alamos National Laboratory. State of New Mexico Environment Department. 24 June 2016 (modified Feb 2017). The 2016 Consent Order, for example, specifies that DOE and NMED must consider factors such as project cost and "hazards to workers or to the public" in establishing cleanup objectives for site remediation at LANL. It also directs DOE to evaluate proposed alternatives to existing cleanup activities in light of various criteria, including any "risks that might be posed to the community, workers, and the environment." (pp. 35-6, 46)

67. "As Low As Reasonably Achievable," or ALARA, is an established principle in the field of radiation protection that requires the reduction of radiation exposure of workers and the public to the lowest "reasonably achievable" levels. In the 1950s, the International Commission on Radiation Protection (ICRP) recommended that, in light of knowledge that "certain radiation effects are irreversible and cumulative," every effort should be made to reduce exposure "to the lowest possible level."

The ALARA principle is a foundational element of 10 CFR § 835, *Occupational Radiation Protection*, a 1993 federal regulation that establishes standards, limits, and program requirements for DOE in order to protect workers from exposure to ionizing radiation during DOE activities. ALARA is not a dose limit per se, but a process that aims to reduce radiation exposure "as far below applicable limits...as is reasonably achievable." The ALARA approach is based on the established principle (i.e., the *linear no-threshold model*) that any level of exposure to ionizing radiation, no matter how low, increases the probability of developing adverse biological effects such as cancer.

In contrast to those set forward for DOE, the federal regulations governing radiological activities conducted under the Nuclear Regulatory Commission (10 CFR § 20) explicitly recognize (a) the role of technology in minimizing hazardous human exposures; and (b) the need to continually incorporate new technological advances into existing radiation dose-reduction strategies. Under the NRC, an ALARA process by definition takes the "state of the technology" into account, in aiming for exposures as far below applicable regulatory limits as is practical.

DOE's radiation protection standard (10 CFR § 835.202) limits DOE occupational doses to 5 rem (5000 millirem) per year; the ALARA Steering Committee at LANL has established an occupational dose "performance goal" of 2 rem (2000 millirem) per year. To put these occupational dose limits into perspective, consider the average radiation doses associated with these common diagnostic procedures: arm or leg X-ray, 0.1 millirem; panoramic dental X-ray, 1 millirem; chest X-ray, 10 millirem—and the steps taken to protect patients and medical personnel from unnecessary exposure during these procedures.

Although current DOE regulations allow occupational radiation exposures 50 times greater than those authorized for the general public, labor organizations and others have argued that workers and members of the public should be afforded the same fundamental protections. From a physiological perspective, occupational dose limits should be reduced considerably, given that workers often suffer exposure over the course of years or even decades.

The substantial differential between DOE's allowable radiation dose limits for workers and members of the public brings to mind current US regulations governing pesticide exposure. A 1996 amendment to federal standards limiting allowable pesticide residues on produce (fruits and vegetables) requires reduction of any residue such that there is "reasonable certainty" that no harm will result to consumers. Yet occupational pesticide exposure is governed by a far more permissive standard, which merely prohibits any "unreasonable" exposure of farmworkers, given the "economic, social, and environmental costs and benefits" of the use of the pesticide.

The resulting regulatory framework, according to the authors of a recent analysis of the disproportionate impacts of pesticide use on BIPOC communities, constitutes a sort of "double standard" for pesticide safety, which affords differing levels of protection to members of different groups. This double standard, which excludes the predominantly Latinx farmworker population from protections all other groups are afforded, represents "one of the most overtly racist aspects of current pesticide law." Given the proportion of Hispanic, Native American, and Black individuals employed as frontline nuclear workers, a similar conclusion could be drawn regarding current regulations governing occupational exposure to ionizing radiation at DOE facilities.

Sources: "Recommendations of the International Commission on Radiological Protection." rev. 1. Dec 1954. Br J Radiol. Suppl. 6. 1955. (p. 10); qtd. in "2007 Recommendations of the International Commission on Radiological Protection." Valentin, J., ed. Elsevier. 2007. (p. 36); Occupational Radiation Protection. 10 CFR § 835. 1993; "Occupational Radiation Protection Program (10 CFR 835)." DOE Office of Environment, Health, Safety, and Security. Accessed 1 Dec 2022; Standards for Protection Against Radiation. 10 CFR § 20. 1991; DOE Standard Radiological Control. DOE-STD-1098-2017. US Department of Energy. Jan 2017; Final Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory. DOE-EIS-380. Volume 1. US Department of Energy. May 2008. (pp. 4-116); "Radiation risk from medical imaging." Harvard Health Publishing. 29 Jan 2020. Report of the Work Group on Exposure Reduction. Interagency Task Force on the Health Effects of Ionizing Radiation. 1979. (p. 95). "Pesticides and environmental justice in the USA: root causes, regulatory reinforcement and path forward." Donley N, et al. BMC Public Health. 2022 Apr 19;22(1):708.

68. "Environmental Health and Justice Program." Tewa Women United. Accessed 1 Dec 2022; "Tewa Matrilineal Resistance to Environmental Violence." Coalition to Stop Violence Against Native Women. 18 Mar 2021.

69. *The Navajo People and Uranium Mining*. Brugge, Doug, Timothy Benally, and Esther Yazzie-Lewis, eds. UNM Press. 2006. (pp. 33-4); *Wastelanding: Legacies of Uranium Mining in Navajo Country*. Voyles, Traci Brynne. University of Minnesota Press. 2015.

70. "Executive Summary and Guide to Final Report." Advisory Committee on Human Radiation Experiments (ACHRE). Washington, DC. 1995. (p. 12)

71. *The Tainted Desert: Environmental and Social Ruin in the American West*. Kuletz, Valerie L. Routledge. 1998. (p. 25); *Environmental Justice in New Mexico: Counting Coup*. Rangel, Valerie. History Press. 2019. (p. 34)

72. "Phase II Investigation of the Paducah Gaseous Diffusion Plant: Environment, Safety, and Health Practices 1952-1990." DOE Office of Oversight. Environment, Safety, and Health. Feb 2000. In 1999, DOE's Office of Environment, Safety and Health (ES&H) conducted an investigation of DOE's Paducah Gaseous Diffusion Plant (PGDP) after serious allegations were made regarding inadequate worker protections at the facility. The investigators concluded that "certain external conditions and influences had a significant effect on the ES&H-related behavior and intentions

of both management and workers at the PGDP during the 1952-1990 period." The PGDP, investigators explained, "was the biggest employer in the region, paying wages significantly higher than previously available in this rural farming area." The Atomic Energy Commission (DOE's predecessor) and its contractors were "under pressure to maximize production." Fifty years ago, the investigators said, there was little knowledge about radiological, chemical, and other industrial hazards and their effects on human health. Attitudes about government transparency and worker protection during that time were "less sophisticated." Note that many of the same "external conditions and influences" that played a role in worker illness and injury at Paducah are still active at LANL today (pp. 2, 69).

73. DOE workforce pipelines have imposed both monetary and opportunity costs on community colleges in the region, and thus on all New Mexicans. Both SFCC and UNM-LA, for example, have recently eliminated programs to train solar installers, citing fiscal and other concerns. Yet at the same 2018 meeting where UNM-LA Dean of Instruction Sharon Hurley informed the Advisory Board that the school's program in Solar Technology was being placed on moratorium, CEO Cynthia Rooney announced that she was meeting frequently with representatives of Triad National Security to discuss higher education and economic development. "We continue to explore opportunities to partner with Triad, N3B, and others," she said.

Beyond its elimination of the program in Solar Technology, UNM-LA has discontinued a certificate program in Early Childhood Multicultural Education as well. A timeline of events and a full discussion of DOE workforce pipeline activities at UNM-LA in 2019 is available from the authors upon request.

Sources: Elimination of solar program at SFCC: "Santa Fe Community College cutting more staff, programs." Pollard, Jessica. *Santa Fe New Mexican*. 14 June 2021; Elimination of solar program at UNM-LA; meetings with Triad, N3B: Minutes of the UNM-LA Advisory Board meeting. 26 Nov 2018. (p. 2)

74. "U.S. & Global Diversity, Equity, Inclusion & Power (DEIP) Undergraduate Requirement." University of New Mexico. Accessed 1 Dec 2022. Note that coursework in U.S. and Global Diversity and Inclusion is not required of students enrolled in certificate and associate degree programs at UNM-LA, including DOE's frontline worker training programs in nuclear waste operations, fissile material handling, and radiation control technology. See: UNM-LA 2020-2021 Catalog. (p. 22)

For more on the little-known role of universities in the US nuclear weapons industry, see: "U.S. Universities are complicit in nuclear weapons production, new ICAN report reveals." ICAN. 13 Nov 2019; and: *Schools of Mass Destruction: American Universities in the U.S. Nuclear Weapons Complex*. International Campaign to Abolish Nuclear Weapons. Nov 2019.

75. As noted in footnote 47, the Subcommittee on Energy and Water Development wrote special funding into House appropriations bills for FY2021, FY2022, and FY2023 to establish plutonium worker training pipelines at minority-serving institutions in New Mexico and South Carolina. The House appropriations bills for FY2022 and FY2023 also spell out the Committee's *human-risk intensive approach* to the vast quantity of unremediated waste that still remains in the DOE complex. The Energy and Water Subcommittee, stating explicitly that it "places a high priority on workforce recruitment, mentoring, and training programs to prepare the next generation of federal and contractor workforce personnel," urged DOE-EM to "implement such programs as necessary" to ensure that the manpower needs of its legacy waste cleanup activities are fully met. Beyond the $10 million it appropriated for plutonium worker pipelines, the Committee set aside a further $10 million to fund DOE-EM's hazardous waste worker training programs in both FY2022 and FY2023.

Although the Committee commended DOE's efforts to implement robotic devices to reduce worker hazards, it allocated only $6.5 million for development of this technology in FY2022. Finally, in stark contrast to the $20 million appropriated for DOE workforce pipelines, no funding was allocated for the implementation of exposure-reducing technologies (ERTs) in FY2023.

As noted on p. 18, DOE-EM has one of the highest total workforce radiation dose across all DOE programs, accounting for more than half of DOE's total dose in 2016. Rather than condemning yet another generation of largely Hispanic, Native American, and low-income legacy waste cleanup workers to serious illness and injury, officials must place far greater emphasis on the adoption of technologies that reduce or eliminate hazardous worker exposures.

As a start, all funds currently appropriated for conventional DOE waste worker pipelines and training programs should be redirected towards educational initiatives (including R&D, degree, and vocational training programs) that further the rapid adoption of remote, robotic, and other exposure-reducing technologies in DOE cleanup activities.

Sources: For the Subcommittee's human-risk intensive approach to DOE legacy waste remediation, see: H. Rept. 117-98. (Accompanies H.R. 4549. Energy and Water Development and Related Agencies Appropriations Act, 2022). 20 July 2021. (pp. 166-8); and: H. Rept. 117-394. (Accompanies H.R. 8255. Energy and Water Development and Related Agencies Appropriations Act, 2023). 30 June 2022. (p. 170)

76. DOE has come under fire regarding its management of weapons production and legacy waste cleanup activities for decades, including its reliance on subcontractors (who are often unfamiliar with the unique hazards at DOE sites), and its use of incentive-fee structures that reward productivity over safety. The 1999 Congressional investigation of the Paducah Gaseous Diffusion Plant, for example, noted that DOE's strategy of executing cleanup activities exclusively through subcontractors increased health and safety risks "by bringing in workers without knowledge of site hazards." DOE's performance-based incentive fees, the investigators concluded, "pitted perceived cost-cutting measures against protecting worker health and safety" (see ref. in footnote 22, p. 25). Nevertheless, DOE's use of subcontractors and incentive-fee structures continues today.

Given this history, it is incumbent upon New Mexico's elected officials to thoroughly scrutinize cleanup-worker safety issues at the DOE facilities in the state, and to push DOE-EM to adopt practices that reduce or eliminate risks to workers altogether. Clearly, DOE pipeline programs that perpetuate further reliance on highly-exposed human labor are a step in the wrong direction.

77. The United Nations Treaty on the Prohibition of Nuclear Weapons (TPNW), which went into effect in January 2021, made nuclear weapons activities—including nuclear weapons development, testing, production, acquisition, stockpiling, use, and threatened use—illegal under international law.

GLOSSARY

Administrative controls Safety measures that aim to reduce occupational risks (e.g., exposure to hazardous materials) by modifying the behavior of workers themselves. Administrative controls include work-process training, job rotation, and restricted access to hazardous materials and areas. Administrative controls are much less effective at reducing occupational hazards than are *engineered controls* (see glossary entry). Principles of occupational safety hold that administrative controls should only be used as a supplement to the latter.

ALARA As Low As Reasonably Achievable, or ALARA, is an established principle in the field of radiation protection that requires reduction of radiation exposure of workers and the public to the lowest "reasonably achievable" levels. The ALARA principle is a foundational element of 10 CFR § 835, *Occupational Radiation Protection*, a 1993 federal regulation that establishes standards, limits, and program requirements for DOE in order to protect workers from exposure to ionizing radiation during DOE activities. The ALARA approach is based on the established principle (i.e., the *linear no-threshold model*) that any level of exposure to ionizing radiation, no matter how low, increases the probability of developing adverse biological effects such as cancer.

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Beryllium A low-density, brittle metallic element that, as a neutron reflector, has frequently been used in the engineering of nuclear weapons components. A thin shell of machined beryllium often surrounds the fissile plutonium core of a plutonium pit.

Beryllium-handling activities are exceedingly hazardous to workers due to the toxicity of beryllium dust, fumes, and soluble salts. Exposure to the beryllium dust that is generated during beryllium machining may cause beryllium hypersensitivity, chronic beryllium disease, and lung cancer. Chronic beryllium disease, a progressively debilitating and often fatal lung disease, is characterized by decreased lung capacity and effects similar to those caused by the poison gas phosgene (Britannica). Given the lack of effective treatment in chronic beryllium disease, its progressive nature with continued beryllium exposure, and the severity of lung obstruction often seen in affected workers, the National Institute for Occupational Safety and Health urges strict control of beryllium exposures (NIOSH). It has been estimated that 1,064 kg of beryllium was used at LANL between 1955 and 1997 (CDC 2010).

Contact-handled TRU Packaged *transuranic waste (TRU)* is classified into two categories based on the intensity of the radiation (dose rate) at the surface of the waste container. Contact-handled TRU (CH-TRU) waste has a surface radiation dose rate of ≤200 millirem/hr, and *remote-handled TRU* (RH-TRU) waste, of >200 millirem/hr (102nd Congress 1992). Because CH-TRU has a lower surface dose rate than RH-TRU, workers in the DOE complex may be required to handle it directly, without the benefit of remote handling technology. Hence, the designation of this waste as "contact-handled."

The contact- and remote-handled designations are made solely on the basis of the radiological characteristics of the waste. Other characteristics of the waste, such as the co-occurrence of hazardous, yet non-radioactive materials, are not reflected in the designation. When radioactive waste also contains hazardous materials (i.e., those with ignitable, corrosive, reactive, or toxic characteristics) it is classified as *mixed waste*. (See glossary entry for *hazardous waste*.)

Despite the lower surface radiation doses involved, CH-TRU handling operations (e.g., waste excavation, packaging, and repackaging) pose substantial risks to workers when hazardous materials are present. Hazardous materials frequently encountered in *mixed TRU waste* include corrosive and explosive compounds, VOCs, and heavy metals. Workers may encounter hazardous materials during *non-mixed TRU* waste handling operations as well, because the contents of individual waste containers, waste pits, and shafts are never known with certainty. Finally, damaged and breached CH-TRU waste containers pose continual risks to workers, including contact with corrosive materials, and the inhalation of radioactive particles and VOCs.

Hazards associated with CH-TRU repackaging specifically include: (a) non-compliant prior packaging of containers, including packaging that unlawfully attempts to reduce the surface dose rate below the 200 millirem/hr limit by shielding highly radioactive items within the waste; (b) the unexpected presence of ignitable, corrosive, or reactive materials within previously packaged containers, leading to fires, chemical burns, and explosions; and (c) the unexpected presence of toxic materials such as PCBs, beryllium, and beryllium oxides that, even in minute quantities, are extremely hazardous to human health. Individual waste containers may have been improperly closed, or may have become damaged during storage or handling. Damaged waste containers may show evidence of container pressurization, bulging, cracks, punctures, or outright leakage. Hazardous materials and conditions may also be encountered during the manual excavation of buried CH-TRU from underground waste dumps, pits, and shafts.

Finally, CH-TRU surface radiation dose rates, while lower than those for RH-TRU, are still exceptional, and of a magnitude never encountered in other radiation-handling or conventional industrial settings. Legacy waste workers who regularly work in close proximity to containers with surface dose rates of 200 millirem/hr inevitably suffer substantial cumulative radiation exposure. To put a 200 millirem/hr radiation dose into perspective, consider average doses associated with these common medical diagnostic procedures: arm or leg X-ray, 0.1 millirem; panoramic dental X-ray, 1 millirem; chest X-ray, 10 millirem—and the steps taken to protect patients and medical personnel from unnecessary exposure during these procedures.

Clearly, legacy waste workers who are tasked with handling CH-TRU waste directly (without the benefit of remote handling technology) suffer substantial risks of exposure to radiation and hazardous materials—risks that are never encountered in typical industrial settings. The adverse health effects resulting from long-term, cumulative exposures of this nature may be substantial. See glossary entries for *transuranic waste (TRU), hazardous waste, mixed waste,* and *remote-handled TRU.*

Defense Nuclear Facilities Safety Board An independent federal organization, established in 1988, that oversees worker and public safety at DOE nuclear weapons facilities. The DNFSB is composed of five experts in the field of nuclear safety with ex-

perience relevant to the Board's independent investigative and oversight functions (DNFSB 2022). The DNFSB reviews the content and implementation of health and safety standards at DOE facilities. However, the Board functions in an advisory rather than a true regulatory capacity.

DOE Department of Energy

DOE-EM or **EM** DOE Office of Environmental Management

Engineered controls Safety measures that aim to reduce occupational risks by altering the design of systems, physical facilities, equipment, or components. In high-risk DOE settings, engineered controls include the use of remote handling methods that put distance between workers and radioactive, toxic, and hazardous materials. Engineered controls are very effective in reducing occupational exposures, and, because they require little or no input on the part of the worker, are also highly reliable. DOE regulations governing occupational exposure to ionizing radiation and beryllium recommend the use of engineered controls at DOE facilities over all other methods.

Frontline worker In the DOE complex, a frontline worker is an individual whose work involves direct and/or frequent exposure to ionizing radiation, organic solvents, heavy metals, or other hazardous materials. Examples at LANL include radiation control technicians, fissile material handlers, specialty machinists and welders, decontamination and demolition workers, and nuclear waste operators.

Hazardous waste Waste that exhibits one or more of the following federally-designated characteristics: ignitability, corrosivity, reactivity, or toxicity (Princeton 2022). *Ignitable* waste is material that burns readily and may be difficult to extinguish. Examples include flammable compressed gases and oxidizers, liquids with low flash points, and spontaneously-igniting solids. *Corrosive* wastes are strong acids and bases that have the ability to corrode steel containers, including storage tanks, drums, and barrels. Corrosive wastes can seriously damage the eyes, skin, lungs, and other biological tissues. *Reactive* wastes are materials that are unstable at ordinary pressures and temperatures. When heated, compressed, or mixed with water, reactive waste may explode violently or give off toxic vapors, fumes, or gases. Finally, *toxic* waste is material that is harmful or fatal when ingested, inhaled, or absorbed, e.g., organic solvents, pesticides, and heavy metals (see glossary entries for *organic solvents* and *heavy metals*).

HBCU Historically Black College or University. HBCUs are defined by the federal government as colleges and universities, established before 1964, whose principal mission was, and is, the education of Black Americans. These two-year and four-year institutions were largely established during an era when Black people were prohibited from attending white institutions of higher learning. HBCUs are recognized for their excellence in a wide range of academic and artistic disciplines and have trained many Black leaders (Smithsonian 2018).

Heavy metals Metallic elements with relatively high densities, atomic weights, or atomic numbers. While some heavy metals (iron, copper, cobalt, manganese, nickel, and zinc) are essential nutrients and are harmless in trace amounts in the diet, others (e.g., cadmium, mercury, and lead) are extremely toxic, acting as carcinogens, metabolic inhibitors, or neurotoxins.

Heavy metals are widely used throughout the US nuclear weapons complex. Heavy metals do not degrade in the environment, and metal-contaminated soils are extremely difficult to remediate, especially when the soil is also contaminated with radionuclides (DOE-EM 2018). Research suggests that antibiotic-resistance genes carried by bacteria found in heavy metal-contaminated soils contribute to the perpetuation and spread of antibiotic resistance (Thomas 2020, Baker-Austin 2006).

Highly-exposed (direct) human labor Work processes that require individuals to work directly with (or in close physical proximity to) known occupational hazards. These processes stand in contrast to those that intentionally put physical distance between workers and hazards, for example, by implementing systems and technologies that enable workers to perform tasks remotely. Examples of highly-exposed work processes in DOE facilities include those in which individuals work directly with radioactive, toxic, or hazardous materials, and must rely on measures such as PPE, gloveboxes, radiation detectors, air-purifying respirators, or HEPA filtration for protection. These measures, are unfortunately far from infallible, and equipment failures that put workers' lives at risk are tragically common in the DOE complex (see glossary entry for *safety equipment breaches and failures*).

Work processes that rely on highly-exposed human labor put workers at much greater risk of harm than do processes that employ engineered controls such as remote handling methods. In the former, worker safety is entirely dependent on the proper use and performance of a chosen safety measure. If the measure is improperly or inconsistently applied or is technically defective, workers are left at risk of injury and exposure. Engineered controls such as remote handling methods, in contrast, enable work at a distance from hazardous materials and areas, and so provide intrinsic protection from (a) exposure to radioactive and hazardous materials; (b) injuries such as crushing and dismemberment; and (c) unexpected events such as container breaches, spills, fires, and explosions.

In 2019, an expert committee appointed by the National Academy of Sciences at the request of Congress completed a two-year assessment of science and technology use and development within DOE's Office of Environmental Management (DOE-EM). The committee sought to identify "technologies and alternative approaches" that could "substantially reduce long-term cleanup costs; accelerate cleanup schedules; and mitigate uncertainties, vulnerabilities, or risks" across the DOE complex.

Among its principal recommendations, the committee called on DOE-EM to reduce the direct participation of workers during cleanup operations. The twin goals were (a) to increase the efficiency of operations; and (b) to minimize occupational hazards. "Many DOE-EM cleanup activities are inherently dangerous," the committee said. The use of engineered systems rather than direct labor would "reduce the need to place humans in dangerous environments" and allow workers to perform hazardous tasks remotely. "Minimizing the need for direct human involvement in hazardous cleanup activities," they concluded, would increase the efficiency of legacy waste operations while significantly reducing risks to workers. (NAS 2019).

HSI Hispanic-Serving Institution. Minority-serving institutions in the US fall into two general categories: *historically-defined* institutions and *enrollment-defined* institutions. Historically-defined MSIs, which include Historically Black Colleges and Universities (HBCUs) and Tribal Colleges and Universities (TCUs), were founded for the express purpose of providing access to higher education to these groups. Many of these institutions have been in existence for over a century (see glossary entry for *HBCU*).

Enrollment-defined MSIs, in contrast, are designated on the basis of enrollment statistics alone. Hispanic-Serving Institutions, for example, are institutions of higher education where students identifying as Hispanic/Latinx constitute at least 25 percent of total student enrollment. In general, institutions where a specific minority group constitutes at least 25 percent of total enrollment are designated as "minority-serving" for that group (NCES 2007).

Education scholar Gina Ann Garcia studies equity and diversity in higher education, with a focus on Hispanic-Serving Institutions. "Despite being recognized by the federal government since 1992," she writes, "HSIs lack a historical mission to serve Latinxs." As institutions that lack a clear mission of service to Hispanic students, she says, HSIs have been criticized as being merely "Hispanic-enrolling" (Garcia 2019).

The HSI category has generated debate about appropriate uses of federal funding for these institutions, and has called varied definitions of what it means to "serve" Hispanic students and communities into question. UNM-Los Alamos, for example, was the recent recipient of $2.3 million in federal Title V funding for Hispanic-Serving Institutions (see p. 10). Given DOE's history of exploitation of Hispanic communities in Northern New Mexico, can UNM-LA's involvement in DOE workforce training programs be considered "Hispanic-serving"?

Justice40 Initiative The Justice40 Initiative is a new federal effort stemming from President Biden's Executive Order 14008 of January 2021. "For the first time in our nation's history," reads the official description of the initiative, "the Federal Government has made it a goal that 40 percent of the overall benefits of certain Federal investments flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution." The initiative aims to assist communities that are disadvantaged by legacy pollution and environmental hazards (White House). Interim federal guidance regarding the Justice40 initiative was recently issued by the Office of Management and Budget (OMB 2021). The interim guidance directs eligible federal agencies, including DOE, to address one or more designated priority areas in their Justice40-related program planning. Ironically, these priority areas include "training and workforce development" related to "legacy pollution reduction" in historically disadvantaged communities.

As discussed in the text, targeted workforce initiatives involving hazardous work activities (e.g., the remediation of heavily contaminated sites) may in fact put impacted communities at further disadvantage. When a targeted recruitment and remediation (TR&R) effort is built around *highly-exposed human labor*, for example, members of disadvantaged communities are recruited to perform work that involves direct exposure to the environmental contaminants at issue. In this instance, the workforce initiative (a supposed benefit to impacted communities) merely layers risks of occupational illness and injury onto existing stressors and environmental exposures. Although the nominal objective may be to benefit historically-impacted and marginalized groups, *high-risk workforce initiatives* only multiply adverse health and social impacts in vulnerable communities. When workforce initiatives pose substantial (and possibly undisclosed) occupational hazards to program participants, injustice is not remedied, but compounded, in targeted communities.

Nevertheless, DOE-EM and its contractors seem to have seized upon the Justice40 Initiative to further their existing (and highly discriminatory) labor practices. In response to the OMB's Justice40 interim program guidance, DOE has launched a new Justice40 pilot program in collaboration with the DOE-EM Los Alamos field office (EM-LA). According to a related news release, "workforce training and development will play a critical role in EM-LA's implementation of Justice40" (EM 2022).

Legacy waste worker recruitment has been an increasing concern for DOE-EM (see footnotes 44 and 61), and implementation of the Justice40 pilot at EM-Los Alamos is currently a top priority for the agency (EM CY22). Indeed, the Justice40 Initiative was the focus of a special panel session during the 2022 Waste Management Symposia, an annual conference sponsored by major DOE-EM contractors, including Huntington Ingalls Industries, Bechtel, Jacobs, and Fluor. Panelists on the session included senior officials from EM-LA and N3B-Los Alamos.

Here, N3B President Kim Lebak noted the many parallels between the Justice40 Initiative and the company's ongoing workforce training initiatives in Northern New Mexico, including the Nuclear Operator Apprentice Program it runs in collaboration with Northern New Mexico College (see pp. 15, 19, 20). The company "actively partners" with communities that have been adversely impacted by environmental contamination at LANL, Lebak said, and more than 50 percent of N3B's workforce development funds "benefited economically disadvantaged communities" in FY21. "N3B's workforce development program wholly aligns with the Justice40 Initiative," she concluded. With N3B's support, including paid tuition and on-the-job training, students in the company's waste worker pipeline programs "prosper in their home communities and bolster local economies." Here N3B's Lebak uses the same talking points used by DOE, LANL, and other officials when promoting the benefits of DOE pipeline initiatives in Northern New Mexico.

Despite the session's nominal focus on a federal initiative designed to remedy historic injustices, the panelists do not seem to have reflected upon LANL's history of exploitation and endangerment of local workers, or to have engaged in any discussion of the negative impacts of their recruitment activities on targeted communities. (These impacts include the needless and life-threatening exposure of workers that is the unavoidable consequence of reliance on direct human labor.) Nor was there any apparent discussion among the panelists of efforts to transition to greater use of ERTs during legacy waste cleanup activities at LANL.

Analysis of DOE workforce pipelines in Northern New Mexico—N3B's Nuclear Operator Apprenticeship Program, for example—reveals a continued reliance on direct human labor during LANL remediation activities, despite the ready availability of ERTs. An orientation towards direct human labor is also evident in officials' comments regarding the new Justice40 pilot at EM-LA. Rather than taking the opportunity to transition to the increased use of ERTs, DOE-EM contractors appear to be using the Justice40 Initiative to lend legitimacy to existing exploitative labor practices.

Officials continue to cite the benefits of recent targeted workforce initiatives to local economies, while completely ignoring the serious occupational hazards that highly-exposed labor practices entail for workers. Were local workforce development efforts to shift to training in the use or development of ERTs, however, equivalent (or better) economic opportunities could be created instead (see p. 18 for new training initiatives at Portsmouth). Such training—which might tie into R&D efforts at universities in the region—would support remediation efforts without forcing workers to endure needless occupational exposures. These new opportunities, unencumbered by risks to human health, would allow vulnerable young Northern New Mexicans to truly prosper in their home communities.

Workforce initiatives advanced by DOE-EM or its contractors should be eligible for federal Justice40 designation and funding *if and only if* the initiatives focus on training in the use or development of ERTs. Workforce development initiatives that put residents of impacted and marginalized communities at serious occupational risk are not deserving of Justice40 (or any other) federal recognition or funding.

LANL Los Alamos National Laboratory. According to its website, "LANL is a multi-program, federally funded research and development center for the National Nuclear Security Administration (NNSA) of the U.S. Department of Energy (DOE)." LANL's priority roles include "serving as a nuclear weapons design agency and a nuclear weapons production agency; addressing nuclear threats; and performing national security science, technology, and engineering." Federal appropriations for LANL have increased substantially during the past several years, in concert with activities supporting the modernization of the US nuclear arsenal.

Despite LANL's designation as one of three NNSA laboratories (LANL, Lawrence Livermore National Laboratory, and Sandia National Laboratory) whose core mission is nuclear weapons, major news outlets in the region routinely highlight LANL's minor, non-nuclear weapons-related activities.

Legacy waste The immense volume (millions of cubic meters) of liquid and solid radioactive and hazardous waste that is the material consequence of US nuclear weapons production and testing during the Manhattan Project and Cold War (Galvin 1995). As of 2022, the Department of Energy is charged with the clean-up and closure of over 140 contaminated former nuclear weapons sites in the US. According to the National Academy of Sciences, approximately 100 of these sites will not be remediable to the extent that unrestricted human access is permissible; these sites will require long-term management by the federal government, "in some cases indefinitely." Contaminants at DOE weapons sites "are found in buildings, equipment, surface and subsurface materials, surface water, ground water, flora, and fauna" (NAS 2003). The half-lives of some radioactive contaminants present at these sites measure in the hundreds of thousands of years.

Material Disposal Area (MDA) LANL has generated and disposed of approximately 17.7 million cubic feet of radioactive and hazardous waste since 1944. Most of this waste is buried in 26 officially-designated Material Disposal Areas (MDAs) at LANL, some of it in unlined trenches, piles, pits, and shafts. MDAs were used for disposal of liquids, sludges, solids, volatile organic compounds, non-nuclear explosive residues, radioactive compounds, and radiation-contaminated materials (DOE-EM 2018). LANL's 11-acre MDA-C (see footnote 61) was used for the disposal of classified materials, heavy metals, hazardous constituents, and radioactively-contaminated materials from 1948 to 1974. A vapor plume composed of VOCs (trichloroethylene) and tritium now contaminates the subsurface vadose zone (the area between the soil surface and the water table) at MDA-C. At MDA-G, approximately 124,000 cubic feet of transuranic waste (TRU) generated during nuclear weapons development and testing at LANL await permanent disposal at the Waste Isolation Pilot Plant.

Mixed waste Radioactive waste that also contains hazardous (ignitable, corrosive, reactive, or toxic) components (see glossary entry for *hazardous waste)*. Mixed wastes include low-level mixed waste, high-level mixed waste, and mixed transuranic waste, depending on the activity of the radioactive elements present. Low-level and mixed TRU waste are generated during the development and production of nuclear weapons. High-level mixed waste is generated during the reprocessing of spent nuclear fuel. Mixed waste is regulated under two separate federal statutes: the Resource Conservation and Recovery Act (RCRA) regulates the hazardous components of the waste, while the Atomic Energy Act regulates the radioactive components (EPA 2022).

MSI Minority-Serving Institution. MSIs are institutions of higher education that serve minority students. Federally-recognized MSIs include Historically Black Colleges and Universities (HBCUs), Hispanic-Serving Institutions (HSIs), Tribal Colleges and Universities (TCUs), and Asian American and Pacific Islander Serving Institutions (AAPISIs). See entries for *HBCU* and *Hispanic-Serving Institution*.

MSIPP The Minority Serving Institution Partnership Program was created "build a sustainable pipeline" between minority-serving institutions and DOE sites (NNSA 2022). At the Savannah River National Laboratory, for example, an MSIPP program run by DOE-EM provides students and graduates of MSIs with "hands-on" education and experience by supporting collaborations between MSIs and DOE national laboratories (SRNL 2022). The program focuses on training at the undergraduate level and above.

DOE received $56 million for the MSIPP in the FY2022 budget, building on the $6 million allocated in FY2021. According to DOE-EM, the funding will enable the agency's current efforts to "aggressively recruit" qualified candidates from the approximately 700 MSIs in the US. The MSIPP "recognizes the need to build on the diversity, inclusion and equity successes at the national laboratories" (DOE-EM 2022).

N3B-Los Alamos Newport News Nuclear-BWXT Los Alamos. A joint venture between the Fortune 500-ranked Huntington Ingalls Industries and the Fortune 500-ranked BWX Technologies, N3B-Los Alamos is the DOE-EM contractor currently engaged in the remediation and disposal of legacy waste at Los Alamos National Laboratory. NNSA awarded a contract of up to $1.39 billion to N3B in December 2017. BWX Technologies manages a total of eighteen "high-consequence" sites for the US government.

NNSA Established by Congress in 2000, the National Nuclear Security Agency is a semi-autonomous subagency of DOE that is responsible for DOE's nuclear weapons arsenal, nuclear nonproliferation, and naval reactor programs. The NNSA is currently engaged in a thirty-year effort ("mission") to modernize the US nuclear weapons stockpile and its related production infrastructure, at an estimated cost of $2 trillion. NNSA operates at nine sites in the US, including the Kansas City National Security Campus, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, the Naval Nuclear Laboratory, the Nevada National Security Site, the Pantex Plant, Sandia National Laboratories, the Savannah River Site, and the Y-12 National Security Complex.

NRC United States Nuclear Regulatory Commission. The NRC is a federal agency charged with protecting the public and the environment from nuclear materials used for non-military purposes. The agency's regulatory functions include the oversight of commercial nuclear power plants; the use of nuclear materials in medical, industrial, and academic settings; and the transportation, storage, and disposal of nuclear materials and waste.

The NRC was established in 1975 when Congress determined that the Atomic Energy Commission's program of "self-regulation"—a source of tremendous controversy since the 1960s—was deficient in numerous critical areas, including radiation protection standards, reactor safety and siting, and environmental protection (NRC).

In contrast to those set forward for DOE, the federal regulations governing radiological activities conducted under the Nuclear Regulatory Commission (10 CFR § 20) explicitly recognize (a) the role of technology in minimizing hazardous human exposures; and (b) the need to continually incorporate new technological advances into existing radiation dose reduction strategies. Under the NRC, an ALARA process by definition takes the "state of the technology" into account, in aiming for exposures as far below applicable regulatory limits as is practical (see glossary entry for *ALARA*).

Personal protective equipment (PPE) Forms of personal protective equipment in use at DOE sites include gloves, safety goggles, hazmat suits, and air-purifying respirators. In the field of occupational safety (see entries for *engineered* and *administrative controls*), PPE use is considered the least effective and reliable safety measure. DOE standards state that PPE should be implemented only when engineered and administrative controls cannot reduce hazards to acceptable levels. In some cases, PPE use can actually create hazards for workers, for example, when it slows the rate of work with radioactive or hazardous materials, increasing the duration of worker exposure.

PF-4 The LANL plutonium facility, where virtually all plutonium-handling operations at LANL are conducted. The approximately 233,000 square foot building, located at TA-55, began operations in 1978 (LANL 2018). At-risk nuclear materials at the facility include weapons-grade plutonium, heat source plutonium, tritium, highly enriched uranium, and smaller quantities of other transuranic isotopes (DNFSB 2019).

According to the Defense Nuclear Facilities Safety Board (see glossary entry), NNSA and LANL have for many years planned to upgrade the "active confinement" ventilation and fire-suppression systems at PF-4 to meet prevailing safety and seismic design requirements. These upgrades—which are clearly essential in a facility designated as "the Nation's Plutonium Center of Excellence"—are needed to protect workers and the public from hazards stemming from plutonium handling operations at PF-4.

The safety upgrades at PF-4 have recently taken on a further urgency, in light of impending new high-risk missions at the facility. Beyond the pit production mission, new high-hazard operations proposed for PF-4 include the increased production of plutonium oxide, and the receipt and repackaging of large quantities of heat source plutonium (Pu-238).

As of this writing, however, the safety and seismic upgrades long recommended for PF-4 have not been implemented. The substantial hazards associated with proposed new missions at the facility thus remain unmitigated. "PF-4's current safety control strategy," wrote DNFSB Chair Joyce Connery in an August 2022 letter to Secretary of Energy Jennifer Granholm, "is not commensurate with the safety risks of its expanding mission."

Rather than undertaking the recommended upgrades at PF-4, NNSA is opting to pursue a different safety strategy at the facility. Apparently, the PF-4 ventilation system will be upgraded to a state that, although more "robust" than that currently, will not meet related quality assurance, safety class, and seismic design requirements (DNFSB 2022). This new safety strategy for PF-4 will be less protective of both workers and the public, and implemented in contradiction to the DNFSB's expert advice.

As discussed on p. 3, the collective radiation dose (TED) at LANL in 2020 was the highest in the US nuclear weapons complex by far, and LANL was the only site where the collective radiation dose was increasing (see footnote 8). Activities contributing to collective dose at LANL in 2020 included: weapons manufacturing and related work at the TA-55 plutonium facility; plutonium-238 work; retrieval, repackaging, and shipping of radioactive waste; and Infrastructure support for radiological work and facility maintenance.

Plutonium A synthetically-produced metallic element with numerous isotopes, plutonium is a member of the actinide series of elements, which includes uranium, americium, and thorium. The principal isotopes encountered in military and non-military use in the US are Pu-238 and Pu-239. All plutonium isotopes are radioactive and fissile (fissionable), meaning that the atom's nucleus can be split when struck by a neutron, releasing immense quantities of energy. Pu-238, which generates significant heat when it undergoes radioactive decay, is used as an energy source for interplanetary probes and unmanned spacecraft. Pu-239 is the principal fissile material used in the manufacturing of nuclear weapons. Pu-239 (and its contaminant isotope Pu-240) are produced in plutonium production facilities and nuclear breeder reactors. Pu-238 has a half-life of 87.7 years, Pu-239 of 24,110 years, and Pu-240 of 6,561 years. Nuclear criticality is a concern when handling plutonium: when quantities in excess of the critical mass of the material are brought into physical proximity in certain configurations, a spontaneous, uncontrolled nuclear fission reaction ("critical excursion") may be initiated, emitting potentially lethal doses of radiation (NRC, EPA, CDC).

US plutonium production began in the 1940s during the Manhattan Project and continued throughout the Cold War. The US built and operated nine plutonium production reactors at Hanford, Washington and five at Savannah River, South Carolina from 1944 to 1988. Approximately 100 metric tons of plutonium was produced during this time (ASTDR). For occupational illness incurred at the Hanford site, and workers' struggles with the workers' compensation program there, see footnote 7.

Plutonium inhalation hazards. Pu-238, Pu-239, and Pu-240 emit alpha particles when they undergo radioactive decay. While alpha particles cannot penetrate the skin (and so present little health risk when outside the body), they are highly hazardous when taken into the body, e.g., through wounds or inhalation.

The machining of plutonium that is central to the production of plutonium pits generates vast quantities of minute plutonium particles (dust). When these particles are inhaled by workers, they are retained in the lung tissue. Here, they emit alpha particles that may damage or kill lung cells, leading to scarring of the lungs, lung disease, or cancer. Plutonium particles may also enter the circulatory system from the lungs and be transported to the kidneys, exposing the blood and kidneys to alpha radiation. Circulating plutonium particles are concentrated in the bones, liver, and spleen, exposing these organs to alpha radiation as well (EPA). Finally, many of the decay products of plutonium (uranium-235 for Pu-239, and uranium-236 for Pu-240) are unstable themselves and also undergo radioactive decay, further damaging tissues and organs (ATSDR 2010; Wikipedia).

Neutron emission hazards. Pu-238 and Pu-240 have relatively high rates of spontaneous fission (1000 times greater than Pu-239), and therefore pose neutron radiation and neutron activation hazards. *Neutron radiation* is a densely-ionizing form of radiation that is more damaging to biological tissues than other forms of radiation (see footnote 8). *Neutron activation* is the process by which neutron radiation induces radioactivity in exposed materials, including human tissues.

Flammability. Plutonium creates serious and highly unusual fire hazards in the settings in which it is handled. Especially when the material is present in finely-divided forms (e.g., chips, powders, and turnings), metallic plutonium is pyrophoric, meaning that it ignites spontaneously in air at ordinary temperatures (<150° C/ 300° F). Once ignited, plutonium metal burns at a temperature of 600° C/1110° F with little or no flame. The combustion reaction can be exceedingly difficult to extinguish (Fire Safety 2015). Plutonium is routinely handled in ultra-dry (<0.5 ppm of H_2O), reduced-oxygen conditions to minimize the risk of spontaneous ignition (Haschke 2000).

Other hazards. The moisture-enhanced corrosion of plutonium that occurs when the metal is exposed to air, for example, liberates a very fine (<10 micron) plutonium-containing powder that presents significant inhalation hazards to workers. Current knowledge of the chemistry of plutonium pyrophoricity and other hazardous phenomena encountered during the handling of plutonium, however, remains far from complete (Haschke 2000). Finally, plutonium, like many toxic heavy metals, may damage the kidneys (NBL 2020).

The United States Transuranium and Uranium Registries (USTUR) at Washington State University studies the effects of the deposition of actinide elements in the human body. The laboratory is located in Richland, Washington, near DOE's former plutonium production site at Hanford. Occupationally-exposed workers may donate their bodies and tissues to the registry (see glossary entry for *United States Transuranium and Uranium Registries*). The fact that plutonium exists in numerous chemical forms and isotopic compositions vastly complicates epidemiological studies of plutonium-exposed populations.

Plutonium pit A precision-machined component used to trigger the detonation of a nuclear weapon. Many modern pit designs feature a hollow sphere of plutonium (the fissile material) surrounded by a neutron reflector machined from beryllium. The neutron reflector functions to bounce neutrons back into the fissile core, increasing the destructive power of the weapon.

Remote-handled TRU Packaged *transuranic waste (TRU)* is classified into two categories based on the intensity of the radiation (dose rate) at the surface of the waste container. Contact-handled TRU (CH-TRU) waste has a surface radiation dose rate of ≤200 millirem/hr, and *remote-handled TRU* (RH-TRU) waste, of >200 millirem/hr (102nd Congress 1992). Remote-handled TRU waste contains neutron activation and fission products (e.g., cobalt-60, plutonium-241, strontium-901, and cesium-137), some of which emit gamma radiation that can penetrate the walls of waste containers and human skin. RH-TRU waste handling therefore requires heavy shielding and remote handling methods (NAS 2000). Beyond its radiological characteristics, RH-TRU waste may also pose toxic and explosive hazards to workers. See *transuranic waste (TRU)* and *contact-handled TRU.*

Safety equipment breaches and failures For decades, DOE facilities have relied on safety equipment such as PPE, gloveboxes, radiation monitors, and HEPA filtration to protect individuals who work directly with (or in close proximity to) radioactive, toxic, or hazardous materials (see *highly-exposed human labor*). Although such measures are ubiquitous in DOE facilities, they are far from infallible, and equipment breaches and failures that put workers' lives at risk are tragically common in the DOE complex.

Respirator failures. At the former Plutonium Finishing Plant at Hanford, for example, an estimated 560 cleanup workers unwittingly wore air-purifying respirators (PPARs) with defective (improperly-sealing) filter cartridges between 2012 and 2016 (see p. 3). The cartridges had been modified by the site contractor, CH2M Hill, because they tended to be dislodged from the respirators when workers maneuvered in tight spaces. The modification prevented the filter cartridges from sealing properly, leaving workers at risk of exposure to airborne radioactive particles and VOCs. Other workers at the site received respirator units that were prone to sudden battery failure. Yet another worker's respirator failed in 2010 when the filter cartridges came into contact with a small quantity of nitric acid, one of nearly a hundred hazardous chemicals present at the site. The worker required four surgeries to repair his esophagus and never returned to work (Malone 2020).

Faulty air monitoring systems. Demolition of the heavily-contaminated Plutonium Finishing Plant near Richland, Washington began in 2017. The project, which involved open-air demolition activities and removal of the resulting rubble, was managed for DOE by contractor CH2M Hill. In December of 2017, analysis of air samples collected at sites outside the demolition zone by the Washington State Department of Health revealed the presence of airborne plutonium, americium, and other contaminants that were clearly linked to demolition activities at the plant. (The Washington State Department of Health has monitored the environment in and around the Hanford Site for radioactivity for several decades to independently verify measurements taken by the Department of Energy.)

Although airborne plutonium and americium were detectable at WSDOH sampling sites located up to ten miles away, they somehow went undetected by the continuous air monitoring system in use at the demolition site itself. Bioassay (urine and fecal) data obtained from the several hundred Hanford cleanup workers who requested monitoring revealed that more than 40 had suffered internal intakes of the radioactive contaminants. Radioactive particles were also carried offsite, including to workers' homes, via contaminated government and private vehicles. The incident triggered an investigation by DOE and a nine-month work stoppage by CH2M Hill.

As has been the practice at many sites in the DOE complex, officials at the Hanford Finishing Plant relied on continuous air monitoring systems to detect airborne radioactive contaminants, and to rapidly alert workers of hazardous conditions. Although the continuous air monitoring system at the Finishing Plant was functioning properly in June 2017 (when radioactive particulates triggered the alarm, leading 350 workers to shelter in place), the plutonium and americium releases in December 2017 went undetected.

Both technical and management failures seem to have contributed to the internal contamination of workers in this incident, with the actions of the site contractor compounding the apparent malfunction of the continuous air monitoring system. Officials at CH2M Hill, placing their full confidence in the continuous air monitoring system, appear to have ignored data from workers' lapel samplers that showed elevated levels of airborne radioactive contaminants in early December. Lapel samplers, which monitor a worker's breathing zone rather than the work area as a whole, are considered the most accurate measure of exposure to airborne contaminants (Bernton 2017, 2018a, 2018b; Cary 2018; AP/King5News 2018).

In 2019, DOE issued CH2M Hill a citation for violations associated with the spread of radiological contamination outside the "established radiological boundary" of the Plutonium Finishing Plant at Hanford. Because DOE had previously reduced CH2M's 2017-18

contract fees (annual performance bonuses) by $2.8 million for violations in association with the incident, the agency chose not to impose any civil penalties in the matter (DOE 2019).

Although DOE cited CH2M Hill for radiological threats that the company's actions posed to the general public, the agency took no steps to penalize the company for the willful endangerment of the hundreds of individuals who were actively involved in demolition at the site. Nor was the contractor held accountable in any meaningful way for actions that caused dozens of individuals to suffer internal contamination with plutonium. (Indeed, CH2M Hill leveraged its reputation and experience in nuclear waste cleanup to negotiate the company's $3.3 billion acquisition by Jacobs Engineering in 2017) (Jacobs 2017).

The total penalty imposed on CH2M Hill for its actions at the Finishing Plant—negligence, willful endangerment, and subsequent injury of workers—therefore amounted to a negligible reduction, on a percentage basis, in the annual performance bonuses earned by the contractor. If the penalty imposed in this case is representative of penalties imposed in cases of this nature more generally, DOE contractors clearly have little financial incentive to reform long-entrenched yet indefensible work practices, including the reliance on highly-exposed human labor.

Legislation recently passed by the state of New York (S621B) will impose substantial penalties on general contractors whose negligence leads to the injury of workers (see the discussion of *Carlos' Law* on p. 38). To encourage DOE contractors to reform deficient work and safety practices, similar legislation should be enacted in states where DOE nuclear weapons research and production facilities are located, including New Mexico and South Carolina.

Glovebox breaches. A glovebox is a stainless steel enclosure fitted with gloves and a radiation-shielding viewing window (see p. 8). Gloveboxes are used in DOE facilities to confine and contain operations involving acutely hazardous materials. A *glovebox breach* is an incident in which an element of the sealed glovebox system is compromised, allowing the hazardous materials within to escape the system. Glovebox breaches in nuclear weapons facilities may rapidly and unexpectedly contaminate nearby workers with beryllium, plutonium, and other hazardous substances. The majority of glovebox breaches involve rips, tears, or punctures of the gloves—the weakest, most exposed, and most frequently-manipulated components in the system.

Glovebox breaches, an ongoing problem at LANL despite numerous initiatives to curb them, are a regular occurrence at LANL's plutonium facility, TA-55/PF-4. A glovebox incident involving a LANL plutonium machinist in 2007, for example, resulted in an internal intake of plutonium that required chelation therapy. The machinist was wearing full-body radiological PPE (coveralls, taped latex gloves, booties, and safety glasses) at the time. This incident was the second in 2007 at LANL that involved a puncture wound and internal contamination of a worker with plutonium (LANL 2007). A 2018 incident involving a worker who was performing maintenance on a glovebox at PF-4 resulted in an internal intake of Pu-238 (heat-source plutonium) through a wound. Because plutonium is sequestered in bone in the human body, this intake led to an 118.5 rem (not millirem) committed dose to bone (LANL 2018). Finally, a 2020 breach in a glove at PF-4 resulted in contamination of a worker with Pu-238 that required chelation therapy, and dispersed radioactive materials throughout the facility. Fourteen other individuals who were working in the area at the time were required to monitor for internal intakes of plutonium as well. Following the 2020 incident, a spokesperson stated that the NNSA was "constantly exploring ways to assure glove integrity and quality." Glovebox breaches, he admitted, remained "a continual challenge" at LANL's plutonium facility. (DOE 2007, 2018, 2020; Los Alamos Reporter 6 July, 8 July, 8 Oct 2020; Cournoyer 2009, 2011; DNFSB 2020).

Much of the safety equipment that is used in nuclear weapons facilities has seen little refinement since the twentieth century and the earliest days of work with radioactive materials. The plutonium glovebox, for example, which dates from the 1940s, is recognized by historians as "among the first and most rudimentary tools of nuclear science." The fundamental design of the glovebox has remained essentially unchanged since the 1940s: workers are still positioned mere inches away from acutely hazardous materials, and the gloves, always the most vulnerable element of the system, remain prone to failure. As historian of science Maria Rentetzi noted in 2017, gloveboxes have created "what often proved to be an illusion of a safe work environment" for those working with radioactive and hazardous materials in nuclear weapons facilities (Rentetzi 2017).

DOE contractors routinely stake workers' health and safety on equipment such as gloveboxes, respirators, and air monitoring systems. Indeed, equipment that is designed to facilitate direct work with hazardous materials (see *highly-exposed human labor*) is curiously celebrated by DOE officials. The traveling "Challenge Tomorrow" trailer that LANL recently developed to share "fun, hands-on STEM activities" with local youth, for example, prominently features a 55-gallon waste drum, a plutonium glovebox, and several sets of full-body PPE.

Billed as a "traveling STEM experience," the brightly-colored trailer offers opportunities to "try out tools exactly like the ones being used here at the Lab," while distributing information about frontline jobs at LANL. Launched in July 2022, the Challenge Tomorrow trailer has since traveled to the Tewa-speaking community of Ohkay Owingeh for an event involving students from the Ohkay Owingeh Community School (K-6) and Pojoaque Middle School; and to a youth STEM event hosted by Big Brothers Big Sisters of Central New Mexico (*Los Alamos Reporter* 8 Dec 2021; LANL 5 Oct 2022, 1 Nov 2022).

Solvents, organic Broadly defined as organic chemicals that can dissolve or disperse other substances, organic solvents have been used in nuclear weapons development and production since the earliest decades. Applications of organic solvents in the nuclear weapons complex include weapons component manufacturing, chemical synthesis, and cleaning and maintenance of parts, tools, machinery, and work areas. Organic solvents pose significant hazards to workers as a result of (a) their general flammability; and (b) the wide range of adverse health effects associated with their inhalation, ingestion, or dermal absorption.

The Rocky Flats Plant outside Denver, Colorado was the principal site of plutonium pit production in the US from 1952 to 1989. Various organic solvents (i.e., halogenated hydrocarbons) were used at Rocky Flats to clean machined plutonium turnings as part of the pit production process. These solvents (and their associated hazards) included: *carbon tetrachloride* (CNS depressant, liver and kidney toxin, suspected carcinogen); *tetrachloroethylene* (neurological effects, liver damage, known cause of kidney cancer, liver cancer, non-Hodgkin's lymphoma); and *Freon TF* (hazards to human and aquatic life, destruction of the ozone layer).

In 1988—a year before the FBI and the EPA raided Rocky Flats for criminal environmental violations—the estimated annual usage of the above solvents at the plant was: carbon tetrachloride, 10,000 gallons; tetrachloroethylene, 3,500 gallons; and Freon TF,

4,500 gallons, for a total estimated usage of 18,000 gallons of per year, for that one aspect of pit production alone (Davenhall 2011). Given the adverse impacts on human health of even minute quantities of these solvents, the volumes once in use at Rocky Flats are staggering.

Efforts are currently underway to begin the large-scale production of plutonium pits at LANL's plutonium facility, PF-4 (see glossary entry). Examples of organic solvents in known past or current use at PF-4 include benzene, carbon tetrachloride, methyl chloride, methyl ethyl ketone, n-hexane, tetrachloroethylene ("perc"), toluene, 1-1-1-trichlorethane, trichloroethylene (TCE), and tricholoromethane (EEOICP data).

Beyond presenting serious occupational hazards for current workers in the nuclear weapons complex, organic solvents create significant risks to workers involved in DOE site remediation as well. According to a recent report from DOE-EM, the use of organic compounds in the nuclear weapons complex in past decades now poses serious challenges to site remediation and cleanup. These challenges include the possibility of uncontrolled exothermic (heat-generating) reactions, and the production of ignitable gases and vapors that endanger workers involved in site remediation. Many organic chemicals at DOE sites undergo "unexpected, undetected, and even unexplainable" changes and interactions in waste processing and ecological systems. These chemical interactions vastly complicate DOE-EM's cleanup efforts (DOE-EM 2018).

Transuranic waste (TRU) Waste material contaminated with transuranic elements, i.e., synthetic radioactive elements that have atomic numbers higher than uranium in the periodic table, including neptunium, plutonium, americium, and others (NRC). All transuranic elements are unstable and undergo radioactive decay.

Transuranic waste is produced during nuclear weapons research, production, and testing, and during the reprocessing of spent nuclear fuel. TRU waste includes tools, equipment, and protective clothing used in these processes (EPA). The Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico is the only permanent geologic repository for transuranic waste in the world. The WIPP facility was designed to have a TRU waste disposal capacity of 6.2 million cubic feet (DOE/WIPP 2006). See glossary entries for *contact-handled TRU* and *remote-handled TRU.*

Triad National Security A limited liability company comprising the Battelle Memorial Institute, the Regents of the University of California, and the Regents of Texas A&M University. Triad was awarded the 10-year LANL Management & Operations (M&O) contract by NNSA in November 2018. The contract was initially valued at $25 billion ($2.5 billion over ten years), but Congressional appropriations for LANL have increased substantially during the last several years.

Tritium A radioactive isotope of hydrogen (hydrogen-3) that is used to enhance the destructive power of modern nuclear weapons. Extremely rare in the natural (terrestrial) environment, it can be produced at great cost ($30,000/gram) in nuclear reactors and high-energy accelerators. Tritium may be released as steam from these facilities, or may leak into the underlying soil and ground water (EPA). Tritium, a weak beta emitter, reacts readily with oxygen to form tritiated water (HTO). When it is ingested, inhaled, or absorbed through the skin, HTO is rapidly distributed throughout the body, especially to water-laden structures such as soft tissues and organs.

The health hazards associated with tritium ingestion depend on its biochemical form. While the majority of any volume of tritiated water (HTO) that is ingested into the human body is excreted within several weeks, some fraction will be incorporated into metabolically-active cells and tissues, and thus become organically-bound tritium (OBT). OBT is retained in the body for a much longer period than is HTO, and because tritium has a half-life of 12.3 years, may continue to damage adjoining cells and tissues for years.

When tritium is released into the environment, some fraction will be retained as OBT by wild and domestic plants and animals. This OBT can harm both the tritium-exposed plants and animals, and any living beings, including humans, that subsequently consumes them.

United States Transuranium and Uranium Registries The United States Transuranium and Uranium Transuranium Registries (USTUR) was established at Washington State University to study the effects of the deposition of the actinide elements in the human body. The laboratory is located in Richland, Washington, near the former DOE plutonium production site at Hanford. Occupationally-exposed workers may donate their bodies and tissues to the laboratory registry.

The USTUR grew out of autopsy studies initiated in 1949 at Hanford, and later postmortem sampling of occupationally-exposed individuals at Rocky Flats. Workers at LANL initiated plutonium studies in the general population in 1959, as did the US Public Health Service in the early 1960s. The Hanford Environmental Health Foundation established a National Plutonium Registry in 1968, and immediately began recruitment of registrants. The Plutonium Registry became the United States Transuranium Registry (USTR) two years later, to reflect the program's interest in the biological effects of the transuranic elements americium, uranium, and thorium. USTR worked to identify "work sites containing suitable populations" and established agreements with these sites "such that recruitment could begin." By 1974, more than 5,800 transuranium workers had been identified, about two-thirds of whom had released their medical and health physics records, and about 800 of whom had given permission for autopsy. At that time, "a total of 45 autopsies had been carried out, two-thirds (30) on Rocky Flats Facility workers" (USTUR).

A parallel registry, the United States Uranium Registry (USUR), was established in 1978 with a focus on occupational exposures in the US uranium mining and milling industries and associated health hazards. The two registries formally merged to become the USTUR in 1992 (USTUR). The National Human Radiobiology Tissue Repository (NHRTR), a tissue collection associated with the Registries, houses tissue samples from USTUR registrants who were occupationally exposed to plutonium, americium, and/or uranium. According to USTUR, available materials at the NHRTR also include tissues from "acquired collections, such as Argonne National Laboratory's radium worker studies and population studies carried out by Los Alamos Scientific Laboratory" (USTUR).

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