A Comparison of Two Potential Repositories:
The Waste Isolation Pilot Plant
and
Yucca Mountain

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I. Defense and Commercial Repositories

For over 20 years, the United States and other countries have been exploring the possibility of disposing radioactive waste in deep geologic formations. An excavation within these formations, called a repository, would hold wastes from the production of nuclear weapons and wastes from the production of electricity by commercial nuclear power plants.

Although the defense and commercial wastes differ in their chemical and radiological composition, they could go to the same repository. Indeed, some countries, such as France and China, plan to build only one repository for both types of waste. For political reasons, however, the United States has decided to build two repositories: one entirely for defense waste and the other primarily for commercial waste.

Ninety seven percent of the defense waste consists of laboratory items, such as rags, rubber gloves, shoe covers, cloth lab coats, plastic bags, laboratory glass, tools and machinery, that are contaminated with transuranic (TRU)¹ elements: elements that are heavier than uranium and contain "more than 100 nanocuries of alpha-emitting isotopes, with half lives greater than twenty years, per gram" (EPA, 1985). Unless inhaled or ingested, alpha particles are not considered dangerous because they cannot penetrate skin or even a sheet of paper. Safely stored in metal containers, most defense waste can be contact-handled, i.e., safely handled by workers without protective clothing. Nevertheless, the waste's TRU activity persists for thousands of years. For example, the half life of plutonium 239 is 24,000 years. Consequently, defense waste needs a repository's security and the United States may build this defense repository, or "Waste Isolation Pilot Plant" (WIPP) near Carlsbad, New Mexico.

About ninety percent of the waste destined for the commercial repository consists of the spent nuclear fuel, which is sometimes called high-level radioactive waste (HLW), taken from nuclear power plants. The other ten percent comes from the defense program. Spent fuel contains a wide variety of radioactive isotopes that are generated in nuclear fission (fission products), activation of lighter isotopes (activation products) and neutron capture by the heaviest metals (e.g., actinides, which include TRU elements). The gamma radiation emitted by fission products, such as cesium and strontium, can penetrate metal and concrete, making it far more dangerous than TRU-contaminated waste. Spent fuel must be handled remotely and obviously needs a repository's security. The United States may build this commercial repository at Yucca Mountain which is located about 100 miles northwest of Las Vegas, Nevada.

¹ The report uses the terms, "defense waste" and "TRU wastes" interchangeably.

II. Repositories Are Needed

After four decades of defense activities, such as nuclear weapons production and the operation of nuclear-powered submarines, 2.3 million cubic feet (DOE, 1993a) of TRU waste has accumulated where it was generated. All of this waste is destined for WIPP whose legal capacity is 6.2 million cubic feet. Ninety seven percent of defense waste (the portion that can be contact-handled) is packaged in 55-gallon steel drums or in metal boxes. The older packages have started to corrode and soon must be taken to WIPP or replaced.

Although well below the legal capacity, the current WIPP inventory does not include the waste that will be generated when the U.S. Department of Energy (DOE) decontaminates and decommissions (D&D) its defense complex. The D&D waste could easily exceed the current inventory. For example, to decontaminate one room at Rocky Flats, Colorado, would create a volume of waste that exceeds the volume of the room. Without WIPP, the DOE cannot clean up its defense complex.

Likewise, the safe and permanent disposal of spent fuel has been a matter of concern ever since a nuclear reactor in Shippingport, Pennsylvania, began producing the first commercial electricity in 1957. Early expectations were that all spent fuel would be chemically reprocessed to recover usable uranium and plutonium, and a residual waste, whose volume would be less than spent fuel, would go to a repository.

In the 1970's, however, government policy towards reprocessing took an abrupt turn when President Carter signed an Executive Order that discouraged private enterprises from investing in reprocessing. Shortly afterwards, a modern fuel reprocessing facility, constructed in Barnwell, South Carolina, was abandoned along with plans for at least one other.

Without reprocessing, U.S. utilities were forced to store more spent fuel for longer periods of time. At the end of 1984, 86 commercial nuclear power plants were operating throughout the United States. Spent fuel containing approximately 10,000 metric tons of heavy metal (MTHM) had already been discharged from the plants (DOE, 1985). By 1990, the spent fuel inventory had reached 21,868 MTHM, and by 2040 may reach 86,049 MTHM (ORNL, 1992).

Although the commercial repository is not needed so urgently as the defense repository, the DOE has a contract with utilities to accept their spent fuel by the year 1998. If utilities must store their waste beyond 1998, they must do so at their own expense. A DOE default would, to say the least, annoy the utilities. The utilities have financed the repository program and by 1998 the cost will probably exceed \$4.5 billion (DOE, 1991a).

Besides the utilities, Congress did not anticipate the rapid accumulation of spent fuel. In 1982 Congress² directed the DOE to start constructing a repository by January, 1993, and set the repository's capacity at 70,000 MTHM³, which is 27,000 MTHM⁴ below the projected inventory.

The U.S. Nuclear Regulatory Commission (1990) believes that spent fuel can be safely stored at a reactor for at least 30 years after its operating license expires. For the older reactors, such as Dresden I which was permanently shut down in 1978, the 30 years of safe storage will expire early in the twenty first century. The DOE (1989) believes that it can begin operating a repository at Yucca Mountain in 2010, but the General Accounting Office (1993) predicts a delay of at least 5 to 13 years. Thus it appears that the 30 years of "safe storage" of spent fuel at some reactors will expire well before a repository opens.

² Nuclear Waste Policy Act of 1982

³ The repository's capacity can exceed 70,000 MTHM if the DOE builds a second repository. However, neither the DOE or Congress currently anticipate a second repository.

⁴ Includes 16,000 MTHM of spent fuel and 11,000 MTHM of defense HLW.

III. The Waste Isolation Pilot Plant and Yucca Mountain

The WIPP facility has been constructed in southeastern New Mexico (Figure 1), 26 miles east of Carlsbad. If certified by the U.S. Environmental Protection Agency (EPA), it will hold the nation's defense waste. The site encompasses 10,240 acres in a sparsely populated area, with about 96,000 people living within 50 miles of the facility. On the surface, a waste handling building would prepare the wastes for transfer underground. A 12-acre excavation for conducting experiments lies 2150 feet below the surface in a bedded salt formation. When completed, the repository area would cover 100 acres giving it the capacity to store 850,000 drums of TRU waste (DOE, 1993a).

The Yucca Mountain facility has not progressed nearly so far as WIPP. If licensed by the NRC, it will hold primarily commercial waste and will be located in southern Nevada (Figure 2), 100 miles northwest of Las Vegas. The site, whose exact boundaries have not yet been established, lies in a sparsely populated area, with about 12,000 people living within 50 miles of the facility. In 1993, the DOE began constructing an exploratory studies facility (ESF). The ESF will comprise two access ramps and 76,900 feet of tunnel (approximately 44 acres) and will lie 800 to 900 feet below the surface in a welded tuff formation. When completed, the repository area would cover 1,600 acres (DOE, 1993b and 1993c).

Neither WIPP nor Yucca Mountain have been approved to receive radioactive waste for disposal or even testing. The approval process, which will be discussed later, is in many ways more challenging than building and operating the repositories.

FIGURE 1
WIPP Location Map

FIGURE 2

Yucca Mountain Location Map

IV. Public Laws

Written by Congress, public laws provide the basis for the nation's federal programs. Two public laws were written specifically for WIPP and three for Yucca Mountain.

Laws for WIPP

"The Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1980" (Public Law 96-164) authorized DOE to construct WIPP. This law exempted WIPP from outside regulators. After WIPP was constructed, Congress passed a second law: "The Waste Isolation Pilot Plant Land Withdrawal Act of 1992" (Public Law 102-579). This law subjected WIPP to outside regulators.

Caught between these contradictory laws, WIPP must now conform to an oversight that did not exist when the facility was conceived and constructed. Before operations can begin, the WIPP must retrofit its past and cast its future decisions in a way that will comply with four regulations: two regulate the hazardous components of defense waste and two regulate the radioactive or TRU components. The next chapter concentrates on the three regulations administered by the EPA: 40 CFR 268, "Land Disposal Restrictions"; 40 CFR 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes"; and 40 CFR 194, compliance criteria which are currently being developed.

Laws for Yucca Mountain

The Nuclear Waste Policy Act of 1982 (Public Law 97-425) authorized the DOE to construct one and if necessary two commercial repositories. Although touted as "the first comprehensive legislation for the management of high-level waste in the history of the United States" (DOE, 1985), the site-selection process was so expensive that five years later, the law had to be abbreviated. Directed by this law, the DOE issued guidelines for selecting repository sites; identified nine sites as potentially suitable for characterization; nominated five sites for characterization; prepared an Environmental Assessment for each of the nominated sites; selected three sites for characterization; and prepared a Site Characterization Plan for each of the selected sites. After characterizing at least three sites, DOE would recommend one to the President. If the President approves and Congress overrides a state veto (if any), the repository must then be licensed by the NRC. This entire process would have to be repeated for a second repository.

Later Congress realized that it would be extremely expensive to characterize three sites--approximately \$18.3 billion based on DOE's (1991a) estimate for Yucca Mountain; so in 1987 Congress amended the Nuclear Waste Policy Act. The amendments streamlined the procedural process. It stopped efforts to find a second repository and dropped two of three sites selected for characterization. The remaining site was Yucca Mountain. The

amendments did not change the regulatory process. The original act had directed the EPA and the NRC to issue repository regulations which they did in 1985 and in 1983. After seven years of review, however, the regulations were found inadequate, so Congress passed another law.

The Energy Policy Act of 1992 attempts to streamline the Yucca Mountain Project further by directing the EPA and the NRC to improve their repository regulations. With assistance from the National Academy of Sciences, the EPA must issue its regulation by 1995. The NRC must issue consistent regulations within the following year. The next chapter discusses these regulations.

Comparison of the WIPP and Yucca Mountain Laws

The public laws seem to be moving the WIPP and the Yucca Mountain Project in opposite directions: as WIPP becomes complex, Yucca Mountain becomes streamlined. Specifically, the WIPP began in 1980 without any regulations or approval procedures, and since 1992 must conform to a complex array of requirements and unsettled procedures. Conversely, the Yucca Mountain project began in 1982 with a complicated set of regulations and procedures. The 1987 law greatly abbreviated the siting procedures and the 1992 law promises more reasonable regulations. The next chapter elaborates on these points.

V. Regulations

Table 1 lists the major regulations that govern WIPP. In 1980, when DOE started constructing WIPP, these regulations did not exist. Then in 1985, the EPA issued radiation standards, 40 CFR 191, that applied to WIPP but would be administered by DOE⁵. In 1992, however, Congress directed EPA, rather than DOE, to administer 40 CFR 191 (i.e., certify that DOE complies with 40 CFR 191) and write another regulation, 40 CFR 194, that would provide technical and procedural criteria for certification. The EPA (1993a) expects to issue these "compliance criteria" on October 28, 1994.

Table 1

WIPP Regulations

Regulation	Topic	Regulator
40 CFR 191	TRU Waste (general standards)	EPA
40 CFR 194 (scheduled for 10/94)	TRU Waste (compliance criteria)	EPA
40 CFR 264, Subpart X	Hazardous Waste (operations)	State of New Mexico
40 CFR 268.6	Hazardous Waste (disposal)	EPA

In addition to the nuclear regulations (40 CFR 191 and 194), the WIPP must also comply with hazardous wastes regulations. In 1987, the DOE announced that WIPP is a hazardous waste facility and therefore subject to the Resource Conservation and Recovery Act (RCRA). Two RCRA regulations apply to WIPP: 40 CFR 264, Subpart X and 40 CFR 268.6.

The EPA's "Land Disposal Restrictions" (40 CFR 268) discourage land disposal of hazardous wastes unless the waste is treated. The DOE, however, plans to dispose of untreated waste at WIPP. To do so, DOE needs a "no migration" variance that would be issued per 40 CFR 268.6. The EPA can render these variances ". . . to allow the land disposal at a particular facility of specific, prohibited wastes not meeting the treatment standards established by EPA" (EPA, 1992). The EPA has granted these variances to industry, provided that the applicant demonstrates that the waste will not migrate for as long as it remains hazardous, or in some cases like WIPP, for 10,000 years.

⁵ A court remanded the 1985 standards in 1987, Congress reinstated all but two of the provisions in 1992, and the EPA revised the provisions and issued the regulation in December, 1993. The 1985 standard also applied to Yucca Mountain, but the 1993 standard does not.

Table 2 lists the major regulations that govern the Yucca Mountain Project. These regulations differ from WIPP's in two important ways:

- (1) All the Yucca Mountain regulations, including the EPA regulation, 40 CFR 191, are implemented and enforced by the U.S. Nuclear Regulatory Commission (NRC); and
- (2) The DOE does not consider spent nuclear fuel to be "hazardous." Therefore, these wastes have not been subjected to RCRA regulations.

Table 2 does not include state regulations that require environmental permits. The Yucca Mountain Project has currently acquired some fifty six permits (TRW, 1993) and will probably need more before site characterization ends.

Table 2
Yucca Mountain Regulations

Regulation	Topic
10 CFR 2	Licensing procedures and information management
10 CFR 19	Notice of potential radiological hazards
10 CFR 20	Radiological protection standards during repository operations
10 CFR 21	Reporting of defects and noncompliance
10 CFR 50 (Appendix B)	Quality Assurance Criteria
10 CFR 51	Environmental Impact Statements
10 CFR 60	Procedural and technical criteria for licensing a repository ⁶
10 CFR 61	Disposal of low-level (greater than class C) waste in a repository
10 CFR 71	Packaging and transportation of radioactive waste
40 CFR 191	General EPA standards incorporated into 10 CFR 60 ⁶

⁶ These regulations will change based on recommendations from the National Academy of Science.

The regulations pose common problems to WIPP and Yucca Mountain. Both repositories could release harmless concentrations of gases at a rate that approaches regulatory limits. These limits apply at inconsistent and inappropriate boundaries. The regulations also force WIPP and currently Yucca Mountain to predict the unpredictable outcome of human intrusion. And both repositories must comply with criteria that do not necessarily contribute to a repository's overall safety. Table 3 lists these issues and the remainder of this chapter elaborates.

Table 3
Common Regulatory Issues

Issue	WIPP	Yucca Mountain
Harmless concentrations of gases violate regulations	Volatile Organic Compounds (40 CFR 268)	Carbon-14 Dioxide (40 CFR 191)
Inconsistent regulatory boundaries	Disposal Unit (40 CFR 268) & Accessible Environment (40 CFR 191)	Accessible Environment (40 CFR 191)
Must predict the unpredictable	Human Intrusion (40 CFR 191)	Human Intrusion (40 CFR 191)
Compliance criteria do not ensure overall safety	EPA Compliance Criteria ⁷ (40 CFR 194)	NRC Performance Objectives (10 CFR 60)

Harmless Concentrations of Gases Violate Regulations

Some of the waste within WIPP would decompose to volatile organic compounds (VOC) and migrate as gases. Microbial degradation of cellulose, rubber and other organic waste would generate VOC's such as carbon tetrachloride, methylene chloride and trichloroethane (EPA, 1990). Also corrosion of metal would generate inorganic gases such as ammonia, hydrogen and nitrogen. Other mechanisms, however, tend to diminish gas concentrations. Microbes will also degrade the VOC's, and passivation of carbon steel along with the accumulation of corrosion products on metal surfaces would inhibit gas generation.

⁷ Although the EPA has not yet proposed 40 CFR 194, EPA (1993b) suggests that the regulation may be similar to 10 CFR 60.

While gases could theoretically be generated, only an imperceptible amount would penetrate 2100 feet of salt and escape to the surface. Still, the VOC's could violate 40 CFR 268.6 without ever reaching the surface. If the gases rise only 1,000 feet in 10,000 years, they would cross the EPA's "unit boundary" and breach the terms of WIPP's no migration variance (see next section). If the WIPP's neighboring oil and gas wells were subject to the same variance, they could not operate.

Likewise, spent fuel within Yucca Mountain would release carbon-14 in a gaseous form, most likely carbon-14 dioxide. This results from the occurrence of carbon-14 in spent fuel, its relatively long half-life (5,730 years), its proclivity to enter the gaseous state as carbon dioxide, and the rapid transport of gases through the unsaturated zone (Van Konynenburg, 1991; Ross, 1992; Ross, et al., 1992; and Park, 1992).

The EPA standards (40 CFR 191) limit carbon-14 releases to an average of 0.7 curies per year (assuming 70,000 MTHM). Unlike the limits for VOC's, however, these apply at the land surface. To put the 0.7 curies in perspective, a typical nuclear power plant releases, without any regulatory restriction, approximately 10 curies of carbon-14 each year, and a typical reprocessing plant approximately 850 curies. Moreover, carbon-14 is part of our daily diet, and is present abundantly in nature (global inventory is 230 million curies) (DOE, 1992a). If the repository's entire inventory of carbon-14 dioxide were released in just one year--a clear violation of the regulations--a maximally exposed individual would receive less than 0.5 mrem. During the same year, this individual would receive 360 mrem from background radiation (U.S. average) and 1.3 mrem from the carbon-14 otherwise present within his or her own body. To meet the regulations, thousands of waste containers must retain carbon dioxide for a time on the order of 10,000 years. These durable containers could increase repository costs by approximately \$3.2 billion (Pflum, 1993a).

Inconsistent Regulatory Boundaries

Under the terms of WIPP's no migration variance⁸, VOC's cannot migrate past a "unit boundary." The concept of a unit boundary was conceived for disposal facilities, such as surface impoundments, landfills and waste piles, that lie at or just below the ground surface. The EPA (1992) defines the boundary to include the outermost extent of the engineered barrier(s), such as a liner, ditches or berms, that contain the waste. If the wastes are not enclosed, the unit boundary includes the downwind edge of the disposal unit at a height of 1.5 meters, the typical height at which humans could inhale hazardous material. The WIPP, however, lies 2100 feet below the ground. Consequently, the EPA (1990) moved the unit boundary 1000 feet underground and thereby denied DOE full credit for the geology directly above the repository (see Figure 3).

Unlike the VOC's, radioactive releases from WIPP and Yucca Mountain cannot exceed limits established for the "accessible environment." As defined in 40 CFR 191, the accessible environment includes the air above the repository and all the lithosphere that lies

⁸ The EPA (1990) issued a variance that would allow WIPP to test with radioactive waste. This variance dictated where the unit boundary would be located.

5 kilometers beyond the repository (EPA, 1985). The "unit boundary," however, does not include the air above the WIPP repository. Unlike the unit boundary, the accessible environment gives DOE credit for all the geology directly above the repository. The DOE, however, constricted the size of WIPP's controlled area (i.e., moved the accessible environment closer to the repository) so that the controlled area coincides with the land area that has been legally withdrawn (Figure 3). Still, this constricted controlled area encompasses more geology than the unit boundary.⁹

Predicting the Unpredictable

In the course of 10,000 years, natural disturbances would not jeopardize the WIPP's security (DOE, 1993a). Nevertheless, the EPA standards penalize WIPP if humans could exhume more waste than the regulations allow. In some of WIPP's worst cases, releases caused by humans could violate the standards.

The standards provide the worst case for human intrusion. Performance assessments can assume that ". . . the likelihood of such inadvertent and intermittent drilling need not be taken to be greater than 30 boreholes per square kilometer of repository area per 10,000 years for geologic repositories in proximity to sedimentary rock formations . . ." (40 CFR 191, Appendix B). When applied to the Delaware Basin, this assumption yields 900,000 boreholes per 10,000 years of which 15 would penetrate the WIPP facility (Guzowski, 1991).

The New Mexico Attorney General (Udall, 1993) claims that drilling frequency at WIPP would be at least ten times higher than the EPA's worst case, and the New Mexico Environmental Evaluation Group (1993) claims that the frequency would be almost 18 times higher. The Attorney General reports that in the two-mile band surrounding the WIPP site, 63 boreholes have been drilled since 1977, making the *actual* drilling rate in that area 340 holes per square kilometer per 10,000 years. The EEG reports that within the same area, 99 wells have been drilled since 1978, making the *actual* drilling rate 530 holes per square kilometer per 10,000 years. Thus, depending upon how the data are manipulated, the "worse case" for human intrusion could be 15 to 265 hits per 10,000 years.

The standards further require that the probabilities and consequences of human intrusion be combined with those of natural disturbances into a single "complementary cumulative distribution function" (CCDF). Because human intrusion is the dominant contributor to the CCDF, the WIPP would be approved or rejected under the standards on the basis of the probabilities and consequences of certain human intrusion scenarios. Yet the probabilities are, in the EPA's (1982 and 1985) words, "not very meaningful" and "only [a] guess."

⁹ As defined by EPA, the controlled area encompasses 100 square kilometers or 38.6 square miles. The land withdrawal area encompasses 16 square miles.

FIGURE 3
Regulatory Boundaries

If a human should inadvertently drill into the WIPP repository and strike a brine pocket below the repository, the brine could carry radionuclides to the Culebra groundwater which lies above the repository horizon (Bertram-Howery, et al., 1990). Without human intrusion, however, radionuclides would not reach the Culebra. Since the impacts of human intrusion are critical to the WIPP's compliance with 40 CFR 191, regional and local groundwater flow within the Culebra formation are being modeled to determine radionuclide concentrations and transport time. In addition to the model, 21 studies are currently in progress or will be undertaken ". . . to evaluate the ability of the Culebra and surrounding units to adequately confine the waste disposed of in the repository after inadvertent human intrusion" (DOE, 1993a, page 5-1).

Besides modeling, laboratory, and field studies, the human intrusion scenario has inspired some "expert opinions." The DOE convened four panels of independent experts to determine the probability that humans would disturb WIPP. The estimates ranged from 0.01 to nearly 1 (Hora et al., 1991). Other experts (Davis and Runchal, 1984), working for the former Basalt Waste Isolation Project, could not agree on a probability that humans may disturb a potential repository in Hanford, Washington. Recently, Tolan (1993) surveyed protective barriers that could deter human intrusion. Among others, he suggests that warnings be inscribed on a large number of small (several centimeters) markers. The markers would be buried with the waste and when a drill hits them, they would be brought to the surface and frighten the drillers away. According to EPA, another deterrent, a monument, could reduce the probability of human intrusion, but none of the experts will say by how much.

The WIPP's extensive analysis of human intrusion is setting an undesirable precedent for Yucca Mountain. The Yucca Mountain Project must also assess the probabilities and consequences of human intrusion, but unlike WIPP, the requirements for Yucca Mountain may change. Congress directed EPA to reconsider its requirements, specifically "whether it is possible to make scientifically supportable predictions of the probability that the repository's engineered and natural barriers will be breached as a result of human intrusion over a period of 10,000 years" (1992 Amendments to the Nuclear Waste Policy Act, Section 801(a)(2)(C)). Although the scenario for human intrusion does not dominate the CCDF for Yucca Mountain (Barnard et al., 1992) as it does for WIPP¹⁰, any scenario would be difficult to defend in a licensing/certification proceeding.

Although faithful to the requirement, the DOE opposes probabilistic assessments of human intrusion. In a letter to the EPA, the Assistant Secretary of Energy stated, "The risk management strategy of including human intrusion in overly stringent containment requirements is masking and jeopardizing the real benefits to society of excellent deep geologic disposal locations" (DOE, 1992b). Earlier, the Assistant Secretary warned,

¹⁰ The DOE can assume that the frequency of human intrusion into Yucca Mountain will be 3 boreholes/km²/10,000 years which is ten times less than what DOE can assume for WIPP (40 CFR 191, Appendix B).

"Releases resulting from human intrusion dominate compliance analyses and make it impossible to proceed with any deep geologic disposal site because of the difficulties of assigning and justifying probabilities and consequences of occurrences" (DOE, 1991b, *emphasis theirs*).

Compliance Criteria Do Not Ensure Overall Safety

For WIPP, the EPA (1993b) is considering compliance criteria that are similar to performance objectives that the U.S. Nuclear Regulatory Commission (NRC) imposes on Yucca Mountain. The NRC breaks the repository system down into engineered and natural barriers and assigns a performance objective to each. For the engineered barriers, the NRC requires the waste packages to contain the waste for at least 300 to 1,000 years (10 CFR 60.113(a)(1)). Following containment, the release rate of any radionuclide from the engineered barrier system is limited to one part in 100,000 per year of the inventory of that radionuclide present at 1,000 years (ibid). And for the natural barriers, the NRC requires a pre-waste-emplacement groundwater travel time of at least 1,000 years (10 CFR 60.113(a)(2)). The regulation goes on to say that if these objectives are met, the NRC will have "reasonable assurance" that the EPA standards will be met.

Unfortunately, the NRC performance objectives and the EPA standards for overall safety do not complement one another. A repository could pass the NRC performance objectives and fail the EPA standards for some radionuclides such as plutonium and americium (NRC, 1983). Conversely, a repository could fail the NRC objectives and pass the EPA standards for other radionuclides such as carbon-14 (Pflum, 1992). Some believe that these performance objectives can actually compromise safety. When the NRC proposed their objectives, Pigford (1981) commented, "The difficulty and challenge of complying with NRC's proposed numerical criteria . . . can overshadow the more important task of focusing on overall safety" Even a former Commissioner (Curtis, 1990) observed the absence of a "technical nexus" between the NRC's performance objectives and the EPA's overall standards for safety. Also, the National Academy of Sciences (1990) and the Nuclear Waste Technical Review Board (1991) have remarked that the NRC objectives are prescriptive and unnecessary.

Hopefully, EPA will not burden WIPP with compliance criteria that are like the NRC's performance objectives. The NRC (1993) believes that its performance objectives for waste packages and the engineered barrier system may not be appropriate for WIPP. Moreover, the DOE could satisfy the Land Withdrawal Act without improved containers or waste forms. The Act specifies only three engineered barriers: backfill, room seals and panel seals. The EPA may not have the authority to require anything more because, "Once the minimum requirements of the law are met, the EPA's authority to mandate the use of additional engineered barriers ends" (EPA, 1993b).

VI. Management and Oversight

Management

The DOE is responsible for securing the necessary approvals, constructing, operating and closing both the WIPP and Yucca Mountain repositories. The DOE Office of Environmental Restoration and Waste Management leads WIPP and the DOE Office of Civilian Radioactive Waste Management leads Yucca Mountain. Both office directors are political appointees who reside in Washington, D.C. The WIPP has two field offices: a Project Integration Office in Albuquerque, New Mexico and a Project Site Office in Carlsbad, New Mexico.¹¹ Both project managers are career civil servants who reside in Albuquerque and Carlsbad. The Yucca Mountain program has one field office in Las Vegas, Nevada. The Project Manager, likewise a civil servant, resides in Las Vegas. The WIPP and Yucca Mountain offices work independently, but on a few occasions EPA rulemakings have brought them together.

The most striking difference between WIPP and Yucca Mountain is that WIPP has a repository but no infrastructure while Yucca Mountain has no repository and a huge infrastructure. Rather than developing an infrastructure that could effectively manage long-term objectives, such as compliance with the regulations, the WIPP program has pursued a short-term goal to conduct in situ tests with actual TRU waste.

Until recently, the DOE wanted to test radioactive wastes at WIPP. Driven by policy rather than science, DOE contractors developed in situ tests without much attention to their utility or practicality. Although DOE secured testing approvals from the EPA and State of New Mexico, the tests were condemned by the National Academy of Sciences (1989, 1991, 1992) and an Independent Technical Review (1993) team. Both concluded that there is no scientific, regulatory, or operational imperative to perform in situ tests at WIPP with radioactive waste.

While the WIPP neglected its infrastructure and concentrated on short-term goals, the Yucca Mountain developed an extensive infrastructure built upon a hierarchy of over 1,700 documents (DOE, 1993d). Since these documents change constantly, it is difficult to determine whether they are effective. For example, between 1988 and 1993 two volumes of requirements for the Exploratory Studies Facility were revised seventeen times, and within the past year over 21 administrative procedures were revised. Unlike WIPP, the Yucca Mountain Project constructed its infrastructure at the expense of its scientific program. The General Accounting Office (1993) reports, "Furthermore, DOE has used most of the funds allotted to the project to maintain a project infrastructure that is large enough to support the agency's objective of completing the investigation in 2001 . . . DOE has been spending relatively little of the available funds to perform essential investigation activities at Yucca Mountain" (page 3).

¹¹ The DOE recently decided to dissolve the Integration Office in Albuquerque and consolidate at the Site Office in Carlsbad. Details of the re-organization have not been released.

The different emphases on science vs. infrastructure are further illustrated in the WIPP's willingness to conduct in situ tests with radioactive waste and Yucca Mountain's reluctance to do the same. Despite recommendations from the NRC (1989), the DOE insists that Yucca Mountain can be adequately characterized without in situ testing of spent fuel.

Oversight

Table 4 lists the five organizations that oversee WIPP and five that oversee Yucca Mountain; similar organizations are side by side.

Table 4
Repository Oversight Groups

Waste Isolation Pilot Plant	Yucca Mountain
State of New Mexico	State of Nevada
Environmental Protection Agency	Nuclear Regulatory Commission
National Advisory Council	Advisory Committee on Nuclear Waste
National Academy of Sciences	National Academy of Sciences
Environmental Evaluation Group	Nuclear Waste Technical Review Board

The State of New Mexico cautiously supports WIPP, but the State of Nevada opposes Yucca Mountain. In 1975, the Governor of New Mexico and local officials invited the DOE (which was then called the Energy Research and Development Administration) to investigate the possibility of building a repository near Carlsbad. The Governor still supports WIPP, but the separately-elected attorney general does not. The officials and citizens of Carlsbad strongly support WIPP, but environmental groups from Santa Fe oppose WIPP.

The State of Nevada has opposed Yucca Mountain since it was nominated as a potentially acceptable site in 1986. When Congress named Yucca Mountain as the only site to be characterized, the state nicknamed the legislation the "Screw Nevada Bill." Subsequently, the state sued the Department of Energy and has done everything in its power to stop site characterization, such as refusing to issue environmental permits. If all else fails, Nevada can veto the President's approval of Yucca Mountain. Congress must override the veto by a two thirds majority or the repository cannot be built. The State of New Mexico does not have this veto power.

As noted earlier, the EPA regulates the defense waste that will go to WIPP, and the NRC regulates the commercial waste that will go to Yucca Mountain. Since defense waste is considered "mixed waste," the EPA Office of Radiation and Indoor Air regulates the radioactive component (40 CFR 191 and 194), and the EPA Office of Solid Waste regulates the hazardous component (40 CFR 268.6 and possibly other RCRA regulations). Currently, it is not clear whether each office will certify WIPP separately or together. Only one NRC office, the Office of Nuclear Material Safety and Safeguards, reviews Yucca Mountain.

The EPA is not as experienced with repositories as the NRC. It was only in October, 1992, that Congress gave EPA the responsibility of overseeing WIPP. The NRC, however, has been involved with repositories since the late 1970's. In fact, the NRC issued its licensing procedures for geologic repositories in 1981: one year before Congress officially started the repository program.

The National Academy of Sciences organizes different groups to oversee WIPP and Yucca Mountain as they are needed. The "Waste Isolation Pilot Plant Panel" reviewed the tests that DOE proposed for WIPP, and currently the "Committee on the Technical Basis for Yucca Mountain Standards" is providing expert scientific guidance on the issues involved in establishing radiation standards for Yucca Mountain. The panel and committee members serve without pay.

The National Advisory Council on Environmental Policy and Technology (NACEPT) advises the EPA on WIPP, and the Advisory Committee on Nuclear Waste (ACNW) advises the NRC on Yucca Mountain. Just organized in 1993, the NACEPT will be asked to evaluate the EPA's criteria for review of the WIPP test and retrieval plans, options for compliance criteria (40 CFR 194), and the assessment of the WIPP's ability to comply with 40 CFR 191. Organized in 1984, the ACNW has a broader charter. It may advise the Commission on any aspect of high-level or low-level radioactive waste management including regulations, transportation, storage, and any technical issues. Generally, the NACEPT is less technically oriented than the ACNW.

In 1978, the Environmental Evaluation Group (EEG) was established to perform a continual, independent technical evaluation of the WIPP project. In 1987, the Nuclear Waste Technical Review Board (NWTRB) was established, by Congress, to perform a similar evaluation of Yucca Mountain. While their charters are similar, their styles differ. The outspoken EEG tends to criticize rather than praise the WIPP program while the more reserved NWTRB gives a more balanced review of Yucca Mountain. The EEG will comment on any subject at any time, but the NWTRB reserves its comments to periodic reports.

VII. Conclusions

Two repositories in the same country, yet Congress and the DOE manage them differently. While Congress encumbers WIPP with unanticipated oversight and inappropriate regulations, Congress streamlines the commercial repository program and promises improved regulations for Yucca Mountain. While DOE encouraged science at the expense of the WIPP infrastructure, DOE postponed its scientific investigations at Yucca Mountain and constructed an infrastructure, large enough to support an ambitious program that was never realized. Somewhere between WIPP and Yucca Mountain lies an ideal repository program. A program where consistent national policy promotes progress; where lucid regulations inspire confidence; where science and infrastructure are balanced; and where oversight groups do not become the tail that wags the dog. Neither WIPP nor Yucca Mountain are ideal programs, but each has its advantages that approach the ideal.

Consistent national policy would steer the ideal repository program in a predictable direction. Here Yucca Mountain has the advantage. Successive legislation has streamlined the siting process and promises better regulations.

From the beginning, the ideal program would know its regulators and regulations. Again, Yucca Mountain has the advantage. More familiar with regulators and regulations, the Yucca Mountain program had the foresight not to declare HLW to be hazardous and subject to dual regulations.

The ideal program would equitably balance its science and infrastructure. Here neither program has the advantage and could possibly represent extremes. The WIPP's emphasis on scientific investigations left it with little or no infrastructure to deal with regulations and oversight. A regulatory infrastructure, for example, could have forewarned WIPP that its in situ tests were not relevant to the regulations. On the opposite extreme, the Yucca Mountain's emphasis on infrastructure left it with less money for scientific investigations. However, now that the infrastructure has been built, the Yucca Mountain Project can turn more resources towards science, provided that Congress approves the funds.

The ideal repository would benefit from a constructive oversight that weighs the impacts of its recommendations. With regard to state and local governments, WIPP has the advantage. The State of New Mexico and the City of Carlsbad are not trying to stop the studies at WIPP. With regard to regulators and their advisors, Yucca Mountain has the advantage. The NRC and its advisor, the ACNW, are far more experienced with Yucca Mountain than the EPA and its advisor, the NACEPT, are with WIPP. Moreover, Yucca Mountain has the infrastructure to deal with oversight; WIPP does not.

Finally, the ideal repository program should accommodate oversight groups, but not indulge their every whim. To some extent oversight groups have surprised the WIPP and Yucca Mountain Project by encouraging unpopular or unanticipated endeavors. For example, the EEG, the New Mexico Attorney General and the EPA have repeatedly encouraged WIPP to

refine its assessment of human intrusion. In response, the DOE has spent around \$300 million (Pflum et al., 1993b) on performance assessments and some test phase work that would give the oversight what they want. Yet the DOE (1991b and 1992b) opposes these types of assessments.

Similarly, the NWTRB and the NRC have encouraged the Yucca Mountain Project to expand the size of the Exploratory Studies Facility (ESF). In response, the DOE will excavate 76,900 feet of tunnel and spend around \$808 million (DOE, 1991a). In 1981, however, before the oversight was established, the DOE anticipated a more modest facility that would comprise 3500 feet of shaft and tunnels (SNL, 1991), and cost no more than \$40 million (NRC, 1981).

In conclusion, the Yucca Mountain Project has the advantage of better laws, potentially better regulations, and with the exception of state government, a more balanced and experienced oversight. Yucca Mountain also has the advantage of an infrastructure albeit cumbersome and unnecessarily large. Both programs acquiesce to their oversight, but whether this is an advantage or disadvantage remains to be seen.

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