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Recommendations for WIPP

Remediation for WIPP to Serve as a Permanent Repository for HLW & TRU

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INTRODUCTION

With the expansion of the US economy since post-war, nuclear energy production had also increased alongside, but had stagnated by the 1990s. The United States Nuclear Regulatory Commission (NRC), which oversees the regulation and policies of the handling of nuclear material and operation of reactors has received an influx of new license applications for reactors (NRC 2021) [1]. Although ultimately less than half of the licenses have been issued, this signals an interest in growing the nuclear energy industry. The most pronounced barrier to continuing this interest is the handling of the waste from nuclear power reactors.

In 1982 the US Department of Energy (DOE) has previously designated the Yucca Mountain Nuclear Waste Repository to be the national deep geological repository for high-level radioactive waste (HLW). However, due to legislation and public disapproval, plans were suspended and the project ultimately defunded in 2019. Another deep geological repository had begun operation in 1994 as the Waste Isolation Pilot Program (WIPP) located 26 miles east of Carlsbad, New Mexico. This program is currently only licensed to handle transuranic wastes (TRU) and to only serve as a temporary repository. With no permanent depository, nuclear power plants (NPPs) are forced to store their waste onsite or to outsource waste management to third party companies. As the only state with two national laboratories, NM’s economy is in a unique position to benefit from handling the waste.

This report intends to give an overview of the importance of nuclear power, the types of wastes involved, the significance of the repositories, and to identify the barriers and recommendations in the path towards WIPP serving as a permanent repository for HLW and TRU.

METHODOLOGY

To gain more background knowledge of the categorization of wastes, the nuclear fuel cycle, repositories, and of the reputation of the nuclear industry in NM, multiple sources of information ranging from technical documents to newspapers were needed.

Regarding the fuel cycle and wastes, texts surrounding nuclear engineering and the official site of the NRC were referenced. This served to give insight to the process of how the waste is produced, to identify the harmful components of the waste, along with how the waste is categorized and managed.

The nuclear industry’s reputation in NM was best learned through newspapers and reports surrounding events at WIPP and associated laboratories. The interface between the industry and the public was also examined through public meetings and panels. WIPP’s design and goals were accessed via its official site. Operations from other parties involved in the fuel cycle were also examined through their official sites and publications.

The limitations of this report were the lack of access to the modeling of WIPP’s repository, to the direct opinions of policy makers, and reliable survey polling of NM residents.

RESULTS

Data from the U.S. Energy Information Administration shows that the US now ranks second in the amount of energy production, with the US having 103 quadrillion Btus versus that 127 quadrillion that of China for the year 2023 (EIA 2023) [2]. Further, a marked stagnation in reactor licensing and construction is seen in Fig. 1 between the years of 1999 to 2011.

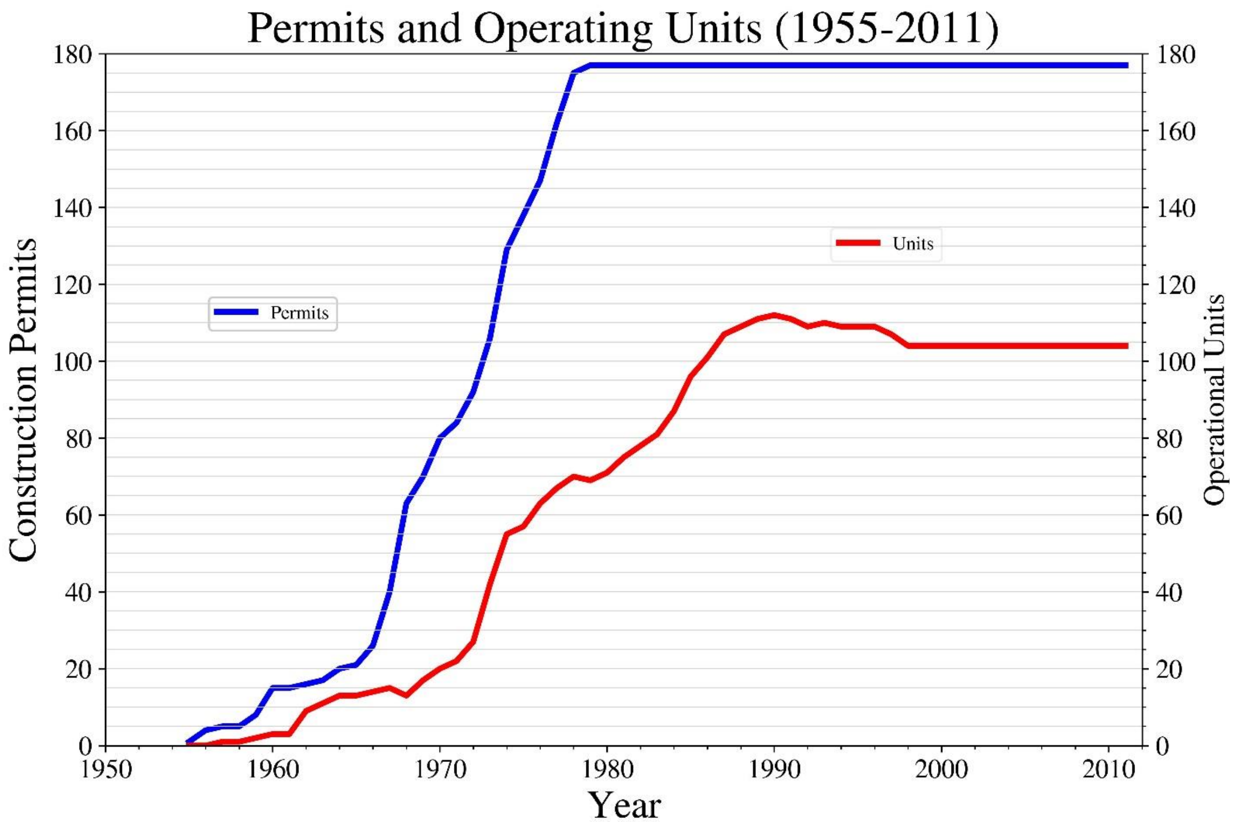

Figure 1. Nuclear Reactor Construction Permits and Operational Units. Data: EIA [2]

The majority of US reactors of the types, pressurized water reactors (PWR) and boiling water reactors (BWR). These types fall into the umbrella of light water reactors (LWR). Traditionally, it was the fission of U-235 enriched fuel that powered these according to the reaction given by Eq. 1.

$$ {}^{0}_{1}n + {}^{235}U \rightarrow {}^{236}\ U^{*}. \quad (1)$$

It's this excited U-236 nucleus that fissions into other nuclei, alpha particles, and neutrons through a release of energy. This energy is harnessed through the heat exchange between the fuel and the circulation of water that then travels to a steam generator. The cross-section of a nuclide describes the probability of a particle (in this case, a neutron) has in the interaction with that nuclide. Though the release of neutrons can maintain the chain reaction for a steady supply of energy, the fission products (FPs) from this reaction have nuclei that have low fission cross-sections, but high absorption cross-sections. These specific nuclides (namely Xe-135 and Sm-149) are referred to as fission poisons as they readily absorb neutrons, but do not contribute further to the fission process, decreasing overall reactivity and power of the reactor (Lamarsh 2018) [3]. These poisons are removed through what's called fuel reprocessing, in which fuel rods are removed from the reactor then placed in a pool of liquid for cooling. Then these rods are removed from the pool and treated with nitric acid to remove the poisons. The fuel can be partially extracted and recycled to be used again for future refueling. However, through this last treatment, waste is still left over in the form of transuranics (TRUs). These are nuclides with a higher atomic weight than uranium and have a tendency to alpha decay, releasing alpha particles (He-4). These α particles pose little to no external risk to humans, but can be very harmful if ingested or inhaled.

The initial fission products also pose a risk to organisms due to their radioactivity. A nuclides activity (the amount it decays) is related from the initial activity A_0 via Eq. 2,

$$A = A_0 e^{-\lambda t} \tag{2}$$

where λ is the decay constant and equals ln(2)/$t_{1/2}$. The variable $t_{1/2}$ is the half-life or the time it takes for a given amount of radioactive material to decay away so that only one half of the original amount remains. It's the long half-life of these TRUs that make them particularly difficult to manage as they pose a risk well beyond the average human life span.

A list of common medium-lived fission products and their respective half-lives are given in Table I.

Table I. Medium-Lived Fission Products. Data: IAEA 2025 [4]

Nuclide	$t_{1/2}$ [year]	Q [keV]
^{155}Eu	4.753	251.8
^{85}Kr	10.739	687.0
^{90}Sr	28.91	545.9
^{137}Cs	30.08	1175.63
^{121m}Sn	43.9	396.9
^{151}Sm	90	76.6

Of the listed fission products, Cs-137 and Sr-90 pose the highest short-term risk to humans. This is because of their intermediate half-life of about 30 years which means they rapidly decay and give off a ionizing radiation at a higher rate. Also, the amount of energy per reaction (Q-value) is higher compared to the others. This leads to higher doses of radiation that a person is potentially subject to.
Cs-137 beta-decays and is readily soluble in water but can still damage cells while it's in the system of humans. Although Sr-90 is an alpha emitter, which means it poses less risk than beta-decay, it still bioaccumulates in the bones of humans if ingested (EPA 2011) [5].

With these health risks in waste, the NRC has sought to categorize wastes according to the sources of origin and levels of activity. Shown in Fig. 2 is a diagram flow chart showing the major steps in the fuel cycle along with the waste generated.

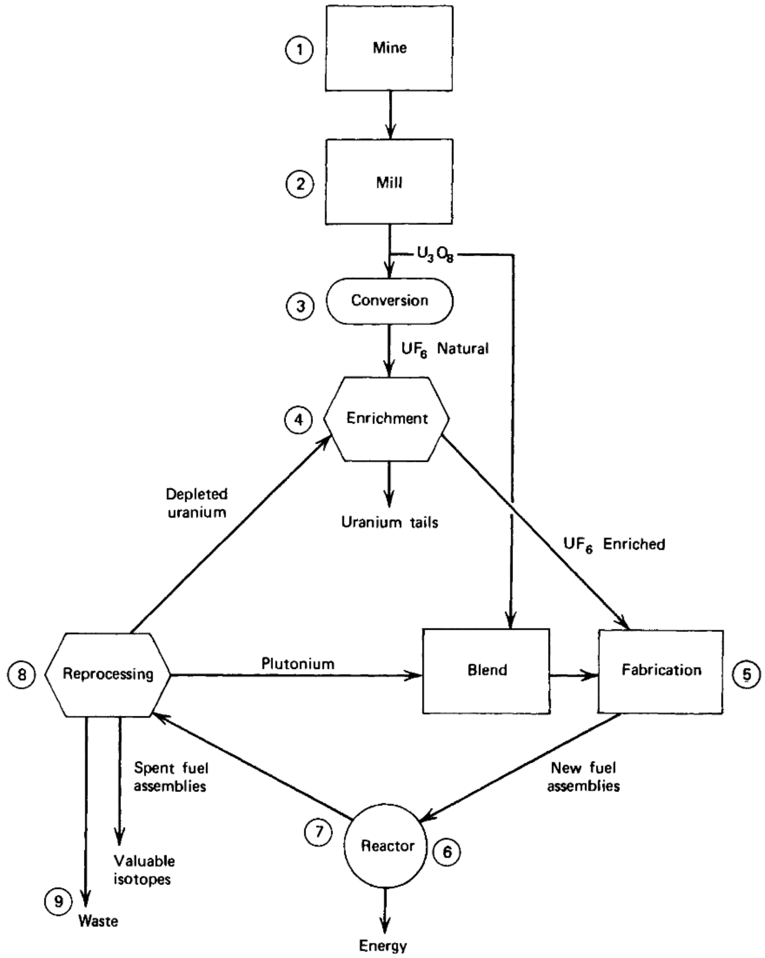

Figure 2. Fuel Cycle Diagram. Source: Duderstadt & Hamilton 1976 [6]

The NRC categorizes HLW as waste from the spend fuel assemblies and from reprocessing (NRC 2020) [7]. Low-level waste (LLW) is generally from materials and equipment contaminated during enrichment and fabrication. This includes gloves, clothing, protective equipment, and instruments. In addition, the UF_6 that is enriched gives rise to depleted uranium (DUF6), categorized as LLW, and is put into uranium tailings (NRC 2024) [8].

The plan for NRC to deposit this HLW was the Yucca Mountain Repository which was to be situated about 80 miles northwest of Las Vegas, Nevada. The goal was to construct a deep geological storage to bury the waste. Initial plans were set in place in 1982 and the Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) appointed Sandia National Laboratories (SNL) as the lead laboratory to conduct geological surveys and model the construction (DOE 2006) [9]. The project was met with growing dissent of the local population and had received reductions in funding towards the late 1990s and early 2000s.

The other geological repository WIPP, was to serve only temporarily for TRU and started operations in 1999 (WIPP 2024) [10]. Situated 2150 feet below the ground, it served well to isolate and contain hazardous material. A salt basin was chosen because they are naturally found in areas of the absence of water so would limit any runoff of contaminated water, and because the salt has plastic qualities that help seal away the waste once buried (WIPP 2024). A depiction of the eight current panels of the site is shown in Fig. 3.

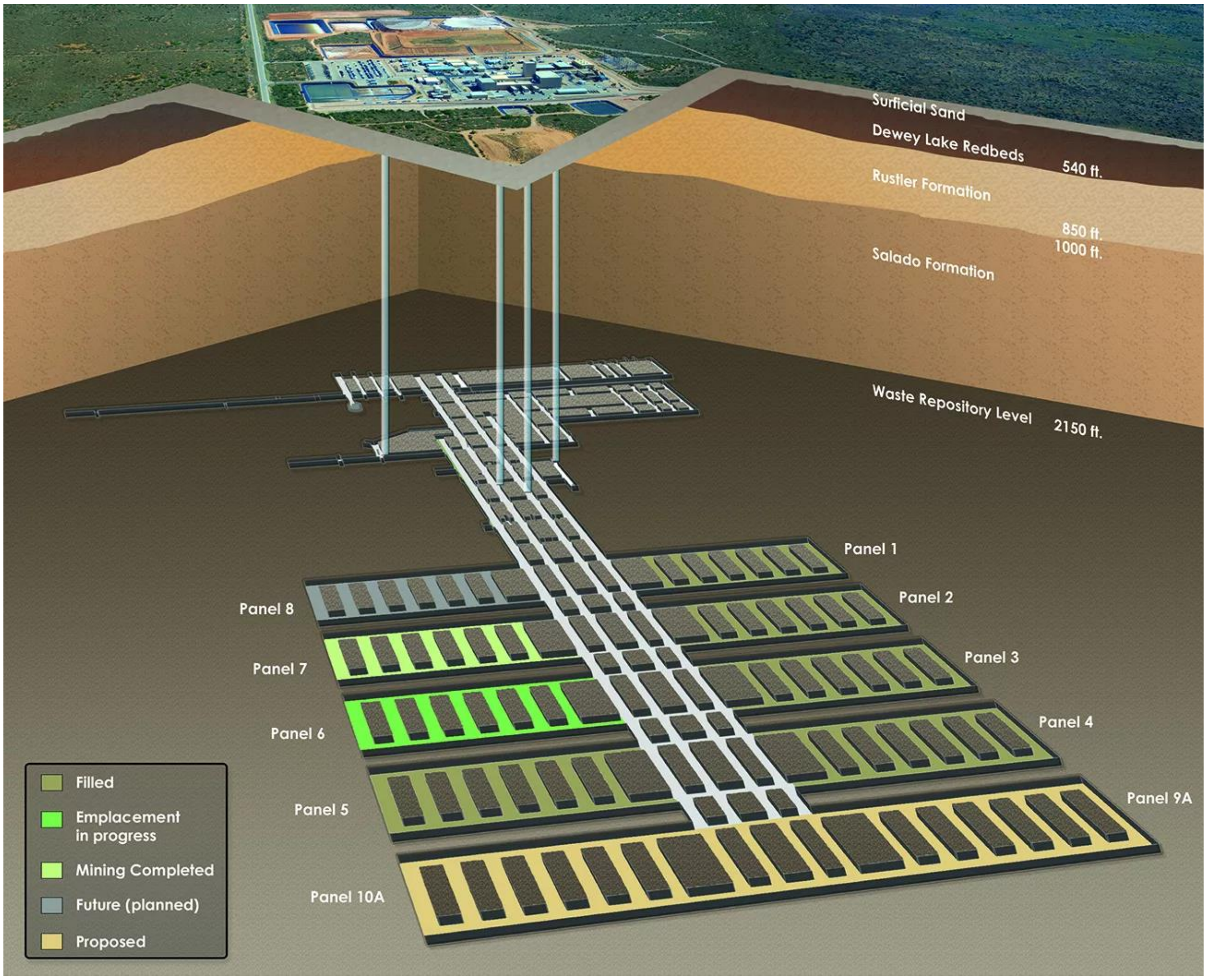

Figure 3. Diagram of the Layout of WIPP. Source: Thakur et al. [12]

Currently there are eight panels and each panel has seven rooms that are 13-feet high, 33-feet wide, and 300-feet long. 100-feet beams of salt (dark gray in Fig. 3) separate each room of waste. The computer modeling of the construction was handled by SNL (SNL 2024) [13].

On February 14th, 2014 an incident occurred when a drum barrel shipped from LANL had combusted and set off radiation detectors. The situation was contained in the coming days, with radiation levels dropping back to near background levels, but the cleanup process would cost millions and the public trust of locals. Initially public outrage was towards DOE's handling of the event, however upon inspection of the root cause of the explosion, it was linked to Drum 68660, which was a shipment from LANL. The likely cause was a clerical error combined with the lack of oversight on account of LANL.

The drum contained legacy TRU, which is waste from the Manhattan Project and subsequent Cold-War era nuclear weapons programs. Traditionally, nitric acid was involved in the purification process for plutonium, and a waste nitrate salt remained in an acidic solution. This was then treated with an acid neutralizer. This would then be solidified with inorganic kitty litter containing zeolite, a micro-porous mineral resistant to radiation, to absorb any free liquids so that to have a more manageable solid waste (Scheele et al. 2017) [14]. Upon revising protocols there was a switch from procedures of remediating the salts with *organic* instead of the original *inorganic* kitty litter. The reaction with the organic wheat-based litter created a rapid oxidation and breaching of the barrel causing damage to adjacent barrels (Clark 2015) [15]. According to the Carlsbad Environmental Monitoring & Research Center, the radiation release was detected, but it posed no risk to the surrounding population after a few days (Thakur 2014) [12].

Following the incident WIPP had improved the detection system to help detect earlier signs of damage and radiation. LANL on the other hand had tried to distance itself from responsibility (Malone 2024) [16]. After clean up WIPP has continued operations with more safeguards in check.

DISCUSSION

The findings show that public opinion is a strong factor in the future of WIPP being a permanent repository. Also, adjacent operations by private companies play a role in the fuel cycle and can increase cooperation with WIPP and the state to help solve the backlog of legacy waste in the state’s two labs.

Public opinion was very against the construction of the original Yucca Mountain site. Aside from the fears of the hazards, the actual mountain itself is of cultural and religious significance to the Western Shoshone indigenous tribe (Stoffle 1990) [17]. The area surrounding the WIPP site does not have a comparable cultural or religious significance.

RECOMMENDATIONS

Several recommendations can be made for WIPP for the future and are as follows:

- Increase public outreach and engagement.
- Negotiate with NMED to increase oversight of laboratory waste handling.
- Increase cooperation with private contractors involved in nuclear fuel cycle.

The major recommendation for WIPP is to increase its public outreach. The form of the community forums has brought the opinion of locals so that WIPP can regain trust, but areas of improvement include transparency, the amount of engagement, and the informing of what types of wastes and the risks involved (WIPP 2024) [18]. The WIPP Joint Information Center would be the main organizational body involved with this. Currently, the mining contractor for WIPP, Salado Isolation Mining Contractors LLC rewards scholarships to local students of Carlsbad and surrounding areas. Continuing and increasing this effort would help locals see the financial benefits more readily compared to hiring outside of the state (WIPP 2024) [19].

Another recommendation is to negotiate with the New Mexico Environment Department (NMED). The NMED is the body that oversees the handling how LANL manages its waste before shipment (NMED 2024) [20]. Coordinating with them so that LANL and other producers of waste comply with WIPP's standards and mitigate future accidents.

The final recommendation is for increased involvement with private companies in the area to handle waste. Holtech and URENCO both have nearby operations. Holtech's Hi-Store Consolidated Interim Storage Facility (CISF) operates out of Eunice, New Mexico (Holtech 2022) [21]. In 2023 Holtech has been given the license to manage HLW for which WIPP is currently not licensed (Holtech 2023) [22]. As a temporary solution, they can help serve as an intermediary storage while WIPP explores interest in becoming a permanent repository.

CONCLUSION

While the US explores its interest in LWRs, emergent technologies such as the molten salt breeding reactors and thorium reactors have the potential to reduce the waste for future power generation (Moir 2004 & 2010) [23,24]. However, in the meantime, the US still needs a permanent repository. WIPP can serve that function with continued efforts and a reshaping of how DOE, and the national laboratories engage with the public.

GLOSSARY OF TERMS

Activity – The amount of which a nuclide or material decays or emits ionizing radiation.
Alpha Particles – A subatomic particle that consists of a helium nucleus.
Fertile – A nucleus that is not readily fissile, but can become fissionable when a neutron attaches itself to the nucleus through a collision.
Fissile – The ability of a nucleus or a material of that nucleus to readily fission into smaller fragments when hit with a neutron.
Fissionable – The ability of a nucleus to fission, but requiring a much higher energetic neutron collision (above 6~9 MeV).
Fuel Rods – Rods made of a fuel made containing a fissile material.
Nucleus (pl. Nuclei) – The innermost part of an atom that consists of the subatomic particles, protons and neutrons.
Nuclide – A specific nucleus characterized by its number of protons and number of neutrons.
Manhattan Project – The US WWII nuclear weapons program led by then Los Alamos Scientific Laboratory (now LANL).
Transuranics – Atoms with atomic weight greater than uranium (e.g. Americium, Californium)

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