Quo Vadis, Herr NucleUS?

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ABSTRACT

USA has the largest and longest running national program for nuclear power generation. In sharp contrast, at the end of 2009, the nation's only candidate UNF- and HLW-disposal solution, the Yucca Mountain UNF/HLW repository in Nevada, was in a naked, catatonic, state (Fig. 1). Despite already being more than 19 years behind its statutory opening date of January 31, 1998, it was placed on indefinite hold in February 2009 pending a review of a politically-handpicked "blue-ribbon" panel that could lead to the abandonment of the YM site. It would also be too small in 2010 for the nation's projected stockpiles of UNF and HLW and require an increase in disposal volume and/or the development of another UNF/HLW repository. In addition, reasonably-plausible disposal solutions for greater than class C LLW and sealed sources are also lacking. As follows, ***with the sole exception of the WIPP repository program***, *at the end of 2009, USA has neither a fully integrated nuclear waste management program nor reasonably-plausible disposal solutions for several long-lived, highly-radioactive, waste categories* (Fig 1).

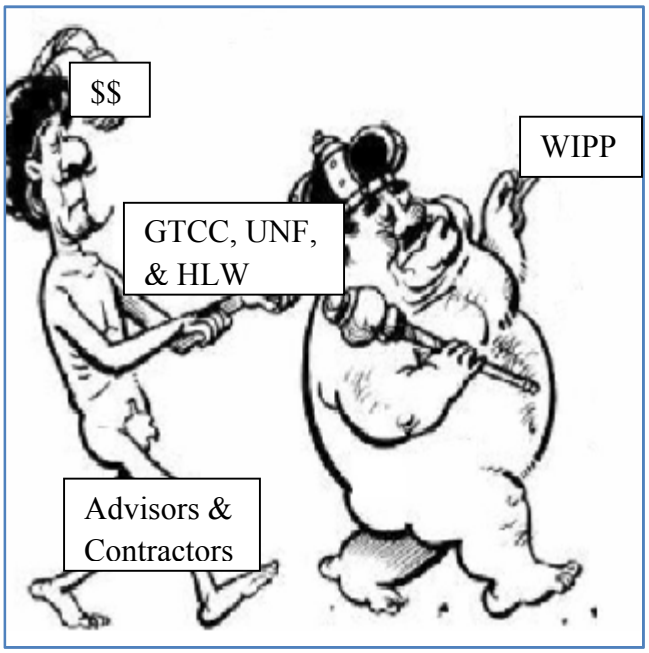

Fig.1. Schematic illustration of the USA's naked, catatonic, disposal programs for long-lived, highly-radioactive, waste at the end of 2009

The timely availability of at least one reasonably-plausible UNF-disposal solution by 2025 is an integral component to the future of NRC's 2005 nuclear waste confidence decision and, in turn, the "Nuclear Renaissance" in the USA and, perhaps, abroad. Based on the author's involvement in nuclear waste management and geological repository programs in the USA and abroad since 1978, the following four repository program components offer proven solutions that could be transfused to mitigate both current and future challenges to the safe disposal of UNF and HLW in the USA: 1) Long-term storage of the UNF, 2) The search for another repository site if needed, should be based on a) Voluntary repository-host communities in which the majority of the local residents supports a UNF/HLW repository in their backyard, b) A design concept, including the repository host rock, pursued successfully by at least one other "nation", and c) An implementing organization with relevant management expertise, a vested interest in developing robust disposition solutions, and holding its executives accountable for progress and cost.

INTRODUCTION

The United States of America (USA or U.S.) has the largest number of licensed commercial nuclear reactors (104) in the world. In addition, at the end of 2008, the U.S. Nuclear Regulatory Commission (NRC) had received expressions of interest in 28 new commercial reactors. If looked upon in the aforementioned perspective, the future for an adequate, sustainable, supply of nuclear energy in the USA looks very promising. However, in order to meet the basic carbon dioxide reduction scenario of the Waxman-Markey Bill, the Electric Power Research Institute (EPRI) and the U.S. Department of Energy (DOE) projected in 2009 that at least 46 and 70 new reactors would be needed by 2030, respectively.[1] Furthermore, the timely availability of at least one reasonably-plausible disposition solution for the radioactive waste categories generated by commercial operations is an integral component to the future of the aforementioned scenarios. Otherwise, the NRC's 2005 nuclear waste confidence decision may be rescinded or rendered invalid, and the licensing of new and relicensing of existing nuclear reactors could come to a multi-year standstill while the NRC decision is being reevaluated and re-promulgated.

Unfortunately, there might not be a reasonably-plausible disposal solution for the nation's used nuclear fuel (UNF) and other high-level radioactive waste (HLW) beyond 2010.[e.g., 2,3] (The term UNF is used throughout this text rather than the often used term "spent nuclear fuel" because "spent nuclear fuel" is not necessarily a waste since it still contains up to 96% of its initial energy and it can be recycled/reprocessed and reused.) In December 2008, the Secretary of Energy (Secretary) informed the U.S. Congress and the U.S. President that the current legal capacity of the nation's only candidate UNF- and HLW-disposal solution, the Yucca Mountain (YM) UNF/HLW repository in Nevada, would be inadequate for accommodating the nation's existing stockpiles of UNF and HLW during 2010.[4] Furthermore, the projected opening of the YM repository was at least 19 years behind its statutory opening date of January 31, 1998. The future of the YM site was further dimmed, as was the USA's ambition to be perceived as a global authority (role model) on and preferred purveyor of nuclear waste management services, when the new Administration placed an indefinite hold on the YM site pending a review of a politically-handpicked "blue-ribbon" panel in February 2009, [5] that could lead to the abandonment of the YM site. In addition, USA has no reasonably-plausible disposal solution for greater than class C (GTCC) low-level radioactive waste (LLW) and more than 13,000 sealed sources at the end of 2009. As follows, the future of nuclear energy and, perhaps, also other nationally-vital commercial nuclear waste generating operations in the USA might be in imminent, and perhaps mortal, danger in 2010, or shortly thereafter, due to the catatonic state of the YM UNF/HLW repository and the lack of a reasonably-plausible disposal solution for UNF and other long-lived, highly-radioactive, domestically-unique, waste categories in the USA at the end of 2009.

Select legal and regulatory milestones and events deemed to be particularly relevant to the virtually "naked" status (Fig. 1) of and the challenges facing the safe disposition of long-lived, highly-radioactive, waste in the USA at the end of 2009 are concisely described and discussed below based on the author's periodic involvements and continuous monitoring of repository programs in the USA and abroad since 1978. It is, however, impossible to give a complete description and conduct an objective discussion of the more than 50-year-long, hitherto-spectacularly-unsuccessful, effort in the USA to develop safe disposal solutions for several of the

nation's long-lived, highly-radioactive, waste categories in this limited space. The selected focus herein is thus on the following two issues:

1. How did the nation's UNF-disposal program get to where it was at the end of 2009?
2. What can be done to mitigate current challenges and to ensure a robust reasonably-plausible UNF-disposition program in the future?

As follows, observation, comments, opinions, and recommendations presented in this text are solely attributable to the author, unless another source is indicated by a number within brackets. The full listings of the numbered sources can be found in the Reference section following the main text. Since the views presented herein are both biased and incomplete, the reader is asked to keep the following three concepts attributed to Jean Jacques Rousseau (1712-1778), William Shakespeare (1564–1616), and Samuel Langhorne Clemens, aka Mark Twain, (1835-1910), respectively, in mind while reading this text:

"No generalization is completely true, not even this one."

"The beauty is in the eye of the beholder."

"There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact."

MILESTONES AND MILLSTONES TO THE NAKED, CATATONIC, STATE OF THE NATION'S USED NUCLEAR FUEL DISPOSAL PROGRAM AT THE END OF 2009

According to gossip, the short answer to why the nation's program for safe deep geological disposal of UNF and HLW is where it is at the end of 2009 is that the majority of the members of the U.S. Congress have chosen for more than 12 years to ignore the illegal status of the YM program, purportedly due to fear that it would open the door for their respective state to be considered for a UNF repository and thereby compromise their reelection (job security). If this paradigm doesn't change in the very near future, it will remain the primary challenge to the timely and cost-effective development of safe disposition (storage, treatment, and disposal) solutions for UNF and HLW. In other words, all the potential remedies outlined in this text would be for naught, unless adequate political will exists to support them. In light of the new Administration's repeatedly expressed interest in clean alternative energy forms and with nuclear energy being the only such option for significantly increased and daily fluctuating electricity demands, perhaps a paradigm change is on the horizon prior to a Pearl Harbor or 9-11 event.

Before addressing other reasons as to why the nation's UNF- and HLW-disposal program is in its current naked and catatonic state, it is important to explain the USA's globally-unique waste-classification system because it departs markedly from the radiation-based waste classification system recommended by the International Atomic Energy Agency (IAEA) and used by other countries. In short, the U.S. radioactive waste classification is essentially based on who generated the waste and "what it is not". Following are examples of a few inherent peculiarities.

As indicated in Fig. 2, USA's nuclear-waste-classification system differentiates between government- and commercially-generated nuclear wastes. The related hierarchy of regulations largely follows this dividing line too. It should be noted, however, that with the exceptions of transuranic radioactive waste (TRUW), UNF, and HLW, both the NRC and the U.S. Environmental Protection Agency (EPA) can transfer their licensing and compliance oversight authority to a given state as long as the state regulations are at least as strict as the related NRC and EPA regulations. The net results of this system are that 1) state regulations typically impose more stringent and restrictive regulations than the corresponding NRC and EPA regulations, and 2) the stringency and restrictions defined in the state regulations vary among states.

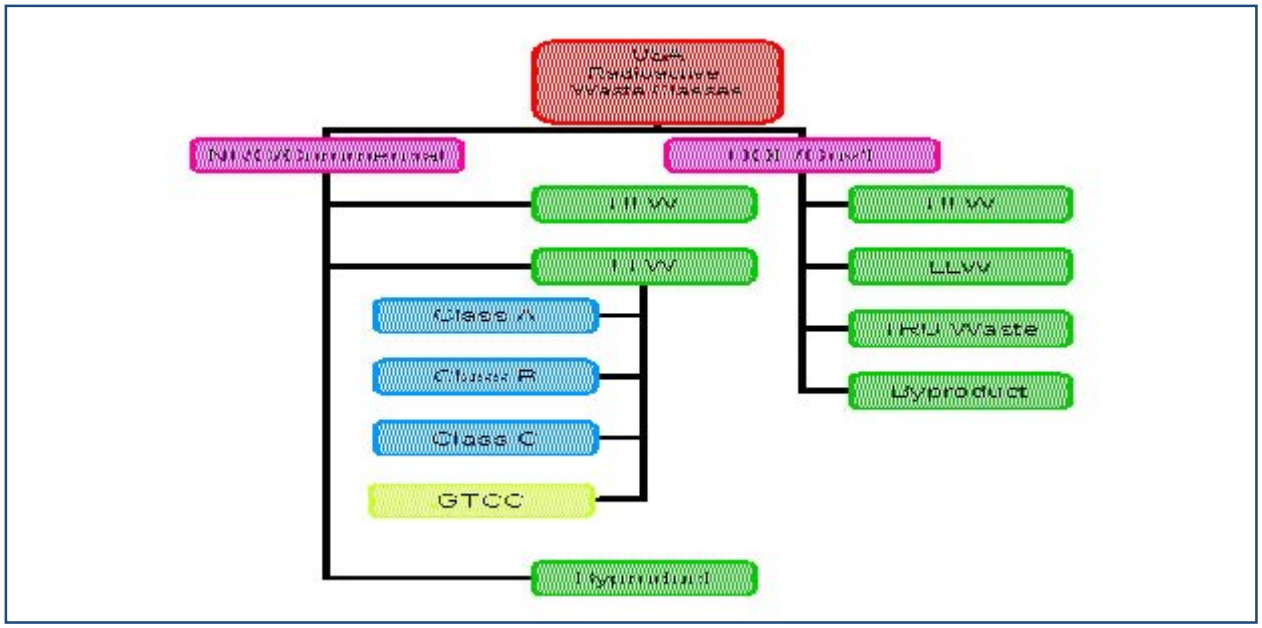

Fig. 2. Schematic illustration of the unique radioactive waste classification used in the U.S.A.

It should also be noted that, whereas the commercial generators are responsible for the safe management and storage of their UNF, only the DOE currently has the legal authority to dispose of the nation's TRUW, UNF, and the HLW. Furthermore, LLW is radioactive waste not fitting the TRUW, UNF, and HLW classifications, GTCC LLW is radioactive waste neither fitting the HLW, TRUW, nor the Class A, B or C LLW classifications, and there are two TRUW categories; contact handled (CH) and remote- handled. The GTCC LLW and the RH TRUW categories essentially correspond to the IAEA's long-lived, intermediate-level, radioactive waste (LL/ILW) category and the CH TRUW category essentially corresponds to IAEA's LLW category. As follows, both the waste classification system and the hierarchy of promulgating and overseeing regulators make the disposal of radioactive waste in the USA very time-consuming and costly. They also constrain the USA in several unique waste categories from taking advantage of designs and lessons learned by foreign programs and vice versa. Lastly, by not following the guidance and conventions issued by the IAEA, USA's image as a global authority and preferred provider of nuclear waste management services is seriously compromised.

Following is a concise semi-chronological description and discussion of select components of the U.S. program for safe management and disposal of its long-lived radioactive waste. Again, the

focus is on the underpinnings of current challenges to the safe and timely disposal of UNF, which currently is commingled with a limited amount of HLW at the YM site. Potential remedies/solutions to identified challenges are discussed both in this and the subsequent section.

In 1957, a Committee carefully selected by the National Academy of Sciences (NAS) concluded that the most promising geological medium for safe permanent containment and isolation of long-lived radioactive waste was rock salt.[6] Following the failure in the 1970s of Project Salt Vault, the leaky Lyons salt mine in Kansas, the U.S. Congress under the very capable and devoted stewardship of the Honorable Senator Mo Udall championed and the President enacted the Nuclear Waste Policy Act of 1982 (NWPA),[7] which remains the current cornerstone of USA's legal and regulatory framework for safe disposal of UNF at the end of 2009. The NWPA directed the Secretary to enter into contracts (known as the Standard Contract) with the nuclear utilities for the acceptance and safe disposal of their UNF. The Standard Contract states that in return for the fees paid into the Nuclear Waste Fund by these utilities' ratepayers, the DOE will:

1. Take title to and dispose of UNF covered by the contract as expeditiously as practicable.
2. Commence operation of an UNF repository no later than January 31, 1998.

The Office of Civilian Radioactive Waste Management (OCRWM) was established within the DOE in 1983 to develop and operate the facilities required for fulfilling these obligations. The NWPA also limited the capacity of the first repository to 70,000 metric tons of heavy metals or an equivalent amount of uranium (MTU) until a second repository was in operation. Congress subsequently approved the commingling of utility-generated UNF and government-generated UNF and HLW in the first UNF repository and terminated the second repository program.

Four years later, the Congress developed and the President enacted an amendment to the NWPA (NWPAA).[8] The purported intent of the NWPAA was to expedite the search and reduce the cost for the nation's first UNF repository. The NWPAA directed the Secretary to only continue the characterization of the YM site for the nation's first UNF repository and to abandon the other two candidate sites within six months. The Governor of Nevada promptly filed a formal Notice of Disapproval, which the Congress overrode. With the benefit of more than 20 years of hindsight, it is clear that the NWPAA included provisions that 1) seriously delayed the progress and increased the cost of the OCRWM program, and 2) generated successful opposition that likely will continue to mar the future of the YM site as long as the current Nevada representation in the Congress remains the same as it is today. For example, the "tenured" Senator from Nevada leading the more than two decades long successful state campaign opposing the YM repository is the current majority leader of the Senate. It should also be noted that one of his former aides is the new chair of the five NRC Commissioners and at least two more Commissioners will be replaced by political cronies. As follows, the future of the YM site may be even less promising than its checkered past history.[e.g., 2,3,9,10]

In 2001, the NRC promulgated site-specific licensing regulations for a deep geological repository for UNF and HLW at the YM site.[11] After overcoming a successful legal challenge of the draft standards, the EPA promulgated the related site-specific public health and environmental radiation protection standards in 2008.[12] However, before describing and discussing these regulations and their perceived adverse impacts and residual challenges, it may

be prudent to mention that, due to the fact that very few individuals fully comprehend the spatial and temporal scales involved, or the state-of-the-art and the beyond-the-state-of the-art concepts and numerical methods used for showing compliance with applicable regulations, the acceptance of the ”artificial” numerical results computed for the current, 1-million-year-long, regulated post-closure period for the YM UNF/HLW repository largely rests upon the following two factors:

1. Understanding the level of protection provided by applicable regulations.
2. Confidence in the regulator's willingness and ability to enforce them.

Furthermore, in the absence of a relational database explaining nuclear concepts, risks, and units in terms readily understood by lay people, which likely comprise more than 99% of the U.S. population in this subject matter area, “objective” lay people face the following two options [10]: a) Accepting the proposed facility based on their trust in the messenger; or b) Rejecting it based on their lack of trust in the messenger and fear of the “unknown” risks.

The promulgation of site-specific regulations for the YM site after more than 25 years of site-specific studies and repository performance/safety analyses generated the immediate suspicion that the preceding nation-wide licensing regulation [13] and/or standards [14] could not be met at the YM site. This suspicion turned into virtual reality by some of the modifications made in the new regulations. For example, the nation-wide licensing regulation limited the time for which the applicant could take credit for the radionuclide containment and isolation characteristics of the waste container/canister in the post-closure safety/performance assessments (P/SAs) to up to 1,000 years, whereas the site-specific regulation did not have any such limit. As indicated on Fig. 3, the current disposal concept at the YM site relies heavily on expensive state-of-the-art and beyond-the-current state-of-the-art engineered barriers, such as the titanium-alloy drip shield, which is estimated to cost approximately $16 billion of the estimated total life-cycle cost of $96 billion. Although the author still believes that the inherent uncertainties in the 10,000-year and longer P/SAs for a repository can be reduced by well-designed engineered barriers,[15] it should be noted that the NRC stated in the explanatory comments to nation-wide licensing regulation that the engineered (man-made) barriers could not be used to compensate for flaws in the natural system, i.e., the geological setting. However, if one considers where the main radionuclide and containment currently is entrusted at the YM site, it is no longer a geological disposal system; it is an engineered barrier disposal system, which is another piece of the YM site's evolution that intuitively evokes concerns about its suitability for hosting a safe UNF/HLW repository.

Furthermore, the fact that DOE Environmental Management (EM) Carlsbad Field Office's (CBFO's) TRUW repository at the WIPP site in New Mexico (Figs. 4 and 5) had already complied with the nation-wide EPA standards in 1998 without taking any credit for the radionuclide containment and isolation of the waste containers (Fig. 4) or any other “man-made” barrier in the disposal rooms, conveyed a very strong message that the YM site will not be able to provide the same level of post-closure public health and environmental radiation protection as that provided at the WIPP site. In addition, at the end of 2009, the WIPP repository had been re-certified twice under the nation-wide regulation, as well as having demonstrated compliance with all other applicable state and federal regulations for more than 10 years, which begs the question, how come the WIPP site can and the YM site can't meet the nationwide standards? The author's short scientific-based answer is the ability of the respective host rock; rock salt at the WIPP site

and welded tuff at the YM site, to contain and isolate the emplaced waste within the "controlled area" until it is rendered harmless to humans, other life forms, and the environment.

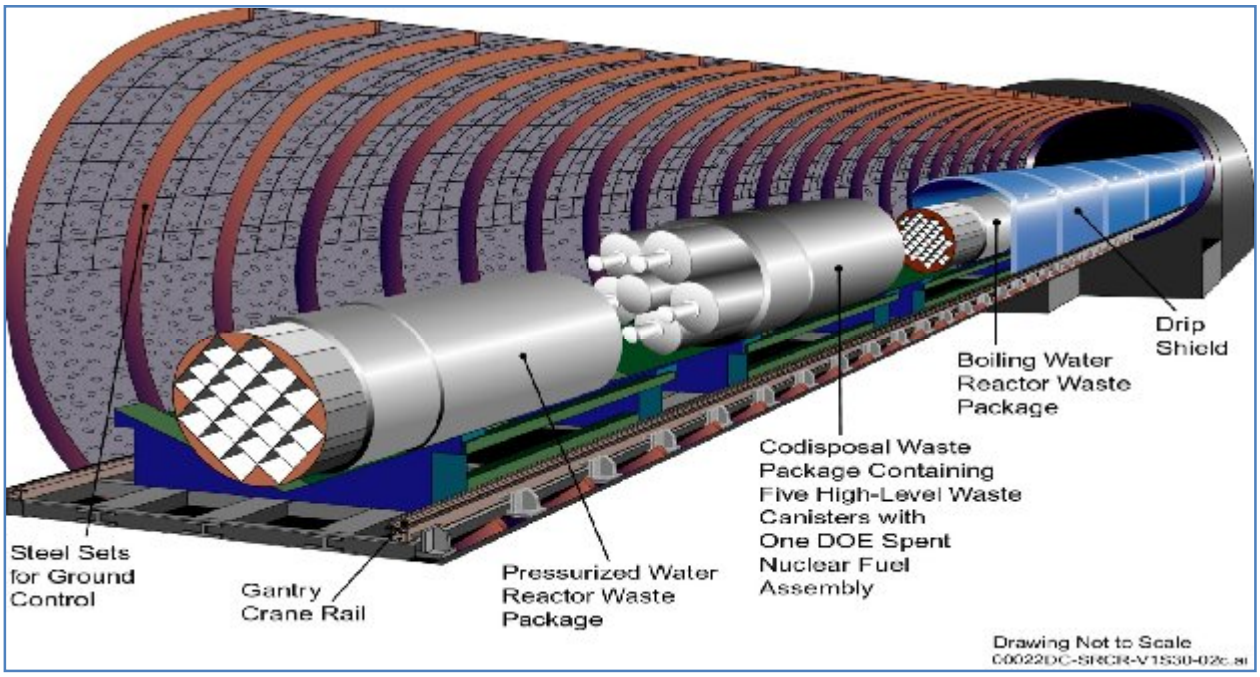

Fig. 3. Schematic illustration of the current disposal room design at the Yucca Mountain site.

Fig. 4. Photograph of a disposal room in the WIPP repository. To the right of the man in the picture are different CH-TRUW containers with white super-sacks on top containing magnesium oxide (MgO). The MgO will stabilize the pH in the rooms after their closure. To the left of the man is the entrance of an emplacement hole for an RH-TRUW container.

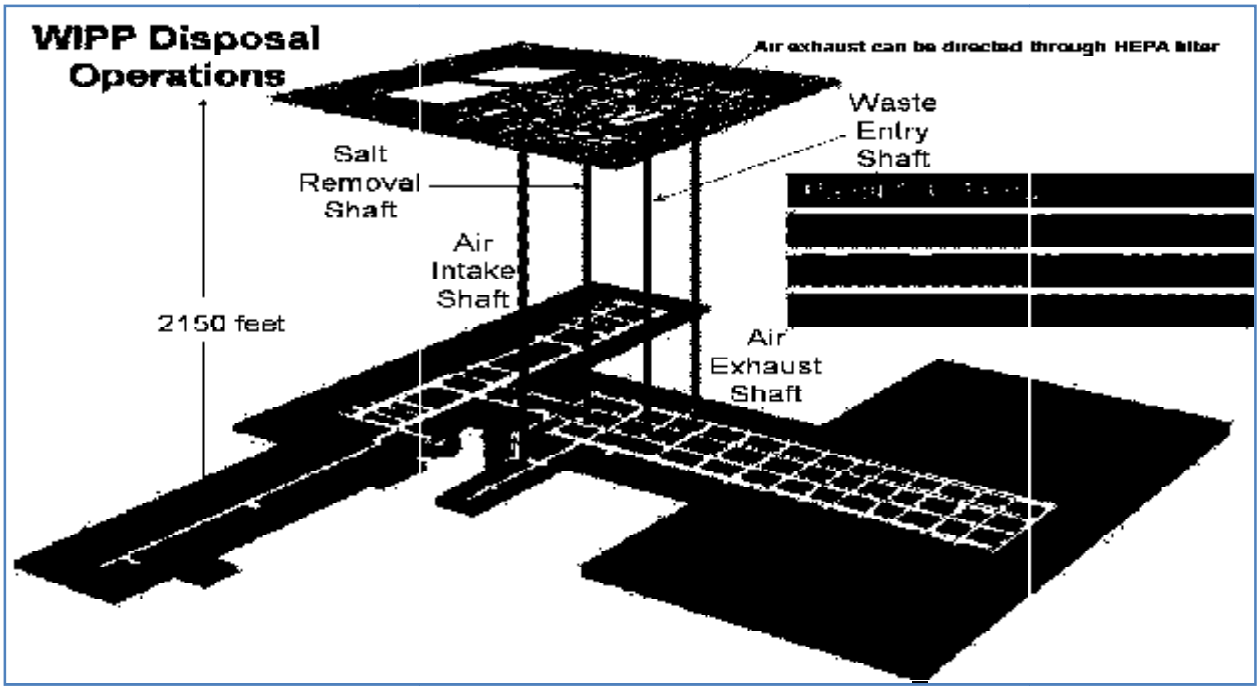

Fig. 5. Schematic illustration of the layout and the current status of the WIPP TRUW repository at the end of 2009. (The tunnels left of the "Air Exhaust Shaft" have been used since the late 1970s for full-scale TRUW, UNF, and HLW tests.[16]) (2,150 feet = ~650 meters)

In June 2008, OCRWM submitted a construction license application to the NRC for a 70 000 MTU UNF/HLW repository at the YM site, of which 63,000 MTU was projected to be utility-generated UNF. Seven months later, the Secretary advised Congress that the projected stockpile of UNF (and HLW) would exceed the statutory limit of the YM repository in 2010 and recommended that the capacity of the YM repository be increased.[4] In the event the requested capacity of the YM repository was rejected, he stated that "the most efficient path to identifying potential sites for a second repository would be to start with the other sites and areas that were under consideration for either the first or second repository before the Amendments Act was passed." However, this was an inaccurate or, at best, an incomplete statement. For example, it does not represent the "most efficient path" toward identifying potential new repository sites because it failed to acknowledge the following time-consuming and costly challenges:

1. The *strong political and public opposition* facing the repository sites, areas, and regions considered in the USA prior to 1987.
2. The meager and, in some cases, *virtually non-existent site-specific databases* on all but one of the previously abandoned sites.

Furthermore, the Secretary failed to mention the option for saving time and money by also evaluating and taking advantage, as appropriate, of lessons learned by other repository programs during the past 23 years as well as the challenges the previous sites had experienced. Although this omission may be inadvertent, it reflects an isolationistic policy employed by the OCRWM program following the enactment of the NWPAA in 1987 that has adversely affected the credibility and trustworthiness of the OCRWM program in the USA and abroad during the past

two decades. Hopefully, any future organization responsible for finding a new UNF-repository site, if needed, will be willing to take a serious look at and adopt applicable components to advantage of lessons learned in other repository programs. The WIPP repository program would be one such particularly logical and readily accessible starting point (Figs. 4 and 5). This and other potential remedies to the naked, catatonic, state of the US UNF and HLW disposal programs at the end of 2009 are described and discussed further below.

The energy section of the new Administration's February 2009 fiscal year 2010 budget priorities outline stated, "The Yucca Mountain program will be scaled back to those costs necessary to answer inquiries from the Nuclear Regulatory Commission, while the Administration devises a new strategy toward nuclear waste disposal."[5] It was subsequently indicated that this strategy may result in the abandonment of the YM site,[e.g., 2,3] which would forfeit the more than 34 years and $13 billion invested to date in the YM site. As follows, there are two possible outcomes of the pending politically-handpicked "blue-ribbon" panel review, i.e., the evaluation of and judgment on the suitability of the YM site to host the nation's first UNF and HLW repository could remain with the NRC or it could be preempted by a political decision to abandon the YM site.

In the event the current hold on the YM site is lifted, it would still add a commensurate or longer period to the projected already more than 19-year-overdue opening of the nation's first UNF repository. It could also rescind and/or trigger a legal challenge of the NRC's 2005 nuclear waste confidence decision. In the event the YM site is abandoned, it would likely trigger both the search for another reasonably-plausible UNF-disposition solution, and require the reevaluation of the aforementioned NRC decision. The first waste confidence decision (the Decision) was issued in 1984 and it defined the following five major NRC findings:

1. Reasonable assurance that safe disposal of HLW and UNF in a geologic repository is technically feasible.
2. That repository capacity will eventually be available.
3. That HLW and UNF will be safely managed until repository capacity is available.
4. That UNF generated in any reactor can be stored safely and without significant environmental impacts for extended periods.
5. That UNF storage will be available as needed.

In 1999, the NRC evaluated the Decision and found revision unnecessary. The NRC decided that it would only comprehensively reconsider the Decision when the repository development and corresponding regulatory activities "run their course" or "significant and pertinent unexpected events" occur that raise "substantial doubt" about the Decision. In 2005, the NRC found no reason to reopen the Decision in the absence of a denial of YM's License or DOE's abandonment of the site. In October 2008, the NRC stated "The NRC continues to believe that it is possible for a repository to be available by 2025 even with some "slippage" in the DOE's schedule. One interpretation of the aforementioned statements is thus that unless the projected opening of the nation's first UNF repository extends beyond 2025, the 2005 Decision does not need to be reevaluated. Conversely, if the projected opening date extends beyond 2025, a new Decision is required, which would require several years to accomplish. It should thus be a political imperative to ensure that the nation has an operating UNF repository no later than 2025.

As summarized above, the YM site has been on indefinite hold since February 2009, and the NRC's ruling on the CLA is pending. In addition, the DOE must apply for a license to receive UNF and HLW before the YM site may open. Pending the outcome of these three events, the opening of the YM UNF/HLW repository might be achievable in 2025; prevailing politics allowing. However, in the event the site is abandoned or the CLA is rejected, 2025 is not even a remotely-likely viable projected opening year for another UNF/HLW repository. If one uses a simplistic linear model to estimate when a new UNF/HLW repository would be able to open based on the siting approach recommended by the Secretary in February 2009, the additional delay from where the program is today would be at least another 23 years, which would place the opening of the nation's first UNF repository no earlier than in 2048. As follows, at the end of 2009, the US program for safe disposition of commercial UNF appears to be in an indeterminate state of flux that may seriously compromise the validity of the Decision, which, in turn, could trigger a new nuclear waste confidence ruling process. It could also overflow into a broad range of Homeland Security and National Renaissance issues. Furthermore, the long-standing lack of a fully integrated nuclear waste management program already has and will continue to adversely affect the USA's ambitions to be perceived as the world leader and prime authority on waste management issues and related services. Indeed, many nations are already concerned about the negative global impacts of the USA' s lack of a functioning nuclear waste management program.

Admittedly, these are speculative scenarios and outcomes but the future of the Nuclear Renaissance and the USA' standings in the international radioactive waste management community are currently at stake due to the naked, catatonic, state of the USA's only reasonably-plausible disposition solutions for UNF. Since we simply can't continue to ignore the perilous future of the nation's UNF-disposal program and silently wait for the inevitable quality-of-life decline resulting from too little and/or too expensive electricity, measures need to be taken promptly at the nation's highest levels to ensure a sustainable supply of electricity for both current and future generations. Simply stated, all other clean alternative energy forms combined cannot provide either the amount or the fluctuating energy needs USA must have for maintaining its current quality of life and international competitiveness in a timely manner. In other words, nuclear energy is the primary clean solution to the nation's current and future electricity needs for at least another two to three decades while other clean energy technologies are being developed on industrial scales.

POTENTIAL REMEDIES TO SOME SELECT CHALLENGES FACING THE SAFE DISPOSITION OF USED NUCLEAR FUEL IN THE USA AT THE END OF 2009

The focus below is on potential remedies to the following challenges to the timely UNF disposal in the USA described and discussed in the preceding text:

1. A globally-*unique nuclear waste classification system* based essentially on who generated the waste and what it is not, rather than its inherent radioactive characteristics.
2. *Site-specific licensing and environmental radiation protection standards*.
3. *A globally-unique UNF/HLW disposal concept in a globally-unique repository host rock.*
4. *A Congress hitherto unwilling to touch the nuclear waste management* issue since 1998.

5. *An implementing organization that has failed to comply with applicable laws for more than 12 years* hitherto and projecting prior to the hold being placed on the YM repository project in 2009 that it will continue to break the law for at least another 7 years under the most optimistic assumption.
6. *An additional politically-imposed multi-year delay to the opening of the nation's first UNF/HLW disposal system*.
7. *Lack of trust in the messenger(s)*, which is a common inherent component to any future resolution of several of the above challenges.

The underlying logic of several remedies is that any repository meeting the criteria defined in applicable regulations and standards are adequately safe, provided the applicable criteria provide a level of radiation protection that equals or exceeds those recommended by multi-national health and radiation protection agencies. An integral bias is that no repository should be located in a community where the majority of the residents are against it because, as has been shown in many nations, gaining local acceptance is simply a matter of a) ensuring that local residents fully understands the risks involved, and b) establishing and maintaining a trusting and respectful relationship, and not having it leads to failure. Unfortunately, a detailed description of the proposed remedies is not possible in the space available. Notwithstanding this shortcoming, some of the remedies outlined below also applicable to other long-lived radioactive waste categories. Since the proposed remedies are embedded in the subsequent text they are highlighted in *italics* to be more visible.

There is no apparent solution to the USA's unique waste classification system because it is enshrined in legal and regulatory frameworks that, if changed, rescinded, or vacated, could bring many, if not all, related existing nuclear operations in the USA to a halt.

There is simply no substitute for *nation-wide licensing regulations, and public-health and environmental-radiation-protection standards for UNF- and HLW-disposal facilities* if public acceptance, and the credibility and trust in the messenger(s), are sought. Indeed, nation-wide regulations and standards are a fundamental condition for acceptance of any nuclear-related facility. In other words, whereas the oversight may be delegated to an Agreement state, *only the NRC and the EPA should be allowed to promulgate nuclear-related licensing regulations and public health and environmental radiation protection standards, respectively*. Case in point, only one Agreement state, Texas in 2008, has licensed a Compact LLW-disposal facility during the past 30 years despite the existence of several other Compact LLW disposal facilities, such as those in New York, Illinois, and California, having shown compliance with all applicable regulations and standards.

There is no apparent remedy to the current disposal concept or the host rock. There is, however, an option to reduce the uncertainty embodied in the P/SAs, if needed, by *a reduction of the current thermal loading*.[15,17]

Although Congress has failed for more than 12 years to act decisively upon the illegal status of the nation's first repository for commercial UNF, three very compelling current reasons for the Congress to come out of the closet and develop a legislative framework for a fully-integrated national nuclear waste management and disposal policy are: 1) the projected energy needs for the

next three decades; 2) the already inadequate disposal capacity of the YM repository, and 3) the existence of WIPP demonstrating the proof of principle for safe disposal of long-live, highly-radioactive, waste. However, due to the long-standing opposition in Nevada to the YM UNF/HLW repository, the composition of the current U.S. Congress and the Commissioners of the NRC, and the actions taken and statements issued by the new Administration, the probability is very high that the YM site will be abandoned or, at best, be kept on a minimal life support system until the NRC rules on the CLA. The two most apparent potential saviors of the YM repository being abandoned prior to the NRC's ruling are:

1. The legal conflict it would generate with regards to the authority currently vested by law in the NRC and the EPA.
2. The fear among the members of the Congress that it would open the door for having a repository in their own home state, which, in turn, could jeopardize their job security.

As illustrated both in the USA and abroad for more than three decades, the prevailing nuclear agenda of the sitting Administration governs both the pace and the cost of a repository program for long-lived, highly-radioactive, waste. The level of residential support in the potential host community for the repository, be it GTCC, ILW, UNF, or HLW, is a close second. As elaborated upon below, lack of early and sustained local political and public support embody a very high probability of failure, whereas early and sustained local public support have been the cornerstones of successful siting of potential underground research laboratories (URLs) and/or repositories in Finland (Eurajoki), France (Meuse/Haute Marne), Sweden (Oskarshamn and Östhammar), and the USA (Eddy County). A potential remedy to unblock the current political hold on the YM site would thus be to *promptly conduct a referendum asking the local residents whether or not they support the YM repository project*. An explanation of the potential incremental increase in risk from the YM repository relative to that of the already existing subsurface amounts of radionuclides at the Nevada Test Site might provide a more readily understood yardstick for conveying the related risks than the projected radiation exposure numbers that lay people don't understand.

The aforementioned strategy is largely based on the following historical events and conditions:

1. The WIPP repository was benefitting from local support from the outset. Indeed, local politicians and residents invited the DOE in 1972 to investigate the local salt beds for a suitable/safe repository site. This local support has been strong ever since and it was instrumental in overcoming the vociferous opposition to WIPP from a small group of long-distance opinions and ideologies, including those in the governor's office and related agencies, that grossly misrepresented and skewed the impression of the prevailing local support.
2. Political representatives of the host community for the YM site, Nye County, support the YM project. However, as illustrated at e.g., Almunge, Malå, and Storuman in Sweden, the Wellenberg facility in Switzerland, and the Sellafield underground research laboratory (URL) in the United Kingdom, the opinions of the local politicians don't always represent the opinions of the local residents. Interestingly, according to independent polls, the residential support of the nation's first UNF repository in the two communities considered in Sweden in 2008 were 79% in the municipality of Östhammar and 86% in the municipality of

Oskarshamn. Furthermore, these levels of local support increased during the then six-year-long detailed site characterization process of the Forsmark, Laxemar and Simpevarp sites. In other words, if both the benefits and the risks are properly explained, as they are in Sweden, the likelihood that a nuclear project will be accepted locally increases. It then boils down to the implementing organization to maintain local support, which requires credible actions and uninterrupted transparency of what the implementing organization's intentions are, and willingness to listen to and timely accommodate requests from the host community.

3. The current Administration seems to be in favor of the abandonment of the YM site. A long-standing national political perception/dogma in the USA is that supporting a nuclear facility is political suicide. However, if the majority of the local residents support the YM project, it may change this paradigm because the political abandonment of the YM site prior to or in contrast to the pending ruling by the NRC on the CLA, would result in the following two major national issues:
   a. It would be in conflict with the NRC's and the U.S. Environmental Protection Agency's (EPA's) long-standing statutory authority to promulgate and implement regulations providing as low as reasonably achievable risks to the U.S. population and the environment from radiation.
   b. It would leave the USA without a reasonably-plausible solution for the safe disposal of its UNF and HLW, unless the WIPP project is accepted as a physical demonstration that UNF can be safely disposed in a deep geological repository. As mentioned above, absent a reasonably-plausible UNF-disposal solution, the NRC's 2005 nuclear waste confidence decision would likely be rendered invalid and the Nuclear Renaissance would come to a screeching halt in the USA, and perhaps, elsewhere, while a new nuclear waste decision is being developed, which would require several years of contested public hearings and a final court ruling due to the prevailing litigious nature and presence of strong anti-nuclear interest groups in the USA. Recent political changes of several of the five NRC Commissioners also convey a strong signal that the prevailing political agenda of the new Administration rather than the staffs' conclusions and recommendations might govern the pending ruling on the CLA for the YM UNF/HLW repository. As follows, a second recommendation is to *promptly initiate a nation-wide campaign explaining the experiences embodied in the WIPP project*, which include a wide range of full-scale UNF and HLW tests.[16,18] Indeed, this might be the only viable solution for extending the NRC's 2005 nuclear waste confidence decision in the event the YM site is abandoned or its CLA is rejected because the WIPP repository physically validates that long-lived radioactive waste may be safely disposed in a carefully sited and designed deep geological repository. It also validates the 1957 expert conclusions that rock salt is the most promising repository host rock.[6] The "blue ribbon" panel and others would thus be well served to consider the experiences gained in the WIPP program since 1975 in the event another repository site for long-lived radioactive waste is needed. However, although rock salt could serve as a primary "safety/performance" host-rock siting criterion for another repository, it is only one of four rock types that have been investigated thoroughly during the past 30 years. The other three rock types are basalt (USA), crystalline/igneous rocks (Finland, Japan, Sweden, Switzerland, and the USA), and low-metamorphosed sedimentary rocks/argillites (e.g., France and Switzerland).

Admittedly, these are speculations but regardless of either outcome, the current legal disposal capacity for the nation's UNF and HLW needs to be increased, the overriding question at this time is WHEN? Regardless of the answer to this question, a proven solution for mitigating the impact of current and future delays to the opening of the nation's first UNF/HLW-repository under the existing legislative framework, whether it would be located at the YM site or elsewhere, the third recommendation is to *promptly develop one or more federal storage facilities for utility-generated UNF*. This solution has been safely operated in many countries for several decades and embodies the following specific benefits to the U.S. UNF-disposal program:

1. The Secretary would be able to take title to the utilities UNF at least five years earlier than current earliest possible opening date of the YM repository, which, in turn, would reduce the breach-of-contract payments due to the utilities.
2. Waste treatment technologies could be developed and/or implemented that would reduce the amount of "UNF" requiring deep geological disposal.
3. Nationwide UNF- and HLW-disposal regulations could be promulgated, including a new NRC nuclear waste confidence decision, since the storage of UNF as well as other nuclear activities at DOE sites are governed by DOE Order 435.1.[19]
4. The thermal output of each waste package is time-dependent and goes down with time, which in turn could be used to either dispose more UNF per unit repository area than the current design if the same thermal loading is maintained, or it could be used to reduce the thermal loading per unit area, which in turn would reduce the uncertainties embodied in the post-closure P/SAs.[15,17,18]

In addition to having violated the law for more than 12 years, the projected opening of the nation's first UNGF repository is currently at last 19 years behind its statutory opening date. Furthermore, no optional solution has been pursued since 1987. Based on the organizational structure and related progress of foreign UNF repository programs, there are compelling reasons to suggest that it would be much more beneficial to the utility ratepayers if the utilities also were responsible for the disposal of its UNF. It would unify the nation's management and disposal of commercial SNF under one industry entity that would work with rather than for the ever-changing political community. The safe disposal of government-generated SNF and HLW (and GTCC LLW and sealed sources), would remain DOE's responsibility, and leave the DOE with the following three long-lived radioactive waste disposal solutions:

- A much smaller "defense-waste-only" repository at the YM site, and/or
- An expanded mission of the WIPP repository/site, and/or
- Buying disposal space in a commercial UNF repository.

However, the first step in a well conceived integrated national nuclear energy and waste management strategy is to *estimate how much long-loved radioactive waste the nation will generate during the coming 50-100 years, when it will be produced, and when and how it needs to be disposed of*. One directly related key issue is whether or not to reprocess the UNF, and if reprocessing becomes part the strategy of the future, how much of the UNF should be reprocessed and when. Furthermore, is indicated above, due in large part to the huge expense and socioeconomic, ideological, and political challenges involved in siting, developing, opening, and operating a new repository and the expected difficulty in finding more than one new

repository sites, a future fully-integrated national nuclear waste management and disposal policy/strategy needs to look outside the UNF box and also consider other long-lived, highly-radioactive, waste categories such as e.g., GTCC LLW and sealed sources and their respective need for safe disposal solutions during the next 50-100 years.

Whereas the NRC and EPA benefit from considerable public trust, the DOE does not. Furthermore, the recent DOE policy to only allow a few select individuals to speak on behalf of the OCRWM program effectively eliminated the small sliver of transparency the program had mustered to demonstrate during the past two decades. As suggested repeatedly in the preceding text, one way to improve the trust in the messenger is to *replace the distrusted messenger*. Specifically, transferring the responsibility to the nuclear utilities would extend their current default caretaking/storing of their UNF on behalf of the DOE.

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