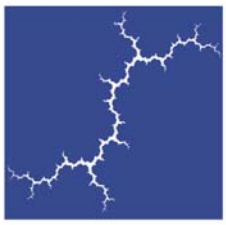


Synapse
Energy Economics, Inc.

The Real Costs of Cleaning Up Nuclear Waste

Appendix B:
Radioactive Exposure from the West Valley Nuclear Site

August, 2008

AUTHORS

Emily Brown, MS

Marvin Resnikoff, PhD

Radioactive Waste Management Associates

526 West 26th Street, Room 517

New York, NY 10001

Introduction

The West Valley Demonstration Project in West Valley, New York reprocessed spent fuel rods from military and civilian nuclear power plants for six years, from 1966 through 1972. The site was also the location of a commercial nuclear waste burial facility which was open from 1963 until 1975. West Valley Nuclear Waste Site was operated by the Nuclear Fuel Services (NFS), a subsidiary of Grace Chemical and then Getty Oil. In 27 campaigns, approximately 641 metric tons of uranium and 1,983 kilograms of plutonium were reprocessed at West Valley Nuclear Waste Site (Table 1).[1] Poor operation practices occurred at the facility, with workers exposed to the highest doses of radiation to any nuclear workers in the United States. NFS routinely hired temporary workers with no prior radiation exposure to work in high radiation areas, exposing them to high levels of radiation that when combined with their time of no exposure would average to 5 rem/year. Some workers received radiation doses up to 12 rem in a single year.

NFS elected in 1976 to not continue reprocessing due to the extensive costs of meeting heightened regulatory requirements. Opposition by the Coalition on West Valley Nuclear Wastes and the Sierra Club were also important in their closure. NFS departed the site following the expiration of their lease at the end of 1980. The site and facility are now owned by the New York State Energy Research and Development Authority (NYSERDA). The West Valley Demonstration Project Act, Public Law 96-368 (WVDPA) was passed in 1980, directing the DOE to begin the solidification of the liquid high-level waste (HLW) and decontamination and decommissioning of the plant. The West Valley Nuclear Services Company (WVNSC), a subsidiary of Westinghouse, was selected to manage and operate the site for DOE. The WVDPA currently requires the State of New York to pay 10-percent of project costs, while the DOE is responsible for the remaining 90-percent.

West Valley Nuclear Waste Site is approximately 30 miles south of Buffalo, NY. The center is located on a plateau which is transected by several streams, including Buttermilk and Frank's Creeks. These streams collect all site surface and shallow subsurface drainage. In 1979 it was noted that the valley walls of Buttermilk Creek and its tributaries are quite steep, but are badly slumped in some areas. Radionuclides were detected in the sediments of the streams as well as in fish and deer tissue in the 1970s.[2] Radionuclides identified as coming from West Valley Nuclear Waste Site have also been found in Lake Ontario sediments.[3] A measurement in water and sediment samples found that cesium-137 from West Valley has made its way into Lake Ontario. This data confirms that the radioactivity released from West Valley travels through Lake Erie towards the Niagara River and into Lake Ontario. This path would take the water along the south shore of Lake Erie towards the Niagara River. The water would thus pass by the Sturgeon Point Treatment Plant, the Van de Water Treatment Plant, and the intakes for the city of Buffalo.

---

[1] WVNSCO and Gemini Consulting Company, 2005
[2] Battelle, Prepared for US DOE, 1979
[3] Joshi, SR, 1988a

Two draft environmental impact statements (DEISs) have been prepared relating to the decommissioning and long-term management of the site. One was released in 1996 and the second prepared but not officially released in 2005. A final environmental impact statement (FEIS) on the long-term management of liquid HLW was published in 1982. The primary areas of concern at West Valley Nuclear Waste Site include the state-licensed disposal area (SDA), the NRC-licensed disposal area (NDA), HLW tanks, process building, groundwater plume, lagoons, low-level waste (LLW) storage buildings, and the drum cell facility. We focus on the HLW tanks within this document due to their high activity and the preference of the DOE to close them in-place, despite a multitude of issues that should prevent this from occurring. We also include a discussion of the SDA and NDA, as they also contain high levels of radioactivity and the DOE would prefer to close them in-place as well.

Figure 1 shows a diagram of the West Valley Nuclear Waste Site, Figure 2 indicates a more clear depiction of where the local hydrology is in relation to the site, and Figure 3 is an early diagram of the site from 1979.

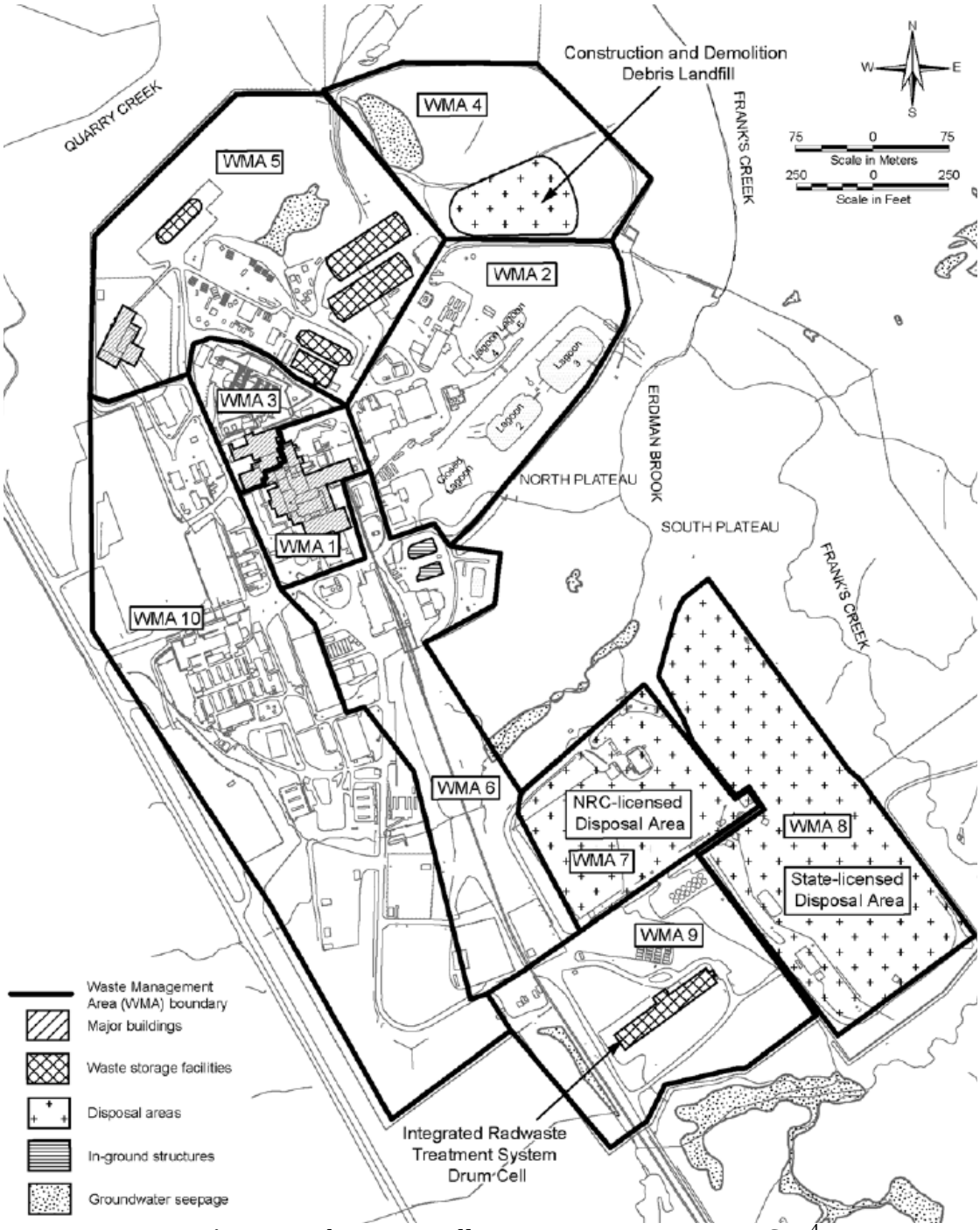


Figure 1. The West Valley Demonstration Project Site[4]

[4] US DOE and NYSERDA, 2005

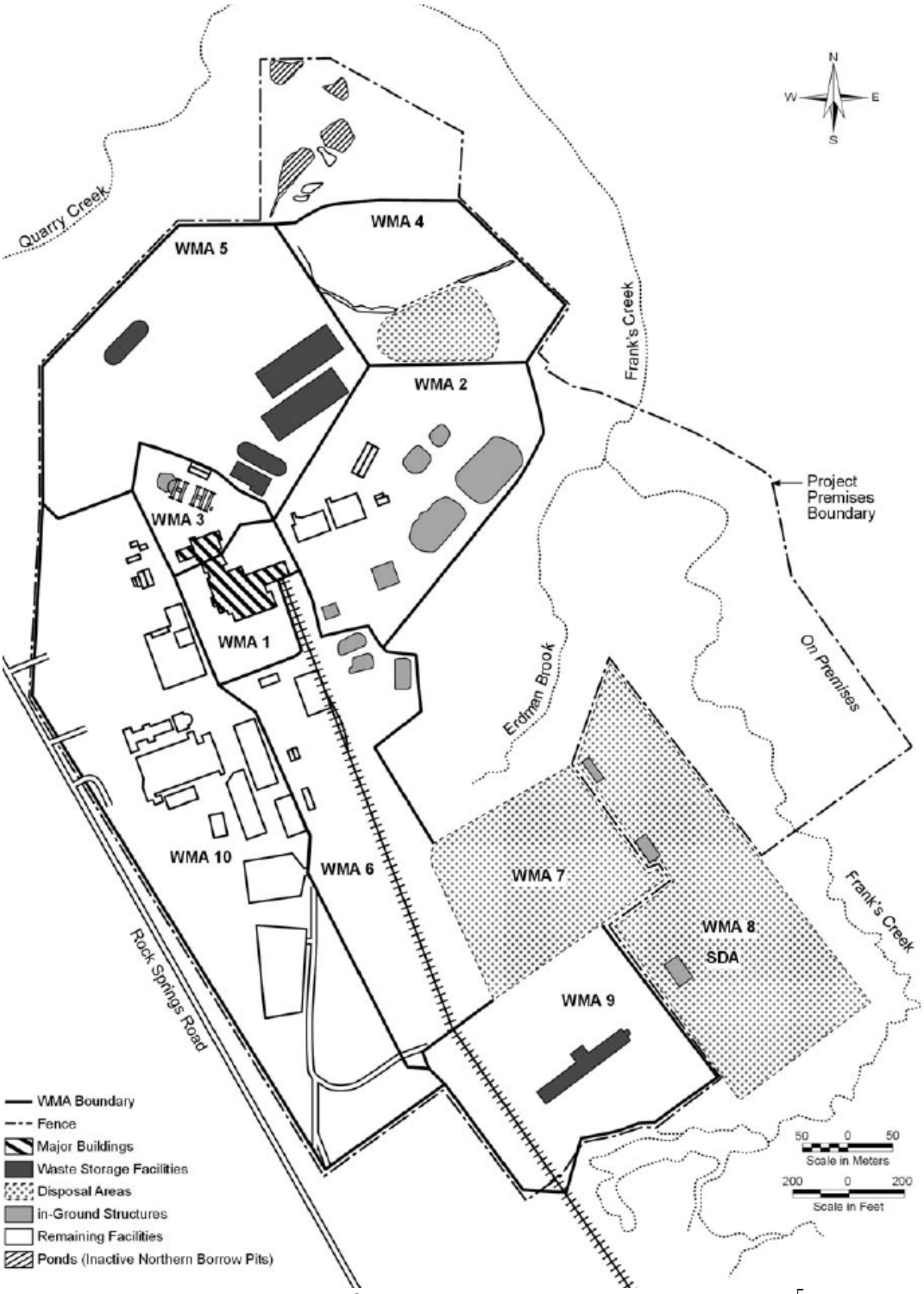


Figure 2. Diagram of Hydrology Adjacent to SDA and NDA[5]

[5] US DOE and NYSERDA, 2005

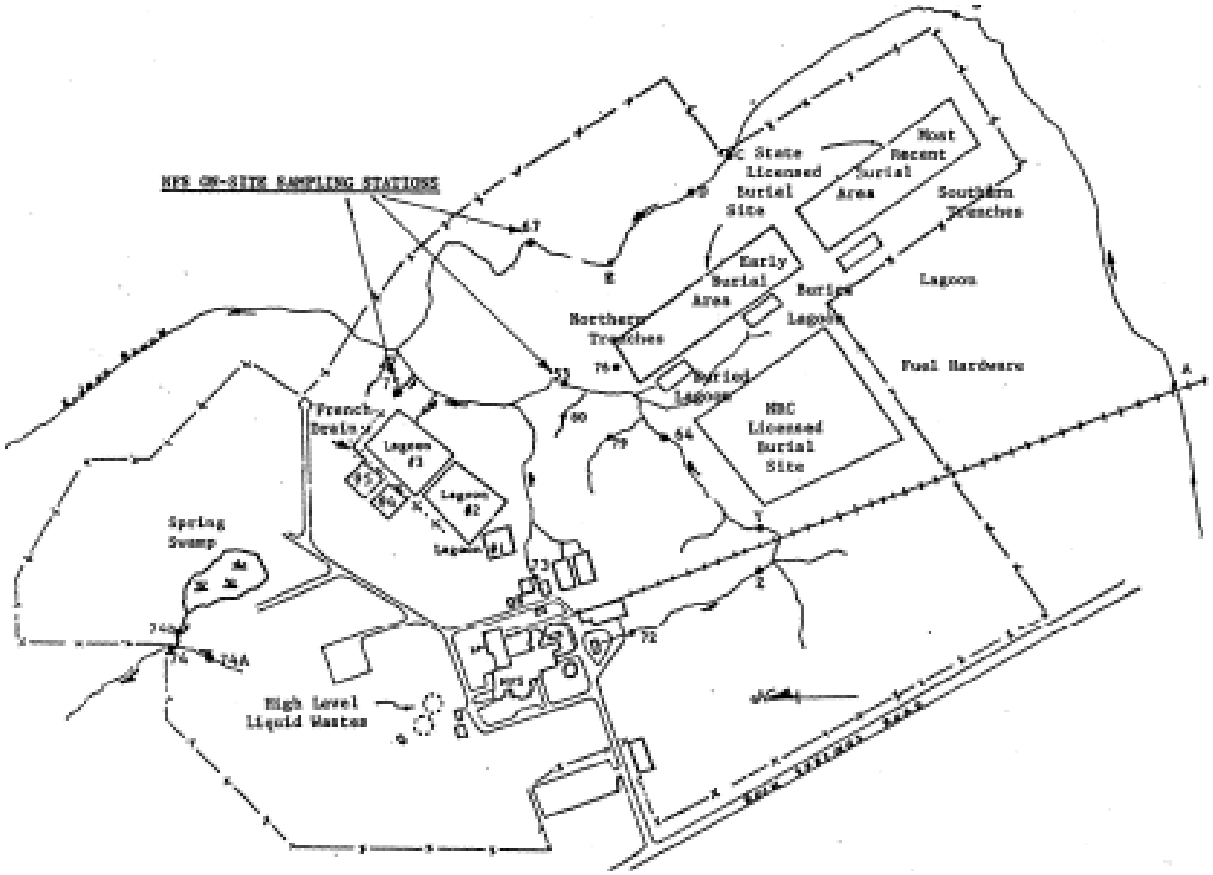


Figure 3. Early Diagram of the West Valley Nuclear Waste Site [6]

Tank Design

Four underground HLW storage tanks were built to store high-level radioactive liquid waste generated from spent nuclear fuel reprocessing operations at the West Valley Nuclear Waste Site. The four tanks are contained within waste management area (WMA) 3. There are two large, 8D-1 and 8D-2, and two small, 8D-3 and 8D-4, HLW tanks (Figure 4). Approximately 600,000 gallons of HLW from irradiated fuel reprocessing generated from 1966 to 1972 was stored in these underground tanks. Much of the waste was removed from the tanks and solidified via vitrification during the time period of 1996 through 2002.

[6] Battelle, Prepared for US DOE, 1979

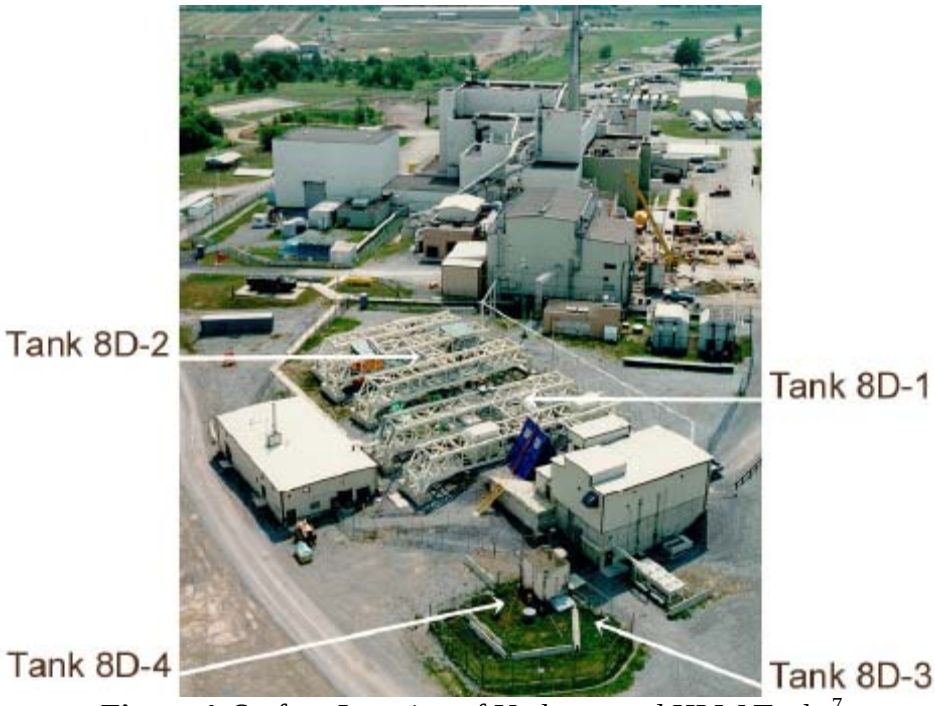


Figure 4. Surface Location of Underground HLW Tanks[7]

Tanks 8D-1 and 8D-2

The two large tanks, 8D-1 and 8D-2, are identical in size and construction. Cracks in the vault for 8D-1 were observed during an initial inspection, and thus Tank 8D-2 was designated as the operational tank. Tank 8D-1 was designated as the spare tank. See Figure 5 for a schematic of both tanks. Each tank is composed of reinforced carbon steel plate with an inside 70 foot diameter, 27 foot height, and volume capacity of 750,000 gallons. The tank carbon steel wall is between 0.44 and 0.5 of an inch thick. The roof of each tank is 0.44 of an inch thick and is supported internally by 45 eight-inch diameter vertical support columns that rest on a horizontal gridwork of wide flange beams and cross members in the bottom two feet of each tank. These steel columns support the roof and risers and are braced by a line of support assembly structures. Each wide flange beam is positioned no less than 20 inches from the tank floor. A support assembly structure includes a section of steel plate that is set vertical to the bottom of a wide flange beam, an interconnecting 1.5 inch diameter steel rod welded to the plate and a one inch thick circular disk fixed to the tank floor on which the steel rod is set. The roof is a series of beams that are approximately 10 feet apart running parallel to one another. These beams are welded to 55 rows of structural channel beams running perpendicular to them. The structural channel beams are 15 inches apart. The bottom of the tank is 0.5 of an inch thick. See Figure 6 for a schematic view of the tank gridwork, including the support columns, wide flange beams, and support assembly structures.[8, 9, 10]

[7] WVNSCO and Gemini Consulting Company, 2005
[8] Ibid
[9] US DOE and NYSERDA, 2005
[10] Battelle, Prepared for the US DOE, 1979

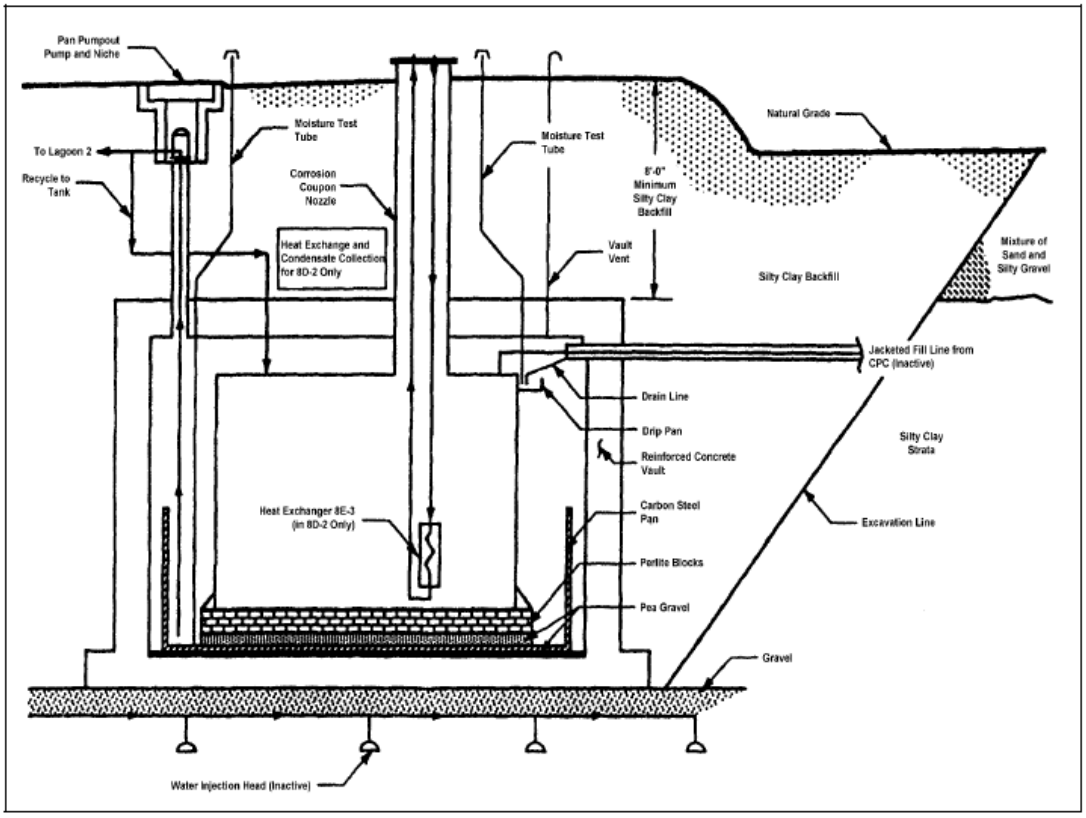


Figure 5. Schematic of Tanks 8D-1 and 8D-2[11]

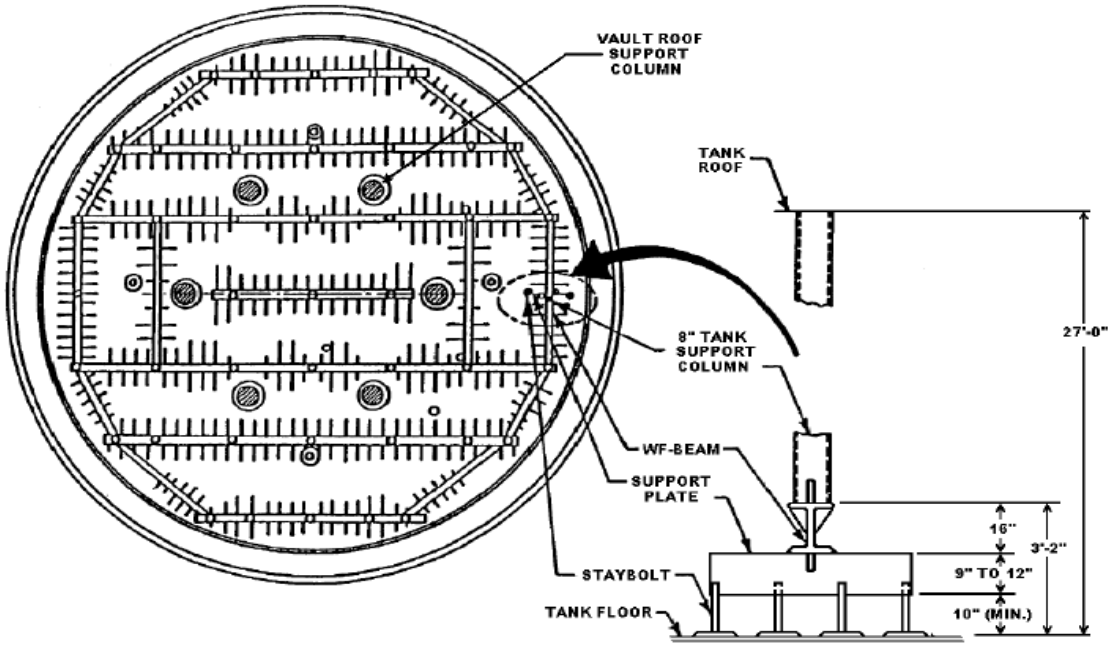


Figure 6. Interior View of Gridwork in the Bottom of Tanks 8D-1 and 8D-2[12]

[11] Jacobs Engineering Group Inc. and Pacific Northwest National Laboratory, 2002
[12] WVNSCO and Gemini Consulting Company, 2005

Each tank sets atop two six-inch layers of perlite blocks that rest on a three-inch layer of pea gravel. This is all contained within a 75-foot diameter carbon steel pan that sits atop another three-inch layer of pea gravel separating the pan from the vault floor. The pan extends about four feet from the bottom of the tank vault floor. Each tank and pan is within a cylindrical vault composed of reinforced concrete with an outside diameter of 78.6 feet. The vault has a height of approximately 36 feet above the vault floor. The vault walls are 1.5 feet thick. The vault's roof is approximately two feet thick. The tank vault floors are approximately 2.25 feet thick, although they are thicker in a ring underneath the vault roof support columns. These six large concrete columns encased in steel pipes extend upward through the tanks to function as structural support for the vault roofs. The columns are approximately 16 feet from the center of the tank. The vault floors set atop a concrete slab that rests on a four-foot thick bed of gravel. The concrete vault roof is 2-feet thick and is supported by the six concrete columns. The top of the vault is between six and eight feet below grade.[13, 14] The vaults for Tanks 8D-1 and 8D-2 are approximately 15 feet apart. The concrete slab on which the vaults rest sits atop a gravel bed. Water was historically injected into the clay below to keep it moist and impermeable and prevent water from flowing through it. The tanks are not attached to the vaults. They sit atop perlite blocks that act to insulate the vaults from heat when the tanks were stress relieved. The pans were not stress relieved.[15] The stress relieving process required that tank temperatures reach 1,000°F, a temperature at which concrete degrades. Cracks occurred due to thermal gradients. An estimated 130°F difference between the inside and outside of the vault is sufficient to lead to cracking. According to the NRC, there are cracks on the exterior surface of the vault due to the thermal gradient.[16]

An early study of the tank model indicated that the horizontal structures along the bottom of the tank would shield and prevent the removal of sizeable amounts of sludge on beam flanges and behind the vertical plates. It was also noted in a 1979 report that "based on experiences at Hanford and Savannah River it is all too apparent that carbon steel tanks have a finite and sometimes unpredictable life, even under protected conditions".[17] Of the 16 HLW tanks made of carbon steel at Savannah River, 11 have leaked, with the primary cause of leaking being nitrate stress corrosion cracking.[18]

During construction in 1965 the vaults floated upwards three to four feet out of position.[19] This occurred after the tank and vault were constructed but prior to backfilling of the excavation. Water filled the construction pit to a depth of 30 feet and the vaults and tanks floated (each weighing 2,850 tons) three to four feet from the concrete pad. While the vaults were floating mud washed under the vaults. After the removal of the water, the vaults settled on the mud at an angle. The tops and bottoms of the vaults cracked as a result of this incident. The area at the base of the slab was repaired with grout and the silty mud between the vault and slab was washed and replaced with cement. Despite this,

[13] US DOE and NYSERDA, 2005
[14] WVNSCO and Gemini Consulting Company, 2005
[15] NFS, 1964
[16] Sierra Club, 1979
[17] Battelle, Prepared for the US DOE, 1979
[18] Westinghouse Savannah River Company, 2001
[19] US GAO, 1980

the vaults continued to rest at tilted angles. It is unknown whether all of the cracks were identified and filled and what stress presently exists on the vaults and slabs due to the tilted position.[20] The integrity of the grout and whether or not it filled all of the voids in the slab under the vaults are unknown.[21] Tank 8D-1 vault remains tilted approximately 13 inches while the Tank 8D-2 vault is tilted approximately two inches.[22] Inspection of the vaults found that the vault for Tank 8D-1 endured more damage, which was the reason it was designated as the spare tank.[23]

At the time of the floating incident a contractor determined that all of the stress from floating was placed on the vaults, and not the tanks, although the contractor did not submit any inspection data or engineering analysis to support this statement. The Atomic Energy Commission (AEC) took their word at face value and did not request a re-examination of welds within the steel tanks. NFS then maintained a minimum of five feet of liquid in the tanks to prevent the tanks from floating in the future if water were to enter the vaults.[24] The NRC assessed the safety of the HLW tanks in the 1970s and determined that they would continue to operate safely because no leaks had been detected from the tanks, general corrosion rates were thought to be less than the tanks were designed for, and all welds had been treated to prevent stress corrosion cracking.[25] A hole was detected in the 0.375 inch thick containment pan for Tank 8D-2 in 1979; the hole is located at an undetermined locations somewhere between zero and three inches from the bottom of the pan.[26] A former worker reported that the pan was tested during construction and held water, and so the hole must have occurred in the following years.[27] It is possible that the floating incident or thermal gradients caused the vaults to crack further thereby placing stress on the pan leading to corrosion. The damaged pan in turn may be placing additional stress on the tank. In addition, groundwater is known to flow into the Tank 8D-2 vault.[28]

The tanks were placed in operation in 1966. A 1979 Battelle report states that the design life for tanks 8D-1 and 8D-2 is 50 years.[29] A later report suggests that the tanks have a design life of 40 years based upon standard industry practice in effect at the time of their creation.[30] In 1979, "although the NFS tanks are stress-relieved, the Government Accounting Office (GAO) believes that the potential for leaks is present based on the experiences at DOE facilities and possibility of earthquakes in the West Valley area". In the 1970s the GAO recommended that the NRC assess the seismic integrity of the tanks, that an analysis of stress relieving data be conducted, and that the present condition of the vault system and soil characteristics be conducted on a priority basis.[31] A seismic analysis

[20] Sierra Club, 1979
[21] Lawrence Livermore Laboratory, 1978
[22]WVNSCO and Gemini Consulting Company, 2005
[23] US GAO, 1977
[24] Ibid
[25] Ibid
[26] NFS, 1979
[27] Sierra Club, 1979
[28] US DOE, 2008
[29] Battelle, Prepared for the US DOE, 1979
[30] WVNSCO, 1998
[31] Battelle, Prepared for the US DOE, 1979

in 1978 found that significant cracking of the vault would occur due to 0.13 g and higher earthquakes.[32] While this would not lead to the immediate release, over time these cracks would provide the HLW with a preferred release pathway to groundwater.[33]

Tanks 8D-3 and 8D-4

Tanks 8D-3 and 8D-4 were constructed two years after the reprocessing plant began operation. The tanks are made of Type 304L stainless steel and are 12 feet in diameter, 15.67 feet in height, with a volume capacity of 15,000 gallons. The walls and bottoms of the tanks are 0.375 of an inch thick and the roof is 0.3125 of an inch thick. Each tank includes two side mounted and one bottom mounted cooling coils to remove heat arising from radionuclide decay.[34, 35, 36]

Both tanks rest within one rectangular concrete vault that is 19 feet wide, 32 feet long, and 25 feet high. The walls, floor, and roof of the vault are 1.75 feet thick. Each tank sets atop support legs that keep the tank 2.75 feet from the vault floor. The vault floor and first 1.5 feet of the vault walls are lined with 0.375 of an inch thick 304L stainless steel plate. A stainless steel sump is contained in the lined vault floor to monitor liquid level. The sump has steam jets allowing any liquid that might enter the vault to be transferred to either tank. The vaults are surrounded by silty till and are covered by soil with a depth of approximately six feet. Figure 7 depicts a schematic view of the tanks.[37, 38]

[32] Lawrence Livermore Laboratory, 1978
[33] NFS, 1964
[34] US DOE and NYSERDA, 2005
[35] Battelle, Prepared for the US DOE, 1979
[36] WVNSCO and Gemini Consulting Company, 2005
[37] Ibid
[38] US DOE and NYSERDA, 2005

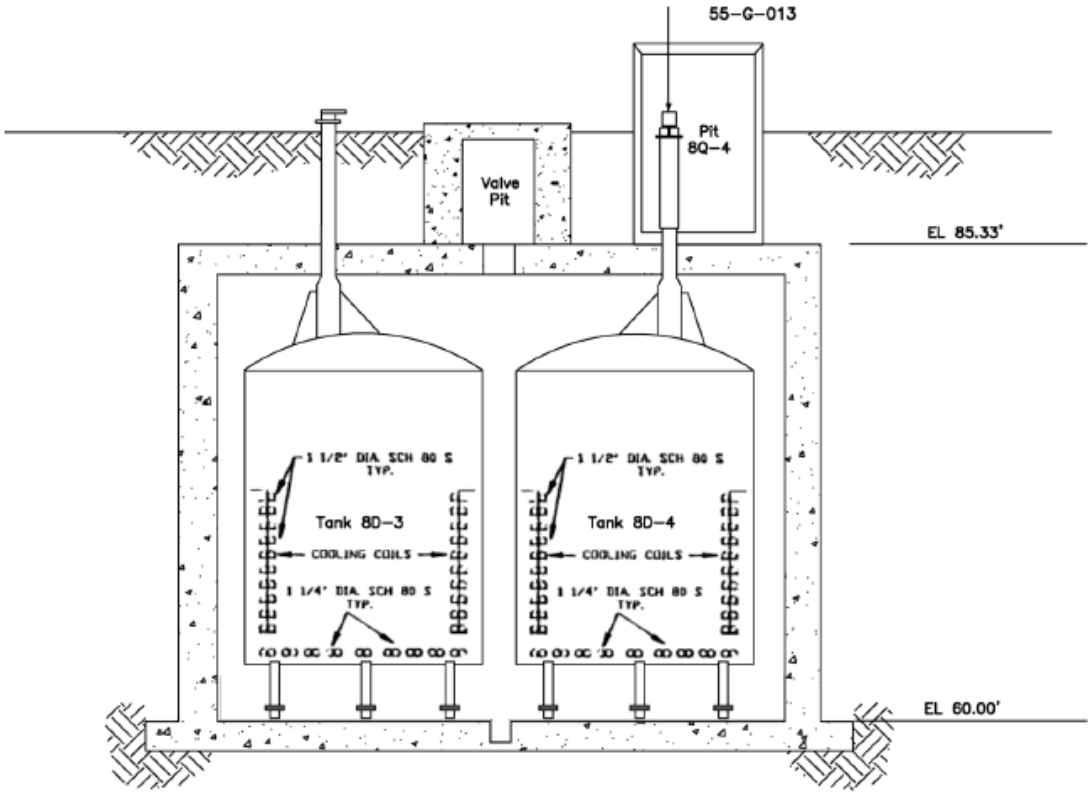


Figure 7. Schematic View of Tank 8D-3 and 8D-4[39]

History of Operation

Spent fuel reprocessing was conducted at West Valley for six years from 1966 until 1972. They operated through a provisional operating license granted by the AEC. Twenty-seven reprocessing campaigns were conducted during operation, 26 of which involved reprocessing solid spent fuel. The final campaign involved reprocessing 1,222 gallons of liquid residuals from an NFS facility in Erwin, Tennessee.[40] Table 1 contains a breakdown of fuels reprocessed at West Valley Nuclear Waste Site. A total of 750 spent fuel assemblies were received by West Valley Nuclear Waste Site, 625 were returned to their generators by 1985. The remaining 125 assemblies were slated for shipment to the Idaho laboratory in 2001.[41]

The reprocessing system was designed to support the recovery of plutonium and uranium from spent fuel with differing matrices. The plutonium uranium refining by extraction (PUREX) method was used to recover material from fuel with a uranium dioxide matrix, while the thorium extraction (THOREX) method was used to recover product from fuel with a uranium dioxide - thorium dioxide matrix. A total of approximately 600,000 gallons of concentrated HLW liquid were generated from these processes.[42]

[39] WVNSCO and Gemini Consulting Company, 2005
[40] Ibid
[41] US GAO, 2001
[42] WVNSCO and Gemini Consulting Company, 2005

The majority of the HLW liquid was generated from the PUREX method. This waste was neutralized with sodium hydroxide prior to being pumped to Tank 8D-2. Sodium hydroxide was also placed in the tank to ensure that a high pH condition remained in the tank. Acidic HLW liquids from one run (Campaign 11) using the THOREX method generated approximately 12,000 gallons of waste which was not neutralized and was stored in the stainless steel Tank 8D-4.[43]

Samples were collected from PUREX waste from the hold tank to confirm the radiochemical content of the liquid stream prior to being pumped into Tank 8D-2. It had initially been anticipated that the waste would self-boil, but this did not occur due to the large volume of non-radioactive liquid added to the tank (100,000 gallons of caustic solution for neutralization and 300,000 gallons of water to assure proper operation of the circulators) and the low heat generation rate of produced waste. A heat exchanger was installed in 1967 to boil off the excess liquid. The condensate from the heat exchanger was then sent to Tank 8D-1. In late 1970, 355,000 gallons of condensate water were removed from Tank 8D-1 to be treated by ion exchange that was then transferred to lagoons for release. The forced evaporation of liquid caused a ring of contamination to form around the top portion of the tank walls. The estimated volumes and contents in the tanks were monitored and tracked in quarterly reports to the AEC during plant operation. A series of liquid level measurements taken from Tank 8D-3 in 1977 determined that liquid was present in the tank. It was concluded that portion of the liquid evaporated from Tank 8D-4 had condensed in the off-gas line flowing back into the tanks. In 1979 this liquid was jetted with 1,500 gallons of water from the reprocessing plant to Tank 8D-4.[44]

Fuel reprocessing was halted in 1972 for modifications to increase capacity, reduce occupational radiation exposure, reduce radioactive effluents, and assess new government regulations. The regulations governing the facility had become much more stringent since the plant had begun operation; seismic and tornado siting criteria for nuclear facilities and more extensive regulations for radioactive waste management, radiation protection, and nuclear material safeguards had come into effect. The AEC required a complete licensing review to determine if proposed modifications were adequate. In 1972 one AEC official stated that the "spread of radioactive materials had imposed a potential threat to the health and safety of the public". One of the primary issues relating to West Valley Nuclear Waste Site and worker exposure was that the facility was designed for contact maintenance as opposed to remote maintenance as a means to initially cut costs.[45] It was determined in 1976 that modifications to bring the facility up to current regulations would be too expensive and NFS abandoned the site in 1980. The US DOE was first directed by the US Congress in the West Valley Demonstration Act in 1980 to solidify the liquid HLW, dispose of wastes from stabilization, and decontaminate and decommission the facility.[46]

[43] WVNSCO and Gemini Consulting Company, 2005
[44] Ibid
[45] US GAO, 1977
[46] WVNSCO and Gemini Consulting Company, 2005

Vitrification

Vitrification was selected by the US Secretary of Energy as the preferred technology to solidify the liquid HLW in the tanks in 1982.[47] In 1979 it was thought that removal of 95-percent of the sludge would be possible based upon reviews of testing at Savannah River. NUREG-0043 estimated that 80-percent of the sludge could be removed by sluicing. It was estimated that based on chemical flushing and sluicing data a conservative 4-percent of the sludge would remain in the tank, and that this remaining 4-percent would contain approximately 20-percent of the original sludge activity.[48] Figure 8 provides an overview of the pretreatment and vitrification process. As a result of neutralization at Savannah River approximately 10-percent of the total waste volume in the tanks would be composed of sludge.

[47] Ibid
[48] Battelle, Prepared for US DOE, 1979

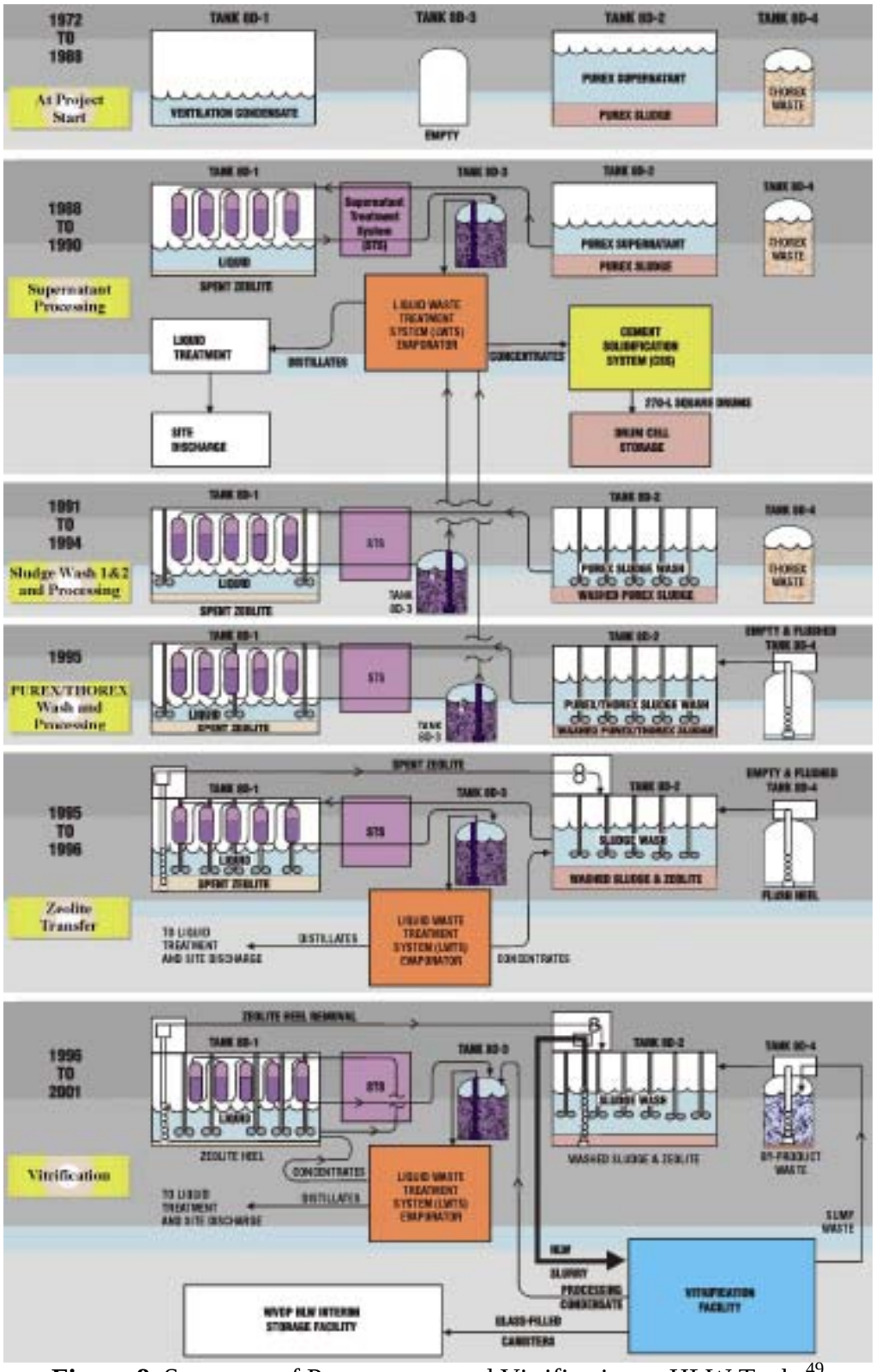


Figure 8. Summary of Pretreatment and Vitrification at HLW Tanks[49]

[49] WVNSCO and Gemini Consulting Company, 2005

Pretreatment

A supernate and multiple layers of sludge had formed at the bottom of Tank 8D-2 because of neutralization of the acidic PUREX waste causing insoluble hydroxides and other salts to precipitate out of the liquid. Chemical pretreatment was conducted to separate the major radioactive species (primarily cesium-137) from the liquids in Tanks 8D-2 and 8D-4, combine the separated radioactive species with the sludge to produce a HLW slurry mixture, and vitrify this resulting HLW mixture into glass form. The supernate from Tank 8D-2 was sent through zeolite-filled ion-exchange columns installed in Tank 8D-1 to remove cesium-137, sodium, and sulfate salts. The spent zeolite from the ion-exchange columns was then emptied into the bottom of Tank 8D-1. The decontaminated solution was sent to a liquid waste treatment system where it was concentrated via evaporation. The left-over liquid was returned to Tanks 8D-1 and 8D-2. The supernate processing occurred from 1988 through 1991, and approximately 618,000 gallons of PUREX supernate were processed. Approximately 99-percent of the major radioactive species in the supernate were determined to have been removed.[50]

Liquid pretreatment and processing removed sodium and interstitial sulfate salts from the sludge in Tank 8D-2. To accomplish this, the tank was first filled with demineralized water and sodium hydroxide solution was added to keep the plutonium and uranium in precipitate. Five mobilization pumps were then lowered into the tank to mix the contents. Liquid additions and mixing were performed to dissolve hardened layers of sludge, solubilized sulfate, and other undissolved salts to blend them with the wash solution and interstitial sludge liquid. The sludge wash solution was then processed through the ion-exchange columns in Tank 8D-1. The sludge preparation was conducted in October 1991 through January 1992 and from May 1994 to June 1994. Approximately 409,000 gallons of sodium-laden liquid were processed during the initial sludge wash campaign. The second sludge wash campaign resulted in the processing of approximately 375,000 gallons.[51]

Sodium hydroxide was the added to Tank 8D-2 to increase the alkalinity of the contents to a pH of 13 to ensure that the contents would remain alkaline following input of the acidic THOREX liquid from Tank 8D-4. The THOREX waste was transferred in three transfers in 1995. Sodium nitrite was then added to Tank 8D-2 to minimize pitting corrosion from the concentration of nitrates in the neutralized THOREX liquid. The contents were mixed in the same manner as during the previous PUREX sludge washes. After mixing in 1995, the blended liquids were processed through the ion-exchange columns in Tank 8D-1. Approximately 314,000 gallons of THOREX/PUREX wash solution were processed. Spent zeolite from the ion-exchange columns in Tank 8D-1 was then transferred to Tank 8D-2 and blended with the remaining HLW slurry in the final step prior to vitrification.[52]

[50] Ibid
[51] Ibid
[52] Ibid

Vitrification

The HLW slurry mixture was transferred from Tank 8D-2 to the concentrator feed make-up tank (CFMT) where it was processed for vitrification. The tank's internal features were washed and flushed to remove remaining flush liquids. Tank characterization activities were also conducted at that time. The vitrification process began by combining the radioactive species in the spent zeolite with the HLW sludge, blending recycled off-gas condensates and distillates and transferring the homogenized slurry to the CFMT. Slurry samples were taken during the first processing step to determine the preferred glass-making recipe.[53]

Liquids resulting from the scrubbing process were transferred back to Tank 8D-4 where they were held until being recycled back into the mixture for vitrification in Tank 8D-2. Distillates from concentration of the batches in the CFMT were transferred back to Tank 8D-3 where they were held until being recycled back into the HLW mixture in Tank 8D-2.[54] It was reported that approximately 84-percent of the original radioactivity was vitrified during Phase 1 processing, and that the remaining 16-percent would be challenging due to the complex gridwork in Tank 8D-2.[55]

Approximately 140,000 gallons of waste water containing dissolved solids remained in Tanks 8D-1 and 8D-2 following vitrification. Much of this water was generated during the final stages of vitrification system flushing. Other liquid wastes included those returned via transfer pathways and non-radioactive liquids introduced through the addition of corrosion inhibitors and dilute liquids generated by operating the ion-exchange columns in Tank 8D-1. The sodium bearing waste water (SBWW) was treated to separate radioactive species, reduce the resulting liquids, and encapsulate the resulting waste for offsite LLW disposal. This was completed by processing the SBWW through the ion-exchange columns in Tank 8D-1. Approximately 130,000 gallons of SBWW were retrieved from the tanks and sent through the ion-exchange filters. Tanks 8D-1 and 8D-2 now contain heels from the SBWW that could not be removed with the current pump system.[56]

We must also emphasize that a much larger quantity of LLW and HLW has been produced as a result of the short-lived reprocessing campaign at West Valley Nuclear Waste Site. In the pretreatment and vitrification process alone, approximately 18,000 71-gallon drums[57] (1,278,000 gallons) of LLW were produced, 569,000 kilograms of vitrified HLW glass stored in 275 canisters were produced, and all four of the HLW tanks remain as radioactive waste (Figure 9). The vitrified canisters are currently stored in the Chemical Process Cell of the Process Building. All of this was generated from an original 600,000 gallons of HLW liquid waste from fuel reprocessing. The LLW was transported by rail south from West Valley Nuclear Waste Site, avoiding the rail bridge that is

[53] Ibid
[54] Ibid
[55] US DOE, 2007b
[56] WVNSCO and Gemini Consulting Company, 2005
[57] US DOE, 2007c

suspended greater than 80 feet above the Cattaraugus Creek gorge. See Figure 10. Movement over the bridge stopped in 1998.

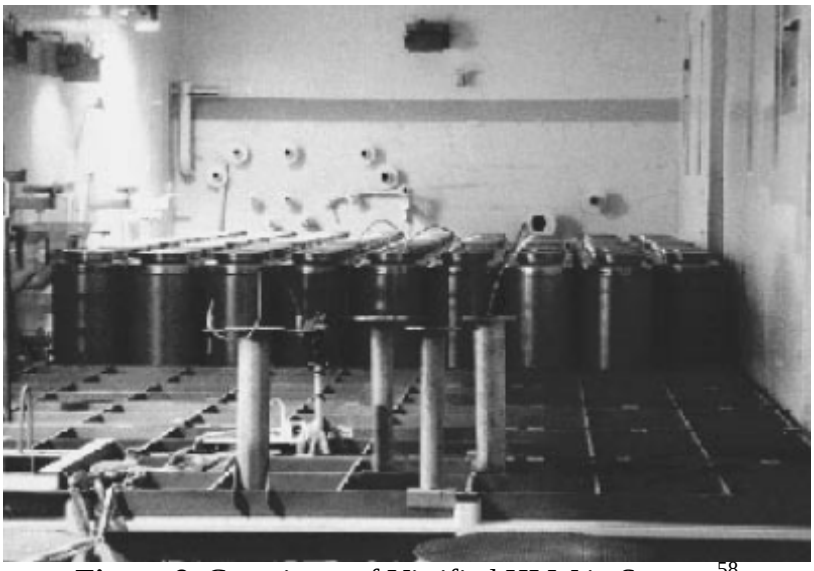


Figure 9. Containers of Vitrified HLW in Storage[58]

Figure 10. The bridge over Cattaraugus Creek, used to transport materials into and out of West Valley until 1998, was originally built in 1898.[59]

[58] US GAO, 2001
[59] Photograph by R. Vaughan

Remaining Heel in Tank 8D-2

Following vitrification, a sludge heel remains within Tank 8D-2. Prior to vitrification it was optimistically estimated in 1996 that a heel of only 3,530 cubic feet would remain in Tank 8D-2 following vitrification.[60] Both fixed (on walls and surfaces) and mobile (sludge and liquid) contamination persists within the tank.[61]

An example of the unrealistic optimism of the DOE early on in the waste management process at West Valley Nuclear Waste Site is that they stated that the gridwork and the hardened sludge in Tank 8D-2 made the case of removal unique and unparalleled elsewhere, yet that they felt "confident that they can extract the waste".[62] The GAO acknowledged the difficulty involved in removing sludge from the uniquely complex gridwork in the bottom of Tank 8D-2.[63] According to the NYSERDA contractors the longer that the sludge remained in the bottom of the tank the greater the probability it would continue to harden further complicating removal. In 1977 it was determined that sluicing would not be adequate to remove the sludge and that total removal of the sludge was not currently feasible.[64]

Corrosion

Pitting corrosion is localized corrosion which results in small holes through metal. It is typically driven by a lack of oxygen within a small area. Pitting can also be initiated by small surficial defects, such as a scratch or slight damage. Chlorides can intensify the formation of pitting corrosion. Typical corrosion rates for carbon steel in water are between 0.075 and 0.2 millimeters per year with pitting corrosion rates 2.5 to 3.5 times the general corrosion rate.[65] The high moisture content within the vaults has caused the tanks to be exposed to wet conditions since their inception.

Typical external tank corrosion rates estimated based on corrosion coupons taken from Tanks 8D-1 and 8D-2 were generally less than 0.075 millimeters per year, although the highest measured rate was 0.188 millimeters in one year. External pitting corrosion is estimated to occur with an average of 0.3 millimeters per year. According to a 2002 tank lay-up report there is likely little remaining corrosion allowance at locations prone to pitting if the current estimated corrosion rate is reflective of tank history. A nitrogen inerting system was installed in 1996 to decrease corrosion rates within the tanks. The corrosion of the external tanks is primarily due to the wet conditions within the vaults. The corrosion rate within the interior of the tank is thought to be within 0.013 to 0.025 millimeters per year, although over time the pH, nitrite, and nitrate levels have not been maintained consistently to the rigor required to minimize corrosion. Confidence in historical corrosion control of the tanks is low. Corrosion was historically controlled with the routine removal of water from the containment pans, control of the pH and

[60] WVNSCO, 1996
[61] Nuclear and Radiation Studies Board, 2006
[62] US GAO, 1980
[63] Ibid
[64] US GAO, 1977
[65] McClure, LW, JC Henderson, and MR Elmore, for Jacobs Engineering Group Inc. and Pacific Northwest National Laboratory, 2002

nitrate/nitrite ratio of the liquid in the tanks, and by maintaining a nitrogen purge in the vaults.[66]

Tank corrosion could be limited if tank surfaces were maintained in a dry state and temperature was held constant between the internal and external surfaces. The primary source of moisture in the vaults is assumed to come from rainwater, snowmelt percolation, and groundwater flow. The groundwater table is higher than the base of the vaults and water is currently pumped out of an area between the vaults for Tanks 8D-1 and 8D-2. In 2002 the hydrology of the site was not known in adequate detail to determine the volume of water required to lower the water table to below that of the vault bottoms. Water is pumped from outside the vaults weekly and from the containment pans several times a year. Very little water is thought to make its way into the vaults, although the humidity within the vaults is close to 100-percent. It is thought that no leaks have occurred into the vaults from the tanks, although radioactive contamination has been detected in water pumped from the inside of Tank 8D-2's vault. The facility assumes that this contamination occurred from leaks during waste transfers that were washed into the vault by water percolation from the surface, although they have no supporting evidence for this assumption.[67]

Waste Description

Tank 8D-1

Tank 8D-1 functioned as a spare tank for Tank 8D-2. It was the site of supernate and sludge mixture decontamination within tank ion-exchange columns during pretreatment and vitrification. The resulting radionuclide laden zeolite from the ion-exchange columns was deposited in the bottom of the tank. Approximately 90-percent of the spent zeolite was transferred from the tank to Tank 8D-2 by the beginning of vitrification in 1996. Since then, the remaining zeolite has been incrementally transferred to Tank 8D-2.[68] Tank 8D-1 is assumed by the DOE to contain 14,000 gallons of residual liquid waste.[69]

Tank 8D-2

In 1979 the sludge in Tank 8D-2 was a mixture of solids and interstitial supernate. The solids were primarily manganese, iron, and aluminum, while also containing uranium, plutonium, and mixed fission products.[70] Tank 8D-2 contained supernate and sludge from PUREX fuel reprocessing. The PUREX waste stored in Tank 8D-2 was neutralized with sodium hydroxide for storage. This neutralization resulted in a precipitated hydroxide sludge that settled at the bottom of the tank covered by a supernate salt solution.[71] The neutralization of the waste caused the majority of the plutonium and other actinites (e.g. americium, curium, neptunium, strontium) to precipitate out of the waste solution and harden into sludge at the bottom of the tank. NYSERDA estimated that 30,000 gallons of

[66] Ibid
[67] Ibid
[68] Pacific Northwest National Laboratory, 2001
[69] US DOE and NYSERDA, 2005
[70] Battelle, Prepared for the US DOE, 1979
[71] Pacific Northwest National Laboratory, 2001

sludge were at the bottom of Tank 8D-2. The exact properties of the sludge were unknown in 1977, and as of then NFS and the NRC had no plans for attempting to extensively characterize the sludge. It was stated that "[b]ecause of the long-lived radionuclides present, any residual sludge will present a separate problem in decommissioning the reprocessing plant site".[72] Wastes from tanks 8D-1 and 8D-4 were transferred to this tank for vitrification.

The remaining sludge and liquid in Tank 8D-2 following vitrification contains cesium-contaminated zeolite, washed PUREX sludge, and THOREX waste. The tank contains residual contamination on the walls and surfaces, as well as a sludge heel. Tank 8D-2 is assumed by the DOE to contain 5,000 gallons of waste.[73]

Tank 8D-3

In 1977 it was discovered that a portion of the liquid evaporated from Tank 8D-4 had condensed in a shared off-gas line and flowed back into both tanks. The resulting liquid in Tank 8D-3 was then jetted to Tank 8D-4.[74] Tank 8D-3 was not used to store reprocessed waste, although it was used in the supernate treatment system process to store decontaminated supernate and sludge wash water for sampling before transfer to the liquid waste treatment system. Tank 8D-3 is assumed by the DOE to contain 1,800 gallons of residual liquid waste.[75]

Tank 8D-4

Tank 8D-4 was used to store approximately 12,000 gallons of acidic THOREX waste and later as a storage tank for the vitrification waste system after the THOREX waste was removed. Due to the acidity of the THOREX waste, the wastes were primarily liquid, thus preventing the formation of sludge. The THOREX waste was transferred to Tank 8D-2 for vitrification. Tank 8D-4 is assumed by the DOE to contain 1,800 gallons of residual liquid waste.[76, 77]

Tank Waste Inventory

Low burn-up fuel, irradiated fuel, mid burn-up fuel, different uranium enrichments, and thorium-based fuel assemblies were all processed at West Valley Nuclear Waste Site. NFS, which operated West Valley Nuclear Waste Site, did not characterize or document the exact proportions of many radionuclides in their waste streams; although Table 1 includes a general break down of the 27 fuel reprocessing campaigns.[78] It was stated by the GAO in 1977 that the physical and chemical characteristics of the HLW sludge in Tank 8D-2 was not completely known. The GAO additionally stated that "removing the

[72] US GAO, 1977
[73] US DOE and NYSERDA, 2005
[74] WVNSCO and Gemini Consulting Company, 2005
[75] US DOE and NYSERDA, 2005
[76] Nuclear and Radiation Studies Board, 2006
[77] Pacific Northwest National Laboratory, 2001
[78] WVNSO and Innovative Waste Solutions, 2002

sludge from the tanks presents an immense problem, because of design obstructions in the bottom of the tank".[79]

According to the 1979 Battelle report 99-percent of strontium-90, yttrium-90, ruthenium-106, rhodium-106, plutonium-239, plutonium-240, plutonium-241, neptunium, americium, curium, total rare earths, and other fission products were contained within the sludge, while cesium-134, cesium-137, barium-137m, antimony-125, and tellurium-125m were primarily contained within the supernate.[80] In a 1980 GAO report, 560,000 gallons of alkaline waste in Tank 8D-2 were assumed to have an activity of 58 Curies per gallon, while the 12,000 gallons of acidic waste in Tank 8D-4 were assumed to have an activity of 200 Curies per gallon.[81] This estimate would mean that a total of 34,880,000 Curies were present within the tanks in 1980.

Several attempts have been made to characterize the remaining waste in the HLW tanks; however the characterization has largely been limited to surface contamination and liquid and slurry samples. Following vitrification a special camera was used in the tank to measure two-dimensional spatial mapping of gamma-emitting radiation in real time. Neutron track recorders were deployed in the tanks to measure neutron fluxes from many reactions, beta-gamma detectors were employed to establish the concentrations of both beta and gamma-emitting radionuclides on tank surfaces, and a burnishing sampler was used to collect samples of the waste from the walls, columns, and other surfaces for radiochemical analysis. Riser-mounted arms and positioning systems have also been used to characterize and locate waste residues, as well as completing limited mobilization of residues. During the waste retrieval process, a ring of dry waste on the walls of Tank 8D-2 was observed. Attempts with limited success have been made to reduce the activity of the ring.[82] As discussed earlier, the forced evaporation of liquid in the tank over time caused the ring to form around the upper portion of the tank walls.[83]

Fewer radionuclides are included in the inventory estimates from the 2005 DEIS. The 2005 DEIS includes carbon-14, strontium-90, technetium-99, iodine-129, cesium-137, uranium-232, uranium-233, uranium-234, uranium-235, uranium-238, neptunium-237, plutonium-238, plutonium-239, plutonium-240, plutonium-241, americium-241, curium-243, and curium-244, while the 1996 DEIS includes those radionuclides in addition to tritium, cobalt-60, cadmium-113m, antimony-125, tin-126, europium-154, radium-226, radium-228, actinium-227, thorium-229, thorium-232, and palladium-231 (Table 2).

Approximately 25,000 gallons of liquid HLW, referred to as retrievable mixed low-level liquid waste by the DOE, remain in the HLW tanks at West Valley Nuclear Waste Site according to a DOE presentation in 2007.[84] This estimate is slightly higher than the total of the estimated volumes given in the 2005 DEIS, of 22,600 gallons.

[79] US GAO, 1977
[80] Battelle, Prepared for the US DOE, 1979
[81] US GAO, 1980
[82] Nuclear and Radiation Studies Board, 2006
[83] WVNSCO and Gemini Consulting Company, 2005
[84] US DOE, 2007b

Tank 8D-1

Tank 8D-1 contains a heel, residual sludge, and zeolite. Stainless steel vessels suspended from the roof of Tank 8D-1 contain flush liquid and 190 cubic feet of solid waste (resin and sand).[85]A depth of 1.4 centimeters of solids was estimated to be uniformly distributed across the bottom of the tank in 2000.[86] Assuming that this depth is representative of current conditions in Tank 8D-1, a solids volume of approximately 177 cubic feet would exist in this tank. The liquid slurry waste removed from this tank was used to estimate the composition of the heel remaining in the tank with the assumption that the remaining waste has been homogenously mixed and that minimal waste is firmly fixed or has been absorbed within the tanks surfaces.[87]

Sludge samples from Tank 8D-1 were taken following an initial sampling in December 2002 to support the characterization of non-dissolved solids in the tank. The samples were taken after operating the tank's mobilization pumps for at least 30 minutes to mobilize sludge particles.[88] The activity estimates from the projected radionuclide content in the sludge from the 1996 and 2005 DEIS reports are in Table 2; the estimated activity from the 1996 DEIS is 525,000 Curies and the estimated activity from the 2005 DEIS is 876,000 Curies.

Tank 8D-2

Tank 8D-2 contains a heel, residual sludge, and zeolite.[89] The radionuclide inventory in Tank 8D-2 is both mobile and fixed. The mobile component was estimated by data collected in the CFMT after Tank 8D-2 transfers, while the fixed component was estimated by direct internal tank measurements and physical samples collected from tank surfaces. Batch 72 transfers were the last to occur. After the final batch transfer, spent zeolite was transferred from Tank 8D-1 to Tank 8D-2, thereby adding to the mobile waste inventory.[90]

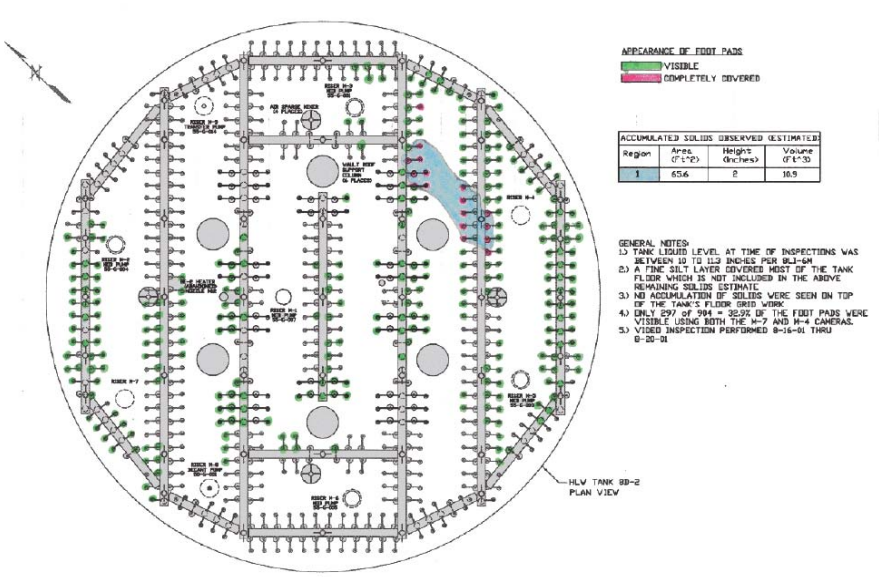
Physical samples were collected from the internal surfaces of Tank 8D-2. These samples were taken with a burnishing sampler, which takes a surface scrape and collects the scraped material in a filter. Sixty-six burnishing samples were taken between February and October 2001. Thirty-nine of the samples were taken from the M-7 riser, 27 from the M-4 riser, and 35 were taken before washing the interior surface of the tank, and 31 were taken after.[91]

Remotely operated sluicers have washed the majority of the interior surface above the gridwork as well as much of the gridwork. A gamma camera, neutron detectors, gamma probes, color video cameras, and a custom designed remote arm to obtain beta-gamma

[85] Ibid
[86] WVNSCO and the US DOE, 2000
[87] Ibid
[88] WVNSCO and Gemini Consulting Company, 2005
[89] US DOE, 2007b
[90] WVNSCO and Gemini Consulting Company, 2005
[91] Ibid

and gamma radiation measurements of tank surfaces have been used in an attempt to approximate the remaining waste.[92]

The volume and spatial distribution of residual waste in Tank 8D-2 has been estimated with the use of remotely operated video cameras. Waste volumes were estimated by comparing the height of the waste to the known height markers on the bottom of the tanks. This along with zeolite cesium-loading estimates and CFMT sample data were used in an attempt to quantify the remaining activity. Video mapping was thought to be effective in identifying thicker deposits of sludge, but not effective in detecting a thick layer of solids spread over the tank bottom. A fine silt layer was noted above the solids heel.[93] The remaining liquid heel and limited light within the tank was stated as making accurate observation in the bottom of the tank difficult. Only 297 of the 904 footpads in the gridwork of Tank 8D-2 were visible with both cameras (Figure 11 green indicates visibility, red indicates complete coverage). Quantification of solids remaining at the tank bottom was determined to be impossible by the DOE and WVNSCO. Video inspection indicated that few solids remained on the tank bottom and that the grid work appeared clean.[94] Figure 11 shows a gamma photograph taken of the bottom of Tank 8D-2.



Tank 11. Solids Distribution and Gridwork at the Bottom of Tank 8D-2.[95]

[92] US DOE and WVNSCO, 2002
[93] Ibid
[94] Ibid
[95] Ibid

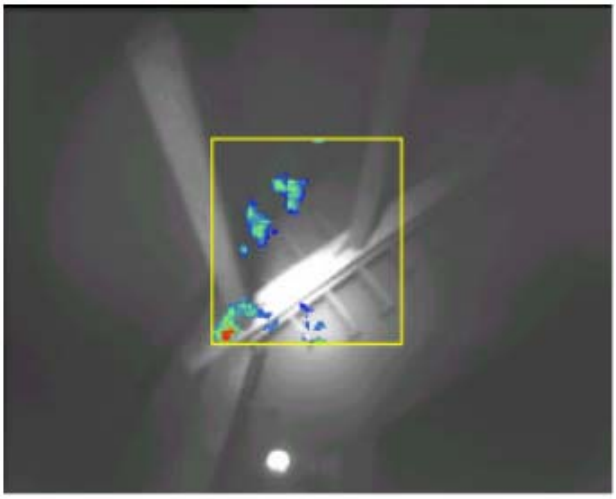


Figure 12. Image of the Bottom of Tank 8D-2 with a Gamma Camera[96]

The depth of solids in Tank 8D-2 was estimated in 2000 to be one centimeter if uniformly distributed across the tank bottom.[97] Assuming that this depth is representative of that currently within the tank, approximately 126 cubic feet of solids would exist. It is our opinion that this volume is an extreme underestimate of the sludge remaining in Tank 8D-2. The infrastructure at the base of the tank is approximately three feet high (See Figure 6). At the time of design, it was recognized that this gridwork would greatly impede the removal of hardened sludge. It is unrealistic to assume that the hardened sludge stuck in this gridwork was adequately mobilized to result in homogenization during the pretreatment and vitrification phases. In addition it is unrealistic to assume that one centimeter of solids are distributed only on the bottom of the tank; if anything they would be distributed over the bottom and gridwork, which includes a great deal more surface area than the bottom alone.

The waste removed from the tank during vitrification was used to estimate the composition of the heel remaining in the tank in 2000 with the assumption that the remaining waste has been homogenously mixed and that minimal waste is firmly fixed or has been absorbed within the tanks surfaces.[98] These samples were used to estimate the residual inventory in Tank 8D-2. A best, conservative, and worst case estimate of the total concentration were determined. The best case is the mean of all reported sample replicates, the conservative case is the mean plus or minus two times the standard error, and the worst case is the highest or lowest of the replicate samples plus or minus the reported uncertainty.[99] The conservative case values were used in the 2005 DEIS. The estimated radioactivity inventory of the sludge from Tank 8D-2 are in the 1996 and 2005 DEIS reports are in Table 2. The activities estimated in the 1996 and 2005 DEISs are 359,000 (when decayed to 2005) and 121,000 Curies. In addition, the estimated radionuclide inventory from 1979 and 1982 are included within Table 2. The initial

[96] Ibid
[97] WVNSCO and US DOE, 2000
[98] WVNSCO and Gemini Consulting Company, 2005
[99] Ibid

estimated inventory in the sludge in 1979 was 17,500,000 Curies, while the initial estimated inventory in both the sludge and supernate was 39,400,000 Curies.[100] The estimated inventory in the sludge in 1982 was 13,700,000 Curies.[101] The 1979 activity value is not fully divided into activity by radionuclide, but the 1982 activity value is and thus we can estimate a value for each radionuclide that remains after accounting for removal and decay.

If we assume that a sludge slurry sample (VAST 01-1281) is representative of the remaining sludge heel remaining and that an unrealistic one centimeter depth of sludge[102] exists only across the bottom surface area of the tank than the total activity in the tank would be 12,509 - 13,287 Curies. If we assume a more realistic depth of one meter based upon the extensive gridwork at the bottom of the tank the total activity would be 1,253,213 - 1,331,162 Curies. These estimates are based upon a best, conservative, and worst case concentrations of 2,660, 2,700, and 2,820 microCuries per gram. If we assume that 30,000 gallons of sludge[103] within this concentration range remained in the tank based upon a volume estimate from 1977 then the activity would be 525,510 - 533,631 Curies.

An alternate method for determining the total remaining activity in Tank 8D-2 is by using the total activity in West Valley Nuclear Waste Site HLW glass as calculated for storage in Yucca mountain. The total activity in the waste was estimated to be 14,500,000 Curies.[104] If we assume that this represents 98-percent of the HLW from the tank, the remaining 2-percent would be approximately 290,000 Curies, which is less than the 404,000 Curies estimated in the 1996 DEIS. If we assume 20-percent than 2,900,000 Curies would remain. According to one WVNSCO report, 15,000,000 Curies, constituting 65-percent of the activity, had been solidified by the end of 1997.[105] If we assume that 15,000,000 Curies are 65-percent of the total activity, then the total original activity would have been 23,100,000 Curies. Two percent of the total remaining activity would be 462,000 Curies, while 20-percent would be 4,620,000 Curies. The activities discussed in this paragraph are likely elevated because they are based on the assumption that all remaining activity is within Tank 8D-2, and not the other tanks.

Based upon the various methods for estimating total activity, the current activity of the sludge heel would fall within the range of 12,509 - 4,620,000 Curies. Given that the majority of radioactivity in Tank 8D-2 was assumed to have settled into the sludge and that removal and mixture of the hardened sludge was quite difficult, it is our opinion that the two percent assumption is likely low. If we assume that the 1979 report was correct in its assumption that approximately 20 percent of the radioactivity would remain in the small sludge heel, higher activities would remain. A complete survey of the sludge has not been possible; instead it has been optimistically assumed that attempts to mix the

[100] Battelle, Prepared for US DOE, 1979
[101] US DOE, 1982
[102] WVNSCO and the US DOE, 2000
[103] US GAO, 1977
[104] Bechtel SAIC Company, 2007
[105] WVNSCO, 1998

sludge with supernate were successful and that the mixture in the entire tank was homogenized. Given the concentration of activity in the sludge, complexity of the gridwork, and the hardening of the sludge it seems unlikely that homogenization was accomplished. To ensure more comprehensive conservatism in dose calculations we include activity estimates with 2 to 20-percent of the original sludge activity reported in 1982 remaining.

Tank 8D-3

Tank 8D-3 contains flush liquid.[106] No radionuclide inventory estimates were included for this tank in the 1996 DEIS. The estimates of radionuclide inventory in Tank 8D-3 included in the 2005 DEIS are based on post-flush estimates. This data is presented in Table 2; the estimated inventory is 1.05 Curies.

Tank 8D-4

Tank 8D-4 contains a liquid heel.[107] The estimates of radionuclide inventory for Tank 8D-4 included in the 2005 DEIS are based on post-flush estimates. The 1996 estimate is 1,930 Curies, while the 2005 estimate is 7,240 (Table 2).

State Licensed Disposal Area (SDA)

The SDA, located in WMA 8, is approximately 15 acres in size and was operated from 1963 until 1975, when a trench cap broke, thereby exposing waste and allowing for water to flow out of the trenches. The SDA is comprised of two sections, the north disposal area and the south disposal area, each with seven trenches, and is currently covered by a geomembrane (Figures 13 and 14). Approximately 2,400,000 cubic feet of waste is buried in the SDA. Thirty-percent of the waste is from special purpose reactors, 24-percent is from commercial power reactors, 19-percent is from nuclear fuel cycle facilities, 14-percent is from institutions, 8-percent is from isotope production, and 5-percent is from industrial waste. Most wastes were buried in their original shipping containers of 5-gallon steel drums, 30-gallon steel drums, 55-gallon steel drums, wooden crates, cardboard boxes, fiber drums, or plastic bags (Figure 15). According to the 2005 DEIS approximately 129,000 Curies are buried in the SDA, while the 1996 DEIS estimates that 158,000 Curies are buried there (Table 3). The estimate in the 1996 DEIS report is from a 1994 West Valley Nuclear Services report, while the estimate in the 2005 DEIS report is from a 2002 URS report.[108, 109] Refer to Table 3 for details on the differences between the 1996 and 2005 estimates. Leachate due to infiltration and groundwater flow is present within the disposal holes and trenches.[110]

[106] US DOE, 2007b
[107] Ibid
[108] US DOE and NYSERDA, 1996
[109] US DOE and NYSERDA, 2005
[110] Ibid

Figure 13. Aerial View of SDA[111]

[111] NYSERDA, 2004

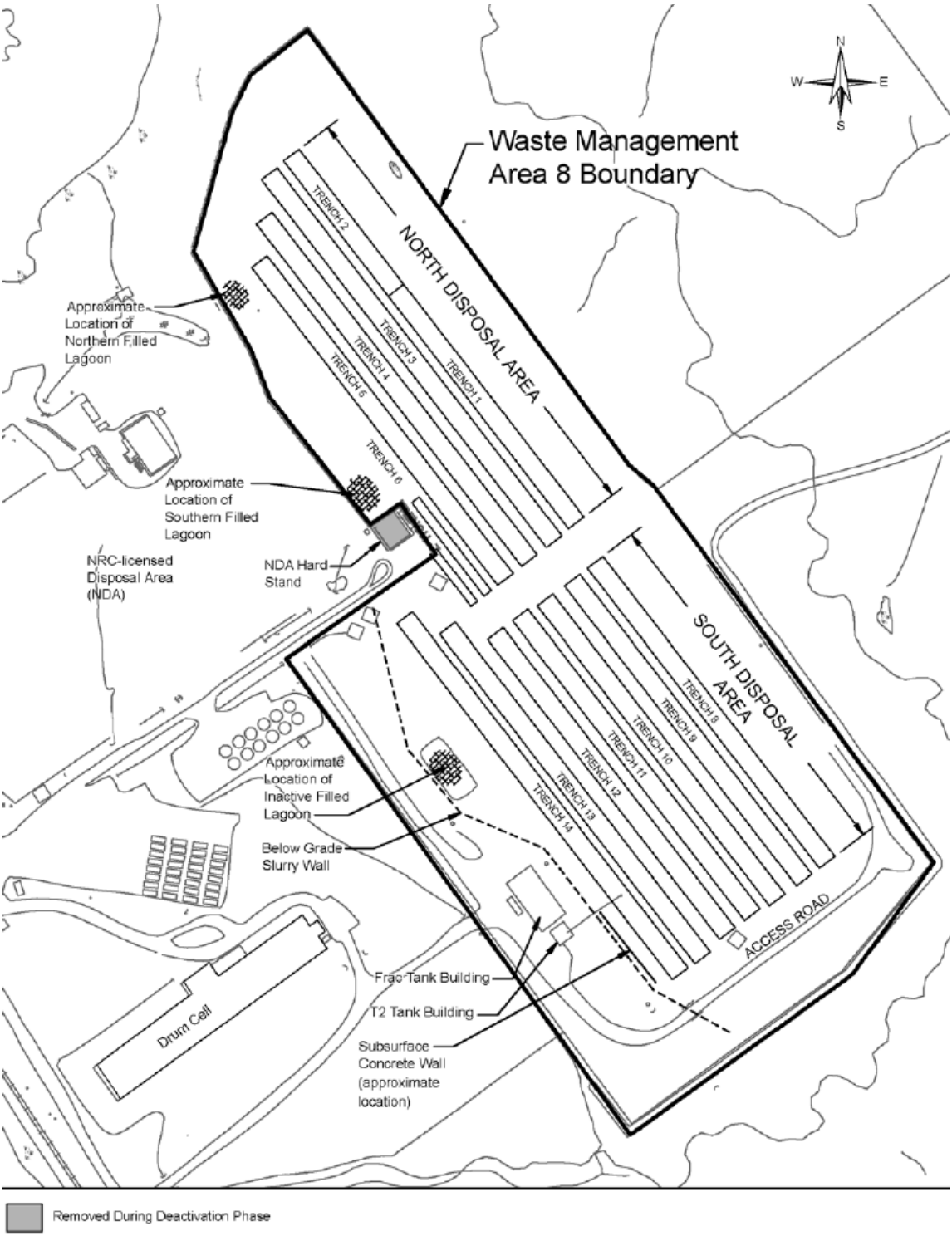


Figure 14. The SDA[112]

[112] US DOE and NYSERDA, 2005

Figure 15. Trench in the SDA[113]

The north disposal area includes Trenches 1 through 7. Six of these trenches are 35 feet across and 20 feet deep. These were utilized to dispose of solid wastes with contact surface readings of 200 millirad per hour or less. The seventh trench is a series of 19 holes used to dispose of wastes having contact surface readings greater than 200 millirad per hour. The holes are 2 to 6 feet wide, 4 to 12 feet long, and 8 to 12 feet deep. The wastes in the holes of Trench 7 are primarily from irradiated reactor parts. Un-weathered till below Trenches 4 and 5 contains tritium contamination for approximately 10 feet and 3 feet of contamination from other radionuclides extends below the trenches. Trenches 1, 2, and 3 are assumed to have similar contamination. The north disposal area trenches are thought to contain approximately 932,000 cubic feet of waste with a total activity of 60,000 Curies.[114]

The south disposal area includes Trenches 8 through 14. The trenches are approximately 35 feet across and 20 feet deep. Solid wastes with contact surface readings of less than 200 millirad per hour were buried here. Un-weathered till below Trench 8 is contaminated with tritium to a depth of 10 feet and other radionuclides extend to a depth of 3 feet. The remaining trenches are assumed to have similar contamination. Based on

[113] US GAO, 2001
[114] US DOE and NYSERDA, 2005

burial records, it is estimated that approximately 1,431,000 cubic feet of waste with a total activity of 70,000 Curies are buried here.[115]

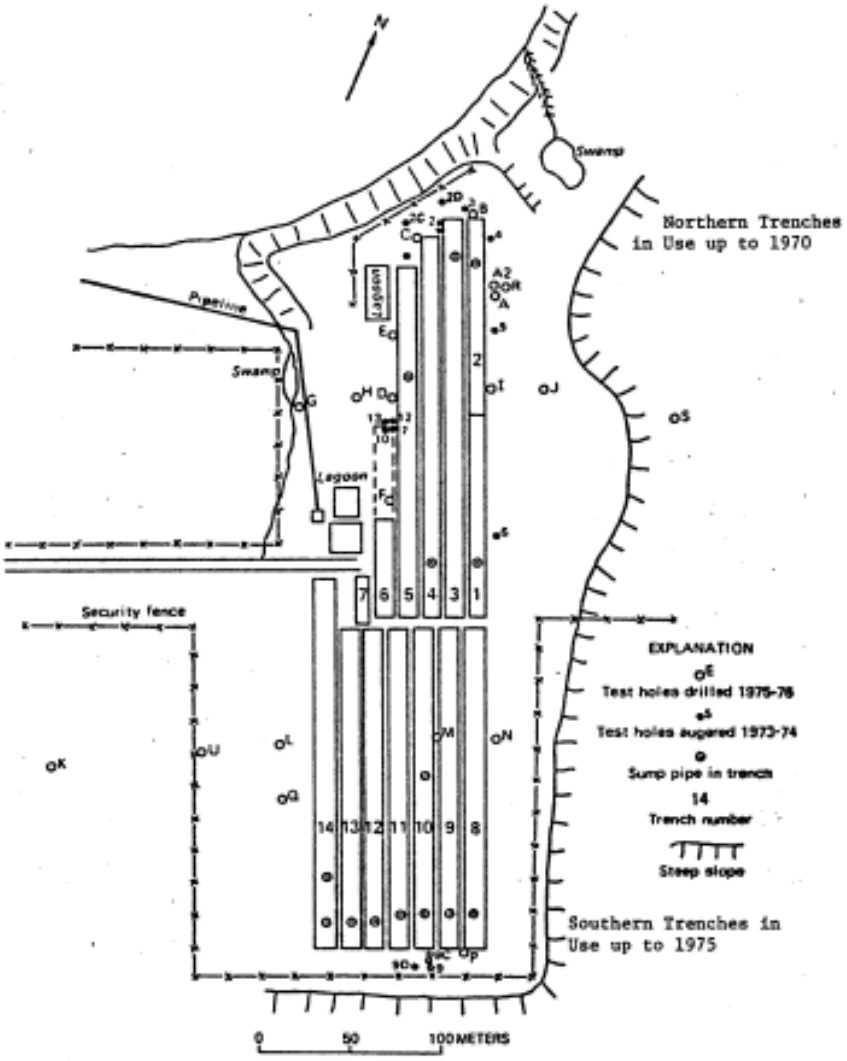


Figure 16. Early Diagram of the SDA[116]

No initial soil borings were taken at depths greater than 40 feet from the area of the SDA. Borings that were taken, were sampled at 5 foot intervals, and so the presence of discontinuities could have easily gone undetected. 14 borings demonstrated the presence of sand lenses, and of the deeper borings taken elsewhere at West Valley Nuclear Waste Site, the permeable area was found to be quite wide.

[115] US DOE and NYSERDA, 2005
[116] Battelle, Prepared for US DOE, 1979

Originally a wetland area was adjacent to trench 14 and another wetland was approximately 400 feet southwest. A map from the SAR showing these wetlands also indicated feeder streams that drained into the southern tributary of Erdman's Creek. The wetland ("swamp") areas can be seen in Figures 3 and 16. Detailed geologic studies were not begun until 1975. A study by the USGS in 1977 found that sandy strata existed in the area as well as impermeable clay, although they emphasized the presence of impermeable clay. The leak from the NDA detected in 1983 later provided proof that the assumption of impermeable clay was inadequate. In a 1977 EPA report it was noted that EPA personnel observed a 2 foot by 65 foot sand lens in trench 13. The discovery led to a brief suspension of burial. NFS then conducted a quick excavation in which they said that the lens was closed on the top, bottom, and sides and burial was continued.

Water was first publicly reported as seeping from the trenches in 1975, leading to the cessation of waste burial at the SDA. In a 1976 report the AEC noted that NFS reported increasing water levels in closed burial trenches and that the possibility of overflow loomed. The accumulation of water in both the northern and southern disposal areas led to both being pumped to control the water level. Water was periodically pumped from these trenches and soil, treated, and released into a nearby stream from 1975 until 1981. The water appeared to enter the trenches from both infiltration and groundwater flow.

Water was especially quick to make its way into trench 14, immediately adjacent to a former wetland area (Figure 16). A farmer that lived in the area most of his adult life and whose dairy farm abuts the West Valley site, stated in a 1987 deposition before the U.S. District Court in western New York, "This (NFS) land had been primarily wetland, with many springs and artesian wells which emptied into two streams on two sides of the trenches...for many years I trapped muskrat at what later became the burial site, and muskrat need fresh (not stagnant) water."[117]

The cover of the SDA was redesigned and has reduced, but did not eliminate accumulation of water in the trenches. NYSERDA has been in charge of the management of the SDA since 1983. NYSERDA has attempted to minimize infiltration to the trenches by installing a geomembrane cover and a barrier wall.[118] In 1987 the continual water infiltration into trench 14 led NYSERDA to construct a concrete barrier approximately four feet thick, 130 feet long between a sandy area to the west of the trench. A sandy gravel area to the west of the concrete barrier was then excavated and the area was refilled with clay. This barrier was ineffective as water within trench 14 began to rise again. A slurry wall was installed in 1992 to the west of Trench 14 to control groundwater infiltration into the SDA. The slurry wall is 30 feet deep, 3 feet wide, and 850 feet long. It is made of native clay and 1-percent bentonite clay.[119]

Three lagoons, Northern, Southern, and Inactive, were constructed in the SDA. The lagoons have since been filled in and the area is assumed to contain non-radionuclide contaminants including BTEX constituents (benzene, toluene, ethylbenzene, and xylene).

[117] Zimmerman, E, 1987
[118] NYSERDA, 2004
[119] US DOE and NYSERDA, 2005

The Northern lagoon is 35 feet wide, 104 feet long and unlined. It was used to store water pumped from the NDA trenches. The Southern lagoon is unlined and was used to store water pumped from the NDA trenches and hardstand. Both lagoons were connected to the low-level waste treatment facility in 1971. The water from both was either treated or discharged. The Inactive lagoon is approximately 50 feet west of Trench 14. The Northern and Southern filled lagoons contain vermiculate sorbent material and native soil; they are thought to be contaminated up to 30 feet below the surface. The estimated contamination in each is 1,880 picoCuries per gram of Cs-137, 25,000 picoCuries per gram of Sr-90, and 320 picoCuries per gram of Am-241. The Inactive filled lagoon is estimated to have the same concentrations of contamination and is composed native soil, contaminated to up to 30 feet below the surface.[120]

The 1996 DEIS includes the following alternatives for the SDA[121]:
Alternative 1 - Exhume the SDA and lagoons.
Alternative 2 - Exhume the SDA and lagoons.
Alternative 3 - Buried waste in the SDA would be stabilized in place with slurry walls, in-situ waste solidification techniques, and capping.
Alternative 4 - No action, monitoring and maintenance as is. Construction of a wastewater treatment area to periodically treat leachate from the SDA. Installation of localized erosion control structures around the SDA.
Alternative 5 - Discontinue operations.

The 2005 DEIS includes the following alternatives for the SDA[122]:
Alternative 1 - Exhume the SDA and lagoons.
Alternative 2 - Manage the SDA for 100 years under a geomembrane cover for waste subsidence and stabilization. After 100 years, install a multilayer cover and additional surface water control structures. The lagoons would be left in place.
Alternative 3 - Install an engineered multilayer cover over the SDA. Selected waste would be grouted. The slurry wall would be extended to the north and a French drain would be constructed up-gradient. Surface water control structures would be constructed. The lagoons would be left in place.
Alternative 4 - Install a geomembrane cover over the SDA. The slurry wall would be extended to north and a French drain would be conducted up-gradient. Surface water control structures would be constructed. Lagoons would be left in place.
Alternative 5 - Monitor and maintain as is.

NRC-Licensed Disposal Area

The NDA is located in WMA 7. It is approximately 400 feet wide and 600 feet long on the South plateau of the West Valley Nuclear Waste Site (Figures 17 and 18). The NDA was operated by NFS under an NRC license for disposal of solid radioactive waste from fuel reprocessing operations. The NDA was licensed to permit burial of all waste generated in the operation and maintenance of the reprocessing plant. Following 1966, solid radioactive wastes that exceeded 200 millirad per hour and other materials not

[120] US DOE and NYSERDA, 2005
[121] US DOE and NYSERDA, 1996
[122] US DOE and NYSERDA, 2005

allowed in SDA were buried in holes here. From 1966 till 1981 wastes were disposed of in a U-shaped area along the east, west, and north boundaries of the NDA. During this time, 163,000 cubic feet of wastes were disposed of in the NDA. From 1982 till 1986 200,000 cubic feet of Class A low-level radioactive waste from decontamination and decommissioning activities at West Valley Nuclear Waste Site were buried in the unused interior of the U-shaped disposal area.[123] The U-shaped disposal area contains reactor hardware (all components), spent fuel from the NPR reactor, ion exchangers and sludges, degraded extractants, filters, failed and discarded equipment, trash, dirt, low specific activity general waste, combination waste, and large unique items (such as the NFSX-1 railcar).[124] It should also be noted that many contents of buried containers are unknown as they were only recorded as "waste".[125]

[123] US DOE and NYSERDA, 2005
[124] US DOE and NYSERDA, 1996
[125] ORNL, R. Clapp and S. Herbes, 1985

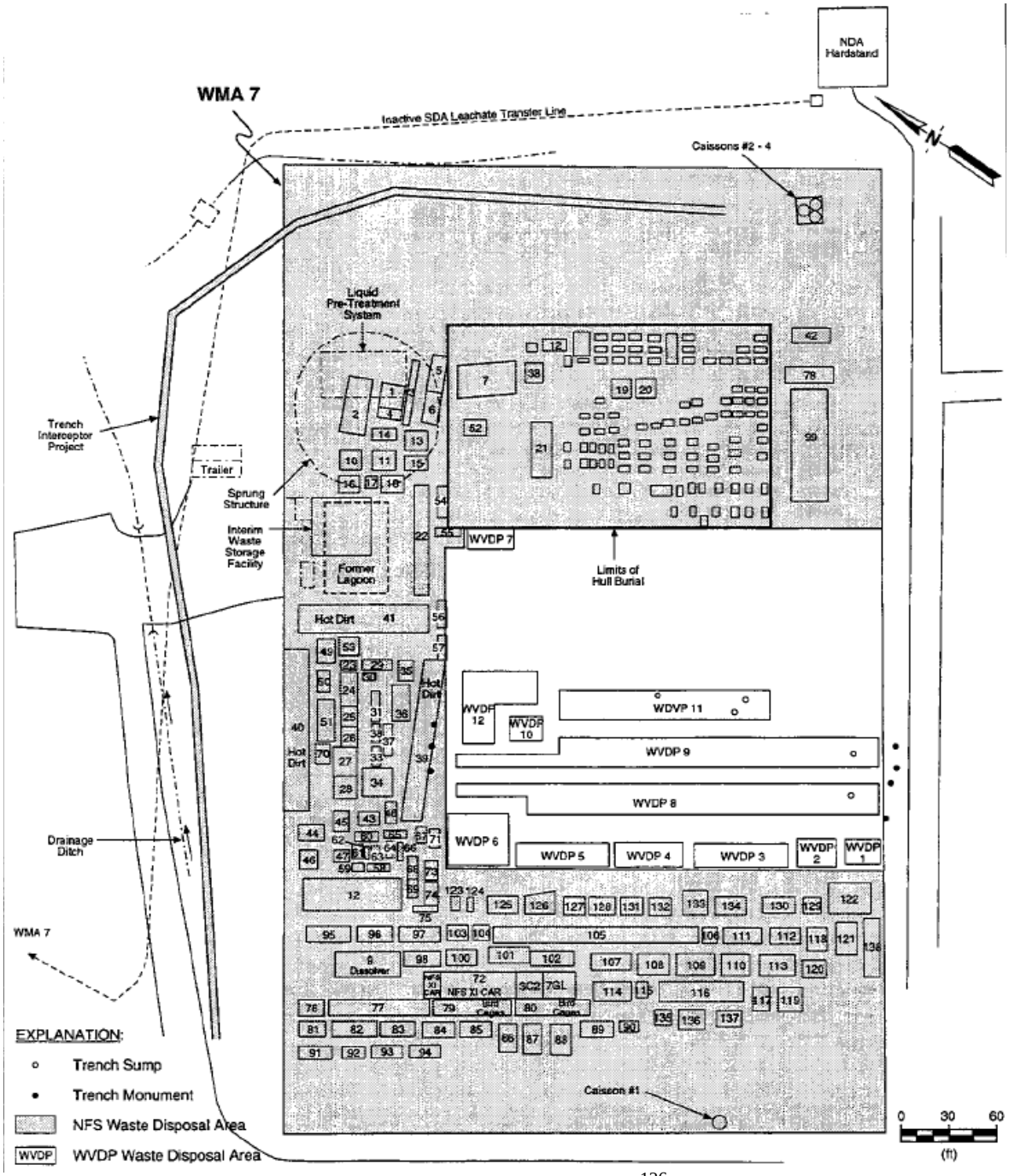


Figure 17. Diagram of NDA[126]

[126] US DOE and NYSERDA, 2005

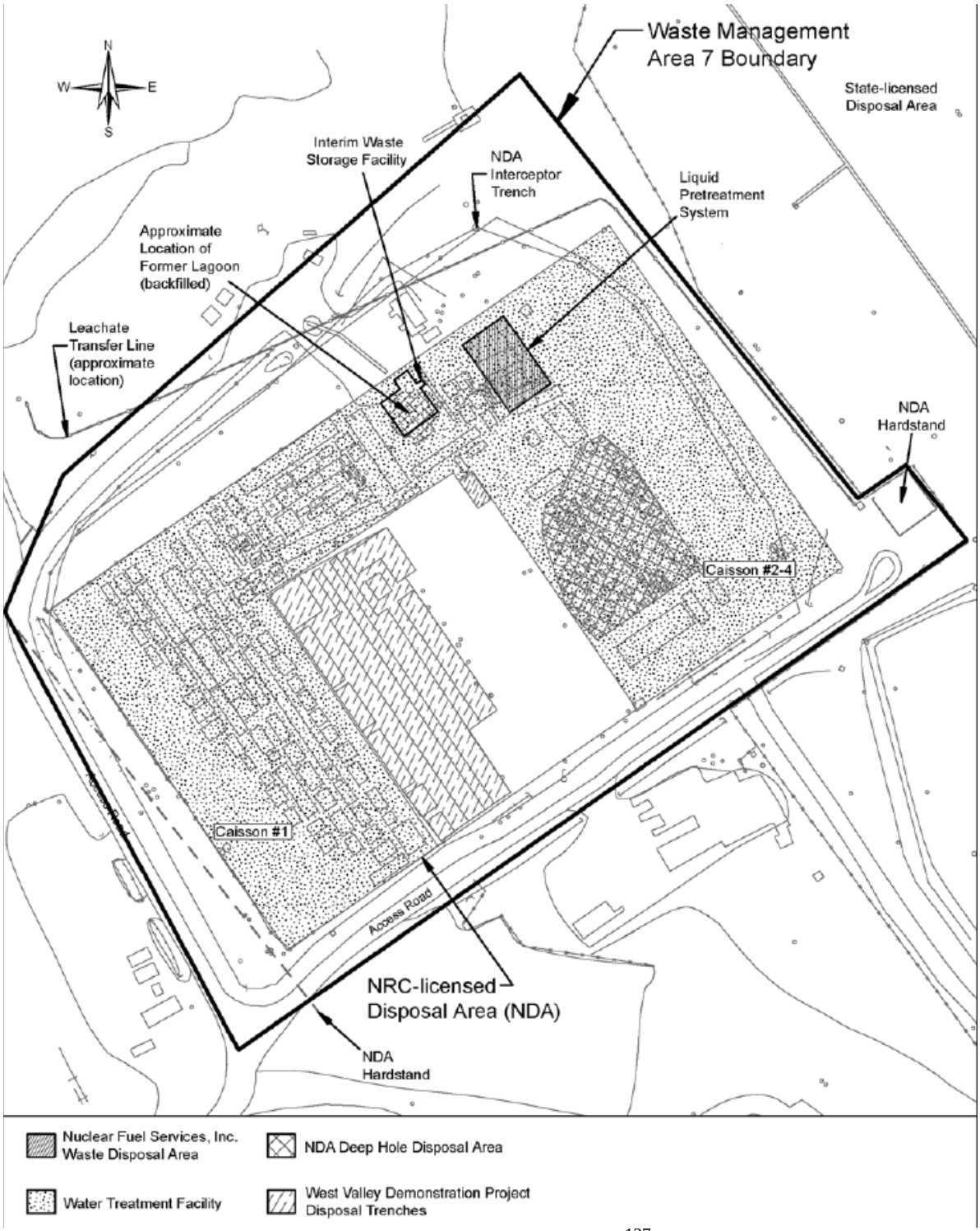


Figure 18. Schematic of NDA[127]

[127] Ibid

The activity in the reactor hardware buried at the NDA was estimated from the radionuclide inventories from the reprocessing campaigns. The fraction of remaining radionuclides in the hulls and hardware following the campaign were estimated and corrected for decay. The radionuclide inventory was then calculated using the ORIGEN2 computer code. The remaining radioactivity was estimated by assuming that 0.2-percent of the fission products and actinides and 100-percent of the activation products remained.[128]

The wastes from decontamination and decommissioning were primarily buried in trenches in the interior of the U-shaped disposal area. There are 6,600 cubic feet of hulls from reprocessed fuel in 100 deep disposal holes in the eastern portion of the U-shaped area. Most of the holes are 2.7 feet by 6.5 feet by 50-70 feet deep. The hulls are primarily in 30-gallon steel drums, which are stacked in deep narrow holes. Three 30-gallon drums contain irradiated un-reprocessed NPR fuel from damaged cladding, which was not taken to the reprocessing plant to avoid excessive contamination. These drums are encased in concrete at the bottom of one of the holes. There are approximately 97,000 cubic feet of wastes remaining in the special holes with total activity of 77,000 Curies. The trenches in the interior of the U-shaped area are about 30 feet deep and 15 feet wide with lengths of 30 to 250 feet. Trenches 9 and 11 have composite liners and caps, while the other trenches are capped with clay. There area approximately 198,000 cubic fee of waste in the trenches with an activity of 71,200 Curies.[129] The estimated activities by radionuclide from the 1996 and 2005 DEIS reports for the NDA are listed in Table 3. The 1996 DEIS report estimates the activity in the NDA from a 1994 characterization report by the West Valley Nuclear Services, while the 2005 DEIS report estimates the activity in the NDA from a report by URS in 2000.[130, 131] The estimates from the two reports differ somewhat; for example, the plutonium-239 activity in the 1996 DEIS report is 2,006 Ci, while it is 579 Ci in the 2005 DEIS report. Overall the activity reported in the 1996 DEIS report was 36,550 Ci greater (151,300 Ci) than that reported in the 2005 DEIS report (114,700 Ci).

Four steel lined concrete caissons with diameters of 7 feet and depths of 60 feet were constructed in the eastern and southern corners of the NDA. Approximately 823 cubic feet of waste in drums is in Caisson 1. West Valley Nuclear Waste Site records do not show that anything was put in the other three caissons. The caissons are plugged with concrete for shielding and covered with a plastic shield. The activity in Caisson 1 is estimated to be 0.2 Curies.[132]

The NRC required that the top of each stack of hull cans be limited to 4 feet below the top of the weathered till. The deep holes contain approximately 65,000 cubic feet of waste with activity of 220,000 Curies. There are approximately 230 special holes in the northern and western parts of the U-shaped area. The holes are approximately 20 feet

[128] Ibid
[129] Ibid
[130] US DOE and NYSERDA, 1996
[131] US DOE and NYSERDA, 2005
[132] Ibid

deep with varying lengths and depths. Most are 12 feet wide and 20 to 30 feet long. There are thought to be 1,000,000 gallons of leachate that would require treatment if the NDA waste were to be exhumed or stabilized.[133]

In 1983 plutonium mixed in a solvent migrated approximately 63 feet from the NDA was detected. The leak was determined to have originated from eight drums in special holes 10 and 11. Levels exceeding permissible concentrations of iodine-129, strontium-90, plutonium-238 and -239, americium-241, cobalt-60, ruthenium-106, and antimony-125 were detected, and traveled at an estimated 5 feet per year. These holes were excavated and the tanks were exhumed in 1986.

Movement of this contamination did not occur in normal plume like dispersion and appeared to perhaps have traveled through fractures. The travel time observed from this leak is especially important because the co-presence of a solvent can increase the permeability of clay by 1,000 to 10,000 times according to a former plant operation manager for Westinghouse. Researchers have observed that the movement of solvent through fractures can also enlarge the size of the original fracture. The detection of fractures at depths lower than 16 feet in the soils near West Valley Nuclear Waste Site is quite difficult according to researchers from the University of Waterloo. The information gained from the leak is valuable because they demonstrate the lack of complete knowledge and unpredictability concerning the subsurface of the entire West Valley Nuclear Waste Site site.

An interceptor trench and liquid pretreatment system were installed on the northeast and northwest boundaries of the disposal area following the groundwater leak detection in 1983. These were constructed to intercept contaminated groundwater. The trench is one foot below the interface of the weathered and un-weathered till and is drained to a collection sump. Liquid in the sump is sampled, analyzed, and transferred to the low-level waste treatment system in WMA 2 for treatment and release. As of yet, no groundwater has been transferred to the connected liquid pretreatment system.[134]

A lagoon for collecting surface water runoff was located in the northeastern part of the NDA. It was filled with radiologically contaminated soil from cleanup after a HEPA filter was dropped at the NDA during disposal operations in 1972.[135]

The proposed alternatives from the 1996 DEIS are as follows[136]:
Alternative 1 - Exhume the NDA.
Alternative 2 - Exhume the NDA.
Alternative 3 - Buried waste in the NDA would be stabilized in place with slurry walls, in-situ waste solidification techniques, and capping.
Alternative 4 - No action, monitoring and maintenance as is.
Alternative 5 - Discontinue operations.

[133] Ibid
[134] Ibid
[135] Ibid
[136] US DOE and NYSERDA, 1996

The proposed alternatives from the 2005 DEIS are as follows[137]:
Alternative 1 - Exhume the NDA. Excavation of the interceptor trench, other buried wastes and former lagoon.
Alternative 2 - The NDA would be managed for 100 years under a geomembrane cover. An engineered multilayer cover and erosion control structures would be constructed and grouting of interceptor trench would occur after 100 years. Other wastes and the former lagoon would be left in place.
Alternative 3 - Selected wastes and the interceptor trench would be grouted. A multilayer engineered system would be installed to cover the NDA. A hydraulic barrier wall, French drain up-gradient, erosion control structures, and new leachate treatment facility to treat leachate from NDA would be constructed. The waste and former lagoon would be left in place.
Alternative 4 - A geomembrane cover over the NDA, a hydraulic barrier wall, French drain up-gradient, and erosion control structures would be installed. The interceptor trench and buried waste would be grouted and the former lagoon would be left in place.
Alternative 5 - Monitor and maintain as is.

In-Place Closure of the HLW Tanks

The 2005 DEIS presents the most comprehensive plan for in-place closure of the HLW tanks. The information presented in this section is from that document. In the event that the tanks are closed in-place they would be filled with a controlled low strength material (CLSM) containing sorbents and reducing materials to retard radionuclide migration. The tank vaults would also be filled with CLSM to a level at the top of the tanks. The headspace between the top of the tank and vault roof, and any tank and vault penetrations, would be filled with strong grout to hinder intruder entry (Figure 19). The CLSM would be composed of Portland cement, fly ash, ground granulated blast furnace slag, phosphatic ore, and water. The liquid remaining within the tanks would be incorporated into the low strength material matrix.[138]

[137] US DOE and NYSERDA, 2005
[138] Ibid

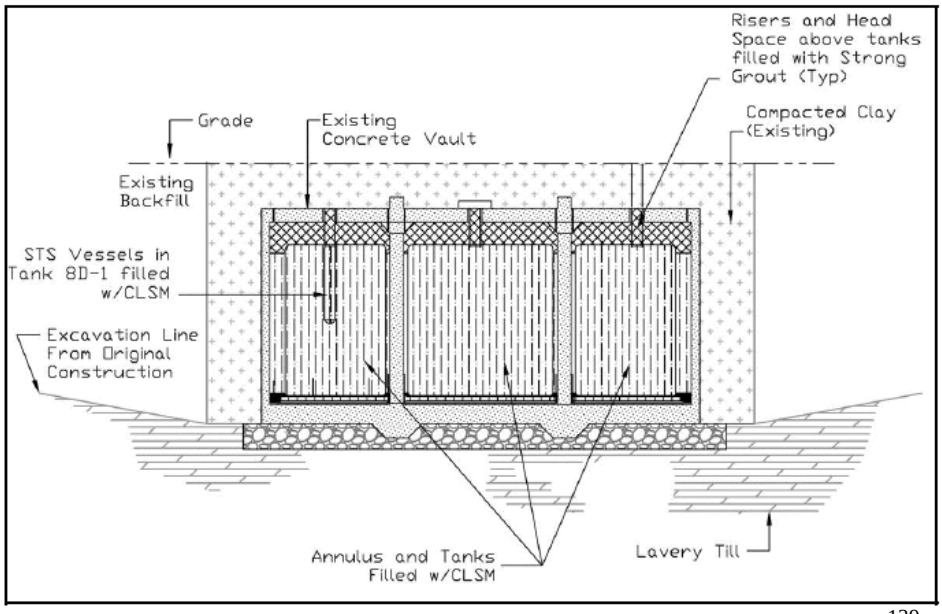
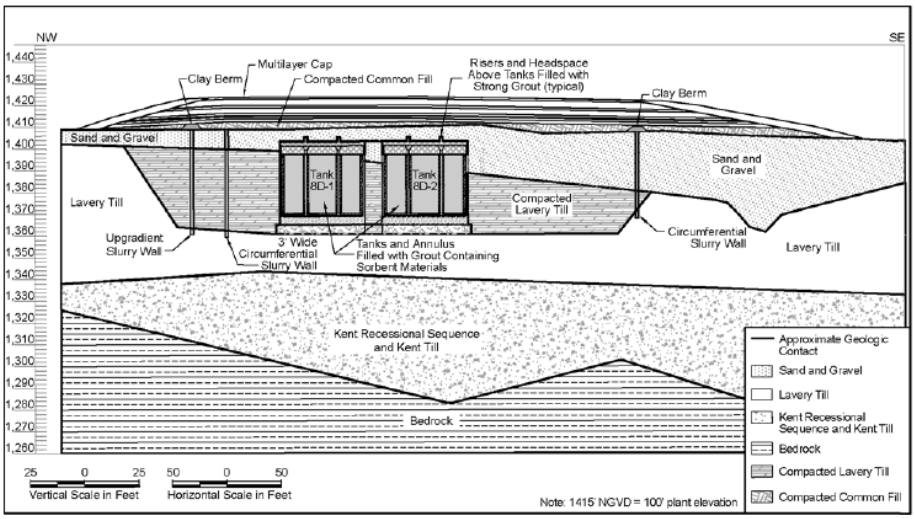


Figure 19. Schematic of In-Place Closure of Tanks 8D-1 and 8D-2[139]

A circumferential hydraulic barrier wall composed of low-permeability soil/bentonite based slurry would be constructed around WMA 1 and WMA 3. The down-gradient portion of the wall would be composed of soil, bentonite, and a sorbent material (such as granular apatite). A second chevron-shaped hydraulic barrier wall would be constructed up-gradient of the circumferential barrier wall. An engineered multilayer cover system would be constructed over the tanks and barrier walls with a total area of approximately 441,000 square feet and an elevation 10 to 30 feet above the existing ground surface. The cover would extend just beyond the top of the barrier walls (Figures 20 and 21).[140]



[139] Ibid
[140] Ibid

Figure 20. Schematic of In-Place Closure of Tanks 8D-1 and 8D-2[141]

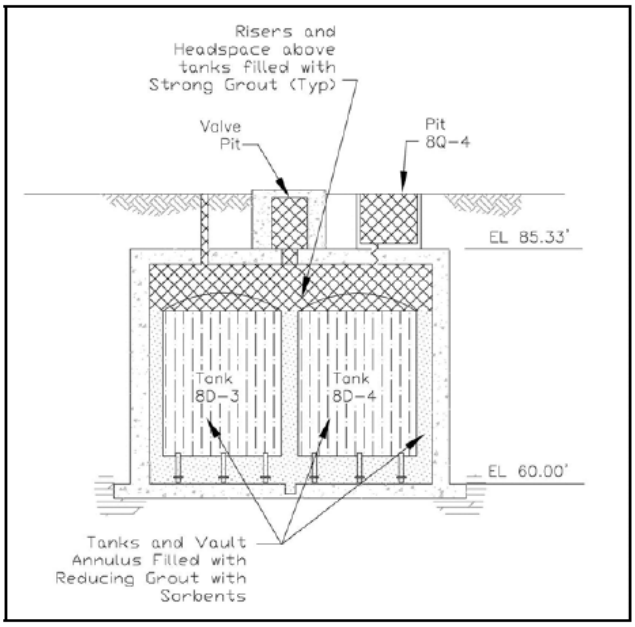


Figure 21. Schematic of In-Place Closure of Tanks 8D-3 and 8D-4[142]

If the HLW tanks are closed in place and Tanks 8D-1 and 8D-2 and their corresponding vaults are filled with CLSM, their weight will increase. The weight of the CLSM within each tank and vault when filled is between 13,957,974 and 19,386,075 pounds (see Table 4 for calculation). The weight of PUREX waste, if filling each tank and vault would be 5,213,542 pounds (see Table 4 for calculation). The effect of more than doubling the original content weight is unknown. It is also unknown how the input of CLSM in and around the tank and vault will affect the integrity of both.

The mean service life for concrete formations and waste package designs are thought to be 500 years with a standard deviation of 170 years, although modern concrete has not existed long enough for this hypothesis to be confirmed.[143] Due to this uncertainty, it is our opinion that a 500 year lifespan for the HLW tanks, CLSM, and vaults is unrealistic, and that a shorter lifespan and an immediate release scenario should also be assessed within the final EIS.

According to a journal article evaluating leakage of radionuclides from concrete containers, the release of radionuclides from cracks are more important than leaching, with the crack depth being one of the most important parameters relating to release. The use of grout and concrete for the extensive periods of time for radioactive decay are beyond that for which industrial applications of concrete are typically used. It is also important to note that waste heels tend to be in areas not easily accessed within the gridwork of the tank bottoms and this combined with the physical limitations from which

[141] Ibid
[142] Ibid
[143] Bejaoui, S, J Sercombe, C Mugler, and H Peycelon, 2007

one can pour grout into the tank may prevent all of the sludge from being secured by the grout or CLSM. The high pH and low E_h (electron activity) associated with grout are important in stabilizing radionuclides. The pH tends to decrease over time, and thus the immobilization of radionuclides becomes less effective. Little is known about how the E_h of grout changes over time.[144] The dissolution of water by calcium hydroxide and aluminate phases and calcium silicate hydrates in cement has an impact on the microstructural properties of concrete. Thus the initial confinement and mechanical properties of concrete can change considerably over time.[145] Another important factor specific to West Valley is that the groundwater table is higher than that of the tank base and this along with tank and concrete deterioration, will result in direct contact with groundwater.[146]

It should also be noted that in the event the HLW tanks are "redefined" as WIR, the area will be a long-term disposal subsurface radioactive waste disposal area. It is likely that once waste at a level higher than the low-level designation is permanently buried, additional similarly "redefined" wastes from other sites may be brought here for disposal as well. The impact of burying more WIR at the site would lead to even greater doses to workers and the public.

1996 and 2005 DEIS

The 1996 DEIS by the DOE and NYSERDA was developed for closure or long-term management of the site. The alternatives described in the 1996 report are:

1. Removal and release to allow unrestricted use
2. Removal, on-premises waste storage, and partial release to allow unrestricted use
3. In-place stabilization and on-premises low-level waste disposal
4. No action: monitoring and maintenance
5. Discontinue operations

A second DEIS for decommissioning and/or long-term stewardship of the site was prepared by the DOE in 2005. The 2005 DEIS doses primarily differ from the 1996 DEIS doses because of changes in the modeling of erosion and assumed engineered barrier performance. The five alternatives described in the 2005 report are:

1. Removal
2. Removal and decay
3. Prompt in-place closure
4. Delayed in-place closure
5. No action

To prevent intrusion on the site for Alternatives 2, 3, and 4 from the 2005 DEIS an 8-foot high chain-link fence, with one or more access points through locked gates would surround the closed facilities or in-place radioactive materials. Motion sensors and video cameras would be installed to activate an alarm notifying local law enforcement. Signs would also be placed around the perimeter to notify the public of the danger of the site. It

[144] National Research Council, 2006
[145] Bejaoui, S, J Sercombe, C Mugler, and H Peycelon, 2007
[146] National Research Council, 2006

is assumed that two full-time security officers will patrol the retrievable storage areas in the 1996 DEIS.

Implementation is assumed to last 30 years. The implementation of decommissioning at West Valley Nuclear Waste Site is assumed to last approximately 30 years. Implementation will last for the amount of time it will take to complete remediation, stabilization, and closure activities for each WMA. Workers will be present onsite during this time, and public access will be limited as it is now. The closure of all WMAs, with the exception of WMA 8, would be in accordance with the NRC-approved Decommissioning Plan and other regulations including the WVDPA. The closure for the SDA in WMA 8 would rely on it remaining under a permit, with continued active monitoring and maintenance. Following implementation the site would be released for unrestricted use or for long-term monitoring and maintenance. The role of the DOE following implementation has not yet been determined, as the DOE and the state of New York have not reached an agreement on this issue. The DOE currently acts as the site operator, while the state of New York is the state owner. Following implementation the DOE would prefer to turn over the control of the site to the state.

The long-term impacts are reported for the 1,000 years following completion of implementation for all alternatives. Calculations in the 1996 and 2005 DEIS reports for the long-term performance assessment were carried out for as long as 10,000 years. This is significant because the longest half-life of a radionuclide in the HLW tanks is 14,050,000,000 years for thorium-232. In fact, 13 radionuclides identified as existing in the HLW tanks have half-lives greater than 10,000 years. In the 1996 DEIS Alternatives 2, 3, and 4 were assumed to have active monitoring and maintenance for the entire time period evaluated. Active monitoring and maintenance were not assumed for Alternative 5. Institutional controls to prevent intrusion are assumed to be maintained for a minimum of 100 years for Alternatives 2, 3, and 4, while no institutional controls are assumed for Alternative 5. The 2005 DEIS, on the other hand, expects institutional controls to be maintained indefinitely in the expected to occur scenarios.

Information on the 27 reprocessing campaigns at West Valley Nuclear Waste Site were used for the preparation of the 1996 DEIS. The Battelle Pacific Northwest National Laboratory (PNNL) used this information to create a theoretical radiological inventory using the computer code system ORIGEN2 that was developed by the Oak Ridge National laboratory (ORNL) to calculate buildup, decay, and processing of radioactive materials.[147] The 2005 DEIS also utilized ORIGEN2 in the creation of the radiological inventory at West Valley Nuclear Waste Site. The 2005 DEIS includes the activities for the HLW tanks estimated in the Residual Radionuclide Inventory Estimate for the Waste Tank Farm Supplemental Report. The inventory for Tank 8D-1 was estimated from residual liquid sampling, sampling following 30 minutes of pump mobilization, an estimate of zeolite activity, and the use of general area gamma probe for fixed contamination, zeolite resin remaining in the ion-exchange columns, and contamination in other pieces of column related equipment within the tank. The mobile component of waste in Tank 8D-2 was estimated with data collected in the CFMT following transfers

[147] WVNSCO and Gemini Consulting Company, 2005

from the tank, and the fixed component was estimated from internal tank measurements and physical samples collected from the tank surfaces. The mobile inventory for Tank 8D-3 was estimated from a liquid sample and the fixed inventory was estimated from transfer factors reported from burnishing samples taken from Tank 8D-2. The inventory for Tank 8D-4 was estimated from a liquid sample. The Microshield computer program was used to estimate the cesium-137 inventory in Tank 8D-4. Refer to the report for an in depth discussion of the inventory estimate methodologies.[148]

Surface water pathways (such as runoff) were not included for the northern plateau of the facility. The DOE assumes that the HLW tanks degrade and offer no resistance and the release of radionuclides via diffusion begins immediately. They also assume that the gravel layer below the tanks is saturated thus providing a mixing zone for radionuclides as they diffuse through the grout and vault.

The DOE eliminated radionuclides from the risk assessment in both the 1996 and 2005 based on their contribution to the dose and degree of presence within the tanks. Table 2 contains the radionuclides used in the 1996 and 2005 DEISs, as well as those from reports in 1979 and 1982, which provide further information on radionuclides eliminated from the DEIS analyses.

In the 1996 DEIS the DOE combined the activity balances between the aqueous and cement-absorbed phases into a single differential balance, which was solved for the radionuclide concentration profile and related release rate. DOE simplified the differential balance by representing the radionuclide inventory and diffusional resistances as occupying separate portions of the waste volume. This type of model is termed a shrinking-core model and is easier to evaluate than the equivalent distributed parameter model.

$$-eA_w \frac{D}{T} \frac{C}{H-z} - eA_w z R_d LC = eA_w R_d \frac{\partial Cz}{\partial t}$$

The following equation was solved for the thickness of the shrinking core:

$$z = H - \sqrt{\frac{2D}{R_d T}} t$$

The release was then calculated from the thickness of the core and the decay-dependent concentration of a radionuclide in the core. For a detailed description of the release model, refer to the 1996 DEIS.

In the 1996 DEIS for the on-site resident family, the exposure to radioactivity was calculated with the RESRAD code. The exposure pathways evaluated include direct gamma radiation, inhalation of dust, and ingestion of contaminated food and water. For biological transport parameters, dose conversion factors, and human ingestion and inhalation parameters, default values given by RESRAD were used. All other input parameters were site-specific and used as calculated in the DEIS. The doses to other onsite receptors were calculated with site specific generated models.

[148] Ibid

The DOE states that, for concrete waste forms, the hydraulic conductivity of concrete is low enough that under most circumstances the release rate of radionuclides dissolved in the pore water is determined by diffusion of the radionuclide through the pore network. The proposed grouting of the HLW tanks would produce a horizontal slab encapsulating radionuclides left in the facilities. The encapsulated radionuclides could diffuse downward into the groundwater flowing below the slab.

In the 1996 DEIS release rate from the concrete/grout slab below the HLW tanks was estimated assuming a one-dimensional conceptual model, in which flowing groundwater maintains radionuclide concentration at one face of the slab at a low value providing a concentration gradient driving force for release of the radionuclides.

The 2005 DEIS includes models that were constructed including a release module, a groundwater transport module, and a human health impacts module. A set of 5 integrated models were developed for analysis of groundwater radionuclide release scenarios. Each used differing types of release and groundwater transport modules, but with a common human health impact module. A layered cylindrical geometry release model was developed to predict the release of radionuclides from the HLW tanks. This model allowed for advection and diffusion. It used finite difference methods to solve mass balances and predict the concentration of contaminant entering the groundwater. A lumped parameter model with layered rectangular symmetry was developed to predict the release from contaminant soil or stabilized waste in the SDA and NDA. It predicted release from the engineered structure, assuming equilibrium partitioning of radionuclides between the solid and pore water phase of the waste form. Release was assumed to occur by advection, but not diffusion. Mass balance equations were solved to determine the release. The groundwater transport module used one-dimensional groundwater flow and was linked with a groundwater release module to predict down-gradient contamination concentrations. An integrated code was developed for the erosion collapse scenario and one for the analysis of impacts from direct intrusion into waste. The equations were then solved and a computer code was developed to include the resulting solution algorithms. RESRAD doses were calculated based upon direct radiation, inhalation, ingestion of vegetables, grain, fruits, meat, poultry and milk, and incidental ingestion of soil.

The expected to occur receptors from the 1996 DEIS include a Cattaraugus Creek resident, a resident from the Seneca Nation of Indians, and the surrounding Cattaraugus Creek population. The 2005 DEIS includes the Cattaraugus Creek receptor, a resident from the Seneca Nation of Indians, and Lake Erie water users as expected to occur receptors. In the 1996 and 2005 DEIS reports the not expected to occur receptors are those that would occur onsite and offsite if institutional controls were to fail and unmitigated erosion or intruder access would occur. The 2005 DEIS states that the not expected to occur results are "primarily used for the purpose of estimating how an alternative would comply with the NRC license termination dose standards".

Dose Comparison

Buttermilk Creek Receptor

The Buttermilk Creek receptor is considered a not expected to occur scenario in both the 1996 and 2005 DEIS reports. In the 1996 and 2005 DEIS reports the Buttermilk receptor was assumed to eat fish from the stream, drink water from the stream, and use stream water for garden irrigation. Refer to Table 5 for the doses calculated in the 1996 and 2005 DEIS reports. The doses calculated for the normal scenario in the SDA and NDA are quite similar in both reports, but the dose calculated from the HLW tanks is much higher in the 1996 DEIS. When the loss of erosion control and the collapse of erosion control are considered in the 1996 DEIS report much higher doses were calculated for the SDA and NDA, although the HLW tanks were assumed to not change. Favorable, best estimate, and unfavorable doses based upon erosion were calculated in the 2005 DEIS. The doses calculated in the 1996 DEIS are much higher for the HLW tanks in the normal scenario and are also much higher for the SDA and NDA when erosion is factored in. The differences between the dose from the HLW tanks in the 1996 and 2005 DEIS is likely due to the assumption that radionuclides are unable to escape the HLW tanks for 500 years due to engineered barriers, and potentially from other assumptions included in the groundwater model. The doses calculated for the SDA and NDA with erosion in the 1996 DEIS are much higher because they include a more realistic perspective on erosion at the site. See the Wilson report for further information on the inadequacy of the erosion modeling in the 2005 DEIS. The calculated doses clearly show that in the event of erosion the doses from the SDA and NDA will be extremely high and that the risk associated with contamination from the HLW tanks is also high. In either event, the doses will be greater than 25 mrem/year.

Cattaraugus Creek Receptor

The Cattaraugus Creek receptor was considered as an expected to occur receptor for normal conditions, and as a not expected to occur receptor with the loss of institutional control and erosion control in the 1996 and 2005 DEIS reports. The receptor was assumed to be exposed via ingestion of water and fish and irrigation. Refer to Table 5 for the doses calculated in the 1996 and 2005 DEIS reports. In the normal scenario, the doses from the SDA and NDA are quite similar between the 1996 and 2005 DEIS reports, although the dose calculated for the HLW tanks is a great deal higher in the 1996 DEIS. The 1996 DEIS does not calculate the dose to Cattaraugus Creek receptors in the event of the loss of erosion control. The 2005 DEIS does include dose calculations for favorable, best estimate, and unfavorable erosion scenarios. The doses calculated for the SDA, NDA, and HLW tanks are all below 25 mrem/year in the favorable and best esimate scenario, although those calculated for the SDA and NDA in the unfavorable case scenario are greater than 25 mrem/year, and thus would present a risk to a Cattaraugus Creek receptor.

Seneca Nation of Indians Receptor

The Seneca Nation of Indians receptor is expected to occur during normal conditions in the 1996 and 2005 DEIS reports, but is considered not expected to occur in the event of a loss of institutional or erosion control. The receptors were assumed to be exposed via

ingestion of water and fish and irrigation. Refer to Table 5 for the doses calculated in the 1996 and 2005 DEIS reports. In the normal scenario, the doses from the SDA and NDA are quite similar between the 1996 and 2005 DEIS reports, although the dose calculated for the HLW tanks is a great deal higher in the 1996 DEIS (it is greater than 25 mrem/year). The 1996 DEIS does not calculate the dose to Seneca Nation of Indians receptors in the event of the loss of erosion control. The 2005 DEIS includes dose calculations for favorable, best estimate, and unfavorable erosion scenarios. The doses calculated for the SDA and HLW tanks are all below 25 mrem/year in the favorable and best estimate scenario, although those calculated for the NDA are greater than 25 mrem/year. The doses calculated for the SDA, NDA, and HLW tanks in the unfavorable case scenario are also greater than 25 mrem/year, and thus would present a risk to a Seneca Nation of Indians receptor.

Lake Erie Water User Receptor

The 1996 DEIS assumes that 350,000 people consume the potentially West Valley Nuclear Waste Site contaminated water from Lake Erie, while the 2005 DEIS assumes that 844,000 people do. Latent cancer fatalities (LCFs) for the exposed populations were calculated in the 1996 DEIS, but not in the 2005 DEIS. The calculated collective doses and LCFs from the 1996 and 2005 DEIS reports are shown in Table 5. The calculated doses for the NDA and SDA are slightly higher in the 2005 DEIS and the calculated doses in for the HLW tanks are higher in the 1996 DEIS. The doses from the NDA and SDA increase when a loss or erosion control and a complete collapse of erosion were assumed to occur in the 1996 DEIS for the NDA and SDA. The collective dose was likely lower for the HLW tanks was likley lower in the 2005 DEIS because of the assumed engineered barrier lifetime of 500 years. When erosion was considered for the calculation of the total dose from all WMAs at West Valley Nuclear Waste Site to Lake Erie water users, the calculated doses were much higher. The calculated collective doses would exceed the 25 mrem/year in the unfavorable erosion case, with an individual dose of 142 mrem/year.

Agriculture Intruder Receptor

The 1996 DEIS assumes that a resident grows crops in contaminated soil that had released radionuclides into groundwater. It also assumes that the agriculture resident is exposed via external radiation from contaminated soil, inhalation of contaminated dust, and ingestion of contaminated food and water. RESRAD was used to calculate this dose. The 2005 DEIS assumes a resident is exposed via irrigation with contaminated groundwater or surface water, deposition of contaminated soil from home construction excavation on the ground surface, deposition of contaminated soil from the well drilling cutting pond, exposure of contaminated material during erosion, inhalation of dust, ingestion of crops, animal products and water, and external radiation. Incidental soil ingestion does not appear to be included as an exposure pathway. The 1996 DEIS scenario assumes a domestic well is located 165 feet from the boundary of the disposal facility. The 2005 DEIS scenario assumes that a well is located on the North plateau between the WMAs and Erdman Brook and that surface water comes from Buttermilk Creek. A resident farmer on the North plateau is assumed to have a well in the sand and gravel layer on the North plateau, while a South plateau resident farmer is assumed to

have a well in the Kent Recessional Unit on the east side of Frank's Creek opposite to the NDA and SDA. The results from the DEIS reports are in Table 5.

Both the 1996 and 2005 DEIS reports calculate high doses to resident farmers. The 2005 report appears to attempt to minimize the doses by providing separate doses for the resident farmer: one for a farmer who gardens in contaminated soil from well drilling or home construction and the second from a resident farmer that uses contaminated groundwater. Neither of the 2005 DEIS scenarios assume that the resident farmer directly ingests the contaminated water. The 1996 DEIS assumes this and the calculated doses are much higher.

Intruder Well Driller or Home Constructor

The well driller was assumed to construct a well for domestic use and be indirectly exposed to waste brought to the surface by the drilling mud. The driller was assumed to pump contaminated fluid to a 4 foot deep 8 foot by 9 foot mud holding pond in the 1996 DEIS. The drill hole was assumed to be 0.7 feet in diameter and 201 feet deep and the worker was assumed to be exposed for six hours in both the 1996 and 2005 DEIS reports. The 2005 DEIS assumed that the worker drilling a well would be exposed via ingestion of soil, inhalation of contaminated dust, and direct exposure to external radiation.

The dose calculation results are shown in Table 5. The higher of the well driller or home constructor intruder was given in the 2005 DEIS, while both were provided in the 1996 DEIS. The doses to the home constructor are elevated above 25 mrem/year in the 1996 DEIS. The doses provided in the 2005 DEIS all exceed 25 mrem/year. The doses to a driller in the 1996 DEIS only exceed 25 mrem/year for Alternative 5 at the SDA.

The 2005 DEIS also includes a calculation of the dose that would occur if an immediate breakdown of institutional control were to occur. The results for this are higher than those discussed above which assume institutional control is maintained for 100 years.

The 1996 DEIS also includes a calculation of the dose in which a worker becomes aware of the hazards onsite and discontinues construction. These results are presented as the discovery intruder in Table 5. In this scenario at the HLW tanks the intruder was assumed to access a riser and be exposed to five minutes of direct radiation while viewing the contents. At the NDA and SDA the individual was assumed to excavate the waste there and be exposed directly for five hours. The results from these calculations are all much higher than 25 mrem/year.

Intruder Recreational Hiker Receptor

The 2005 recreational hiker was assumed to hike over Tanks 8D-1 and 8D-2 for 30 meters and Tanks 8D-3 and 8D-4 for six meters while walking 1.6 kilometers per hour, 365 days a year for 30 years. No dose was calculated for a recreational hiker in the 1996 DEIS. See Table 5 for the dose calculations from the 2005 DEIS. The doses were calculated for the favorable, best estimate, and unfavorable erosion scenarios. The doses calculated for the NDA exceed 25 mrem/year in the best estimate scenario and the doses calculated for the SDA and NDA in the unfavorable scenario exceed 25 mrem/year.

Criticism

Although the DOE describes the loss of institutional control as "not expected", it is inevitable that at some point in the next thousands of years the DOE (or its successor) will in fact lose control over the site. These should be considered as event that is "expected" to occur. "Intruders" represent another "not expected" scenario, although the area is popular for hunting, sport fishing, and water recreation, and over time is unlikely to be retained as such to prevent entry to members of the public. In addition, the method of blocking entry to the public outlined in the 2005 DEIS are not impressive. An eight foot fence with motion detectors and cameras that will alert local enforcement does not create a large deterrent which will be sustained over time. This in combination with the eventual loss of institutional control makes it inevitable that future individuals will unintentionally "intrude" on the site. The Environmental Protection Agency (EPA) advises that active institutional controls should not be assumed to last for more than 100 years following disposal.[149]

The DOE also assumes that several erosion scenarios are unlikely to occur, although in actuality, as outlined by the Wilson report, erosion will be more extensive than projected in the 2005 DEIS. The doses calculated from the "not expected" scenarios should be realistically considered as expected to occur. The erosion model used in the 1996 DEIS has been identified as being more accurate than the one from the 2005 DEIS as it is based on "chunks" of property and waste falling into creeks as the plateau edge recedes toward the facilities. The 2005 model assumes that erosion occurs equally on all land surfaces. NYSERDA and Wilson have been extremely critical of the erosion modeling for the 2005 DEIS. The 2005 DEIS describes three potential erosion rates which are "not expected to occur". These include one that is "favorable", one that is a "best estimate", and one that is "unfavorable" with widely varying resulting doses. Due to the unrealistic modeling used in the 2005 report, if anything we should consider the unfavorable scenario as "expected to occur". As Wilson states when discussing erosional factors, "[a]ll five factors indicate system failure (facilities breached or sapped by erosion) in less than 10,000 years and two factors indicate system failure in less than 1,000 years. However, the factors will act in concert with each other and likely lead to some facility failures in as little as decades at plateau margins or centuries at plateau interiors."[150] See the Wilson report for a full review of erosion at the site. This discussion of erosion pertains to the entire West Valley Nuclear Waste Site site, not just the HLW tank area.

Although we disagree with many aspects of the 2005 DEIS, it is our opinion that some of the scenarios it considers not likely to occur, are in actuality likely to occur, and thus the doses calculated for those should be considered. In both the 1996 and 2005 DEIS reports the doses calculated for many scenarios they consider "not expected" exceed the standard of 25 mrem/year for a decommissioned facility. It is our opinion that these calculated doses should be considered as likely to occur.

[149] EPA, 2002
[150] Wilson, MP, 2007

In addition to diffusion, release of radionuclides through cracking of the CLSM and vaults should be considered as an additional mode of radionuclide release from the HLW tanks. The vault for Tank 8D-1 is already cracked, which is a strong indicator that the vault for Tank 8D-2 will also crack. The doses we calculate in the following section are based upon the assumption that cracking has occurred and will inevitably continue, thereby acting as a preferential release pathway from the tanks.

The site is located atop the federally-designated Cattaraugus Creek sole source aquifer (52 FR 36100), and thus it is important to remember that future residents of the area surrounding the site will be impacted by any groundwater contamination. The DEISs look at doses from specific locations within the site and downstream, but do not discuss the potential that one of the aquifers below the site might be utilized for a community domestic water source. Depending on the location of such a source, it might pull groundwater from the site or contaminated surface water at locations not currently included in the DEISs. This is especially probable if the population in the area grows significantly in the next several thousand years and as readily available fresh water supplies continue to decrease. The 2005 DEIS does not appear to have considered that contamination might enter the sole source aquifer and what doses people might receive if that aquifer becomes contaminated. Approximately 50% of the drinking water to those living in the designated sole source aquifer area is supplied by the Cattaraugus Creek Basin Aquifer System.[151]

It is assumed within the 2005 DEIS that the HLW tank barrier will prevent intruder entry for 500 years. A 100 year lifetime is assumed for all other engineered barriers on the site. Portland cement, the most commonly used cement in the production of concrete was invented 184 years ago in 1824.[152] The use of CLSM was first documented in 1964, and thus its realistic long-term lifespan is unknown. In addition, CLSM materials are not designed to resist abrasive and erosive actions or aggressive chemicals.[153] There is no valid basis for the DOE to unequivocally state that the grout and CLSM in the HLW tanks will have a 500 year lifespan. Although DOE contractors have conducted a great deal of work on the longevity of concrete, there is little evidence to support the 500 year lifetime assumption. It is acknowledged by the National Research Council that short- and long-term performance of tank fill materials are lacking and require further research.[154] Concrete degradation can result from corrosion, stress cracking, leaching of concrete constituents, and the biodegradation of coatings and sealants. Portions of the concrete will crumble and become more permeable over time. Cracks can result in increases of hydraulic conductivity by several orders of magnitude. Microcracks can occur as a response to the addition of reinforcement bars, drying shrinkage, and expansion or contraction during temperature changes.[155] Concrete that is buried in saturated soils can deteriorate via dissolution of the soluble materials in the hardened cement. Concrete

[151] US EPA, 1987
[152] Wikipedia, 2008
[153] Portland Cement Association, 2008
[154] National Research Council, 2006
[155] INEL, Prepared for US NRC, 1990

vaults storing LLW are required to be constructed above the groundwater table.[156] Leaching may reduce the pH of the concrete and make it more porous. The long-term performance of concrete is dependent upon the quality of the concrete materials and good construction practices. Groundwater quality can also have an impact on deterioration of concrete; acidic groundwater is especially destructive.[157] A 100 year lifespan and the possibility of an immediate breach and cracking should have been assumed for this barrier.

In addition, we do not know the effect that filling the tanks and vaults with CLSM will have on the integrity of the tank and vault. The tank and vault for 8D-1 and 8D-2 have already been stressed from the period prior to operation when they floated and re-settled in tilted positions. The assumed lifespan of the tanks at the time of their construction was 40 to 50 years. Thus the tanks and vaults should consistently be assumed to immediately fail. The tanks also do not stand freely in the vaults; six steel encased concrete columns support the roof. Shifting during an earthquake prior to the addition of CLSM could cause the tank to hit one of the columns, potentially leading to rupture which would cause the radioactivity to be released at a higher rate into the groundwater.

It is assumed within the 2005 DEIS that a leak occurring in conjunction with the adoption of Alternative 5 would be detected in a timely manner and an effective response would occur if it were to happen within the first 100 years. Given the historical negligence of regulatory agencies at the site, it should not be assumed that a leak at any time would be detected or remediated in a "timely" manner.

The 2005 DEIS lists 360 mrem per year as the background dose to individuals from radiation. This value is overstated and includes radon exposure. For reference, the environmental standards for normal operations of a uranium fuel cycle facility are that annual total effective dose equivalent (TEDE) dose not exceed 25 mrem per year to any member of the public as the result of "planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and to radiation from these operations".[158] The TEDE in this case is the dose limit to members of the public, and is defined as "the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures)"[159].

The 2005 DEIS report states that "the maximum accident MEI dose is below any dose for which any health effects could occur in an individual, and much lower than allowable worker annual doses".[160] This statement is inaccurate; there is no scientifically accepted "safe" dose limit. According to the National Commission on Radiation Protection and Measurements (NCRP), "[i]n keeping with previous reviews by the NCRP the Council concludes that there is no conclusive evidence upon which to reject the assumption of a

[156] US NRC, 1992
[157] NIST, Prepared for US NRC, 1989
[158] US EPA, 1993
[159] US NRC, 2008
[160] US DOE and NYSERDA, 2005

linear non-threshold relationship for many of the risks attributable to low-level ionizing radiation although additional data are needed".[161] The ICRP states that "while existence of a low-dose threshold does not seem unlikely for radiation-related cancers of certain tissues, and cannot be ruled our for all cancers as a group, the evidence as a whole does not favor the existence of a universal threshold, and there seems to be no particular reason to factor the possibility of a threshold into risk calculations for purposes of radiation protection".[162] The statement within this report is misleading in that is indicates that there is a defined "safe" level of radiation, which is not true.

The 2005 DEIS misuses the U.S. lifetime chance of getting cancer of 0.22 to put risk "in perspective". This is an extremely misleading statement used in an attempt to minimize any cancer risk. Many factors go into the development of cancer (genetics, nutrition, occupational exposure, residential exposure, lifestyle choices, sensitivity variation, unknown, etc.). Simply reducing this complexity to a one in five chance of getting cancer for comparison in this DEIS is unfounded. It should also be remembered that the total cancer risk from the site is in addition to the background cancer risk. So if the normal person has a 2 in 5 chance of getting cancer, the risk from West Valley Nuclear Waste Site increases this chance.

One interesting finding from the 1982 FEIS was that dispersal of liquid HLW following a plane crash into the HLW tanks would result in a dose of 30,000 rem to a maximally exposed hypothetical individual and 500,000,000 person-rem to the surrounding population through external exposure to radionuclides deposited on the ground and through inhalation.[163] A similar "worst case" scenario should have been evaluated for the buried HLW tanks. What would happen if intentional sabotage to the tanks following in-place closure were to occur? What would happen if intentional sabotage to the building containing the high-level vitrified waste canisters were to occur?

Because no agency guidance was available for conducting a radiological ecological risk assessment, one was not conducted for this area in either DEIS. It is thus assumed that ecological risk is not being considered as a driving force for clean up of this site.

High Level Waste versus Waste Incidental to Processing

It is important to remember that the waste remaining in the HLW tanks has not yet been accepted as "waste incidental to reprocessing" (WIR) and is still considered HLW. According to a DOE radioactive waste management order HLW can be reclassified as WIR and managed as LLW if it meets certain criteria.[164] If reclassification does not occur, then the alternatives involving in-place closure of the HLW tanks would no longer be legal, because wastes with radionuclide concentrations that exceed the standard for Class C low-level waste are not acceptable for near surface disposal.[165] It is ridiculous that a simple change in the wording of a waste type, not based upon its activity and longevity, could determine the mode of final

[161] NCRP, 2001
[162] ICRP, 2005
[163] WVNSCO, 1998
[164] US GAO, 2001
[165] US NRC, 2007

disposal. Renaming a particular radioactive waste stream has no impact on the risk assessment or the dose calculated for the public. This point should have been more clearly discussed in both the 1996 and 2005 DEIS reports. These reports have been prepared assuming that this redefinition will be legally upheld. By preparing these reports as such and presenting the estimated costs of each alternative preemptively, the DOE is attempting to affect the outcome of redefinitions.

Dose Calculations

Dose calculations to onsite persons are presented in the 1996 and 2005 DEIS. We do not recalculate these doses, but instead rely on the 1996 DEIS results as being indicative of the exposure to onsite persons. We do, however, consider these doses for a loss of institutional control as likely to occur given that institutional control will inevitably fail at some point in the future. A summary of those doses, as well as those from the 2005 DEIS can be seen in Table 5. As is discussed throughout this report, if the SDA, NDA, and HLW tanks are left in place, the institutional controls protecting them are likely to eventually break down due to a lack of institutional continuity and erosive forces. Doses calculated in the 1996 DEIS to onsite receptors should be considered as ones that could quite possibly occur. The doses calculated in the 1996 DEIS to onsite "intruders" are the greatest for the "resident farmer intruder". The doses for Alternatives 3, 4, and 5 to the "resident farmer intruder" range from 310 - 1,100,000 rem/yr, with the greatest dose coming from the HLW tanks. A person exposed to 1,100,000 rem/yr would die before receiving the entire dose. The risk to onsite persons in the future are enormous if the SDA, NDA, and HLW tanks are closed in place.

We approach dose estimation in a different manner than is carried out in the DEIS reports. Our calculations are based upon the 1996 DEIS, Appendix A, and review of historic documents on the erosion and hydrology at the West Valley site[166], as well as HLW escaping from the tanks not via diffusion, but via cracks in the grout, CLSM, and vault. This method is both conservative and realistic, while those incorporated into the DEIS's rely upon less conservative assumptions and are limited in scope. Our doses are based upon the erosion rates discussed in the 1996 DEIS. In Appendix A a further discussion of erosion as it differs between the 1996 and 2005 DEIS reports are expounded upon. Although it is not possible to make exact erosion rate quantification due to numerous factors and highly erosive characteristics of the site, it is unlikely that the plateaus can withstand erosion for 1,000 years. In contrast, the 2005 DEIS assumes that the erosion of the high-level waste tanks would occur at some point between 10,000 and 25,000 years, and carries dose calculations out through 10,000 years.[167] We assume that erosive factors will destroy the multiple natural and geotextile layers and erode most of the top of the plateaus thus uncovering the tanks, SDA, and NDA at some point approximately 1,000 years in the future. The covers of the NDA and SDA do not have to completely erode away in order for release to occur. As soon as a trench is breached it will begin to release radioactivity directly into the surface water. As can be seen in the 1996 DEIS, that could occur within 500 years. While the waste within the HLW tanks is

[166] Wilson
[167] US DOE and NYSERDA, 2005

contained within tank and vault barriers, the NDA and SDA are not contained by such barriers. As erosion occurs, sections or chunks of the waste may directly fall into the waterways at one time.

Groundwater at West Valley Nuclear Waste Site flows in an easterly or northeasterly direction; most of the groundwater is thought to discharge into Frank's Creek or its smaller tributaries.[168] According to the 1974 Safety Analysis Report, the HLW tanks are approximately 1,500 feet from Quarry Creek, 2,000 feet from Erdman Creek, and 800 feet from a tributary to the east of the plant. The reported groundwater velocities flowing towards these were 9.1, 7.3, and 9.5 feet per year, respectively.[169] Conversely, in the 1982 FEIS the travel time for groundwater from the HLW tanks to enter Frank's Creek, 1,410 feet away, was determined to be 62 years, which would correspond with a groundwater velocity of 22.7 feet per year.[170] The permeability of the sand lenses scattered throughout the soil profile is assumed to be no greater than 0.00005 centimeters per second, which is equivalent to approximately 52 feet per year.[171] If one were to make a conservative assumption that groundwater could travel entirely through sand lenses from the HLW tanks to the various creeks and tributaries, the contamination could reach Quarry Creek in 29 years, Erdman Creek in 38 years, the tributary in 15 years, and Frank's Creek in 27 years. The travel time for groundwater to move vertically from the tanks to the till shale layer aquifer below is 17 years.[172] We use the travel time resulting in a velocity of 22.7 feet per year reported in the 1982 FEIS to Frank's Creek as the groundwater velocity near the HLW tanks in our calculations. We use the mid-point groundwater velocity of 4.92 feet per year[173] near the NDA and the groundwater velocity of 2.20 feet per year[174] near the SDA.

It is important to note that some radionuclides are retarded by sorption to soil particles. Groundwater transport of radionuclides depends on many factors, including interactions among the radionuclide and non-radioactive carrier isotopes, other dissolved species, and solid mineral species in the soil. Samples analyzed for tritium near the SDA found that tritium in water preferentially migrates through higher permeability areas, such as sand lenses. Glacial till at West Valley Nuclear Waste Site contains many fractures, providing a preferential pathway for downward migration.[175] Because of the sand lenses and fractures it is our opinion that use of the moderate values of the reported groundwater velocities in our calculations provides for conservatism.

Frank's Creek is a tributary which flows into Buttermilk Creek, which flows into Cattaraugus Creek, which eventually flows into Lake Erie (Figure 22). Buttermilk Creek has an average flow rate of 45.9 cubic feet per second and in 1982 had a maximum gage height of 8.5 feet. Cattaraugus Creek has an average flow rate of 353 cubic feet per

[168] US DOE, 1982
[169] NFS, 1974
[170] US DOE, 1982
[171] ORNL, 1985
[172] US DOE, 1982
[173] US DOE and NYSERDA, 1996
[174] Ibid
[175] ORNL, 1985

second when it joins with Buttermilk Creek, and a maximum flow rate of 706 cubic feet per second, and in 1982 had a maximum gage height of 14 feet.[176] According to US Geological Survey (GS) measurements from 1940 through 2007 near the outfall of Cattaraugus Creek into Lake Erie, the average flow rate is 750 cubic feet, with a maximum average flow rate of 1,587 cubic feet and a minimum average flow rate of 250 cubic feet.[177]

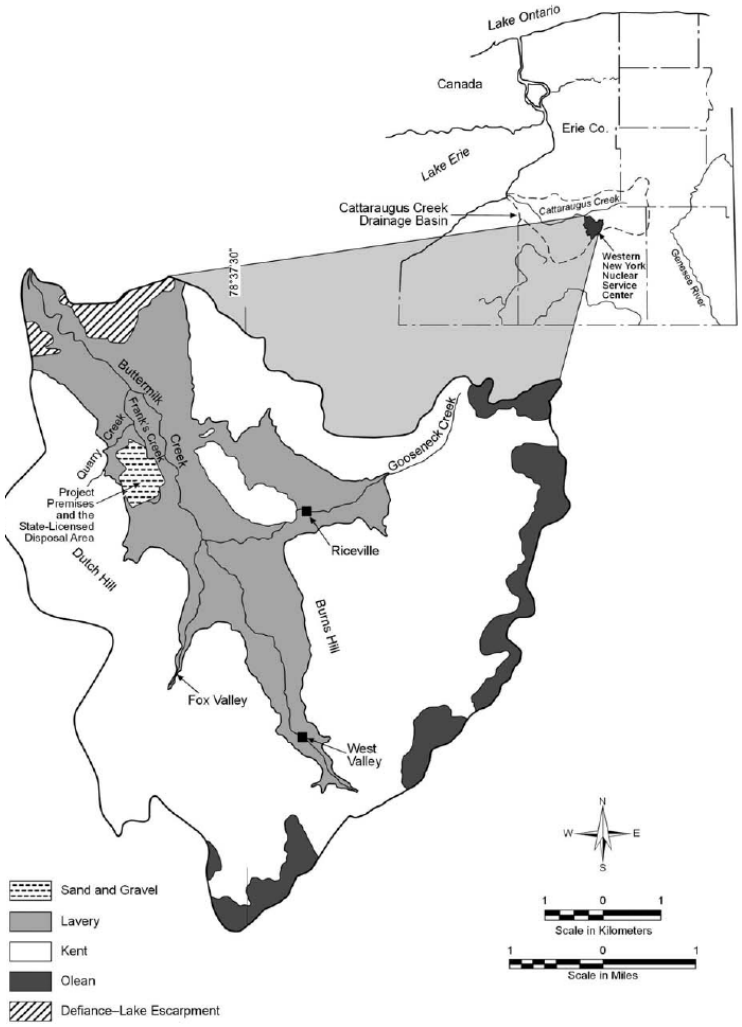


Figure 22. Surface Water Pathways from West Valley Nuclear Waste Site

The 1996 DEIS used the 3DLEWASTE software to model groundwater transport.[178] The executable modules and files for this model are no longer available from the EPA due to their lack of compatibility with current operating systems. The EPA cautions users to use the simulations from recompiled source code at their own risk.[179] We do not currently have Appendix E of the 2005 DEIS which details the groundwater modeling for that report, although we do know that three different release models and two different

[176] US DOE, 1982
[177] USGS, 2008
[178] US DOE and NYSERDA, 1996
[179] US EPA, 2007

groundwater transport models were developed for analysis of release from the West Valley Nuclear Waste Site.[180] Since we do not have the resources to conduct an in-depth ground and surface water model of radionuclide transport through a software model, we conducted a simplified one-dimensional model for transport from the HLW tanks, NDA, and SDA through groundwater moving horizontally into the surface water. We assume that groundwater is moving towards Frank's Creek, which then flows into Buttermilk Creek approximately 3,000 feet downstream. The Buttermilk Creek receptor is approximately 7,000 feet downstream of its confluence with Frank's Creek. The Cattaraugus Creek receptor is approximately 3,000 feet downstream of the Buttermilk Creek Receptor at the confluence with Cattaraugus Creek. The Cattaraugus Creek eventually flows into Lake Erie.

While we have total activity estimates from several reference documents, only three contain comprehensive listing of activity by specific radionuclide for the HLW tanks. These references are the 1982 FEIS, the 1996 DEIS, and the 2005 DEIS. We use all three of these for conservatism in our dose estimate. We assume that the remaining activity in the sludge following vitrification from the 1982 FEIS is somewhere between 2 and 20 percent, after accounting for decay through 2005. The 1996 DEIS inventory estimate is also calculated to account for decay through 2005. The release fraction from the HLW tanks assumed in the 1982 FEIS if the tanks were to leak and the vaults were to crack was 0.01 per year for the sludge, while it was 0.2 per year for the supernate.[181] We utilize this assumption in our calculations for sludge.

We assumed that a fraction of 0.01 of the total activity was released from the NDA and SDA. Our assumptions are based upon the 1996 DEIS which shows the edge of the plateau retreating into approximately 90-percent of the SDA and NDA 1,000 years in the future. The edge of the plateau projected 500 years into the future shows approximately 50-percent of the surface area of the cover of the SDA and NDA remaining. The projected plateau edge at 500 years would expose a portion of all of the trenches in the SDA and many of the disposal areas in the NDA. Based on the figures in the 1996 DEIS it appears that the trenches will likely be breached by 300 years into the future. It is not necessary for all of the materials within the disposal areas to erode into the waterway in order for radioactive materials to be released; once the trench contents are exposed, both surficially and from the side, water will enter the trenches and carry radioactive contamination into the surface water, as it has in the past. We assume that after 100 years, there is no active maintenance on the site. For the years 100 through 300, we did not assume that radioactive material would move on the surface; in that sense, our results are conservative. Moreover, we now assume a moderate groundwater velocity, not the most rapid groundwater velocity, even though groundwater moves quite rapidly through sand lenses. In addition, as erosion occurs, chunks of materials within the SDA and NDA will also fall into or be washed directly into the surface water. It is important to note that approximately 97.5% of the reported activity buried within the NDA is contained on the eastern edge which will be the area most quickly to erode in the NDA.[182] Actual release

[180] US DOE and NYSERDA, 2005
[181] US DOE, 1982
[182] HyrdoGeoLogic, Inc., Prepared for the US NRC, 1991

will occur at a non-linear rate which will vary and may occur more rapidly or more slowly. The variation will include large storm events which could flush a great deal of contamination into the surface water in a short period of time. In addition uncertain factors such as the presence of ethylenediaminetetraacetic acid (EDTA) in the SDA may mobilize some radionuclides at a rate faster than would normally occur.

After opening in 1963, the SDA trenches were found to be filling with water, creating the "bathtub" effect. In the early 1970's, following infiltration through the cracked clay cover, several trench covers broke through and waste was actually exposed. For the newer trenches, water began filling trench 14 and once the water level reached that of the sand lens, trench water would migrate horizontally and begin to fill the adjacent trench 13. Action was taken as the trenches were pumped and attempts were made to prevent further infiltration with a cover and a barrier wall, both of which have been effective to varying degrees in the intervening years. As has occurred in the past, once trenches in the SDA fill with infiltrating water, the water would move out and could travel along the ground surface towards surface water or through the subsurface. As institutional controls should be assumed to not persist longer than 100 years and as degradation of covers has occurred more quickly than anticipated at other nuclear sites, such as Maxey Flats, we assume that release from the SDA and NDA begins in 100 years.[183] While the trenches will be breached due to erosion at some point estimated to be approximately 300 years in the future, radioactivity would be released at an earlier time if the cover is damaged. In addition, NYSERDA has indicated that the level of the water table within the SDA is currently decreasing.[184] While this indicates that the cover is currently effective in preventing infiltration, it also demonstrates the existence of a pathway for movement out of the SDA, such as via evaporation through cover vents or the subsurface. The NDA is also recognized as having a potential pathway for an increased rate of release of groundwater from the disposal area in the event of infiltration. As the disposal pits fill with water the water level will increase and once it reaches the weathered till will be able to move laterally at an increased rate. The presence of any mobilizing materials, such as the solvent leak that occurred in the 1980's, could increase the movement of radionuclides.[185]

While we recognize that the bathtub effect may be considered a worst case scenario, we must also consider that similar occurrences have happened in the short lifespan of both the NDA and the SDA. Therefore we consider the events as a potential scenario given that institutional controls are likely to break down in the future centuries and the uncertainty of weather patterns and maintenance of the site in the long-term.

We use the mean of the estimated activities from the 1996 and 2005 DEIS reports as the sources for estimated activity in both disposal areas. We assumed that the SDA was approximately 250 feet from Frank's Creek and that the NDA was approximately 500 feet from Frank's Creek for the first 100 years and half of that at 200 years. The calculations

[183] US EPA, 1985
[184] NYSERDA, 2005
[185] HydroGeoLogic, Prepared for the US NRC, 1991

for 500, 1,000, 10,000 and 100,000 years assume that the distances from the edges of the SDA and NDA to the creek is negligible due to erosion.

In the calculations we account for the radioactive decay of each radionuclide as well as the decay of plutonium-241 into americium-241.

The following assumptions were made for the calculation of the doses.

- The distance from the HLW tanks to Frank's Creek is 1,410 feet.[186]
- The distance from the NDA to Frank's Creek is approximately 500 feet.[187]
- The distance from the SDA to Frank's Creek is approximately 250 feet.[188]
- Groundwater velocity from the HLW tanks towards Frank's Creek is 22.7 feet per year.[189]
- Groundwater velocity from the NDA towards Frank's Creek is 4.92 feet per year.[190]
- Groundwater velocity from the SDA towards Frank's Creek is 2.20 feet per year.[191]
- The distribution coefficients are assumed to be those presented in the 1996 DEIS.[192] Coefficients were not available for cerium, iron, niobium, palladium, praseodymium, ruthenium, and zirconium; their corresponding retardation factors were assumed to be 1.0.
- The reported activities for the NDA and SDA in the 2005 DEIS are accurate.
- That a fraction of 0.01 of the activity in the HLW tanks, NDA, and SDA leaks into the groundwater each year for which a dose is calculated.
- We do not assume partitioning and sedimentation of radionuclides.
- Doses were evaluated at times 100, 1,000, 10,000, and 100,000 years for a one-time release scenario.
- Doses were evaluated at times 100, 200, 500, and 1,000 years following an initial release in 2108 for a continual release scenario.

We then use ICRP 72 dose conversion factors (DCFs)[193] and the water ingestion exposure factor of 730 liters per year[194] in the following equation to calculate the dose.

$$Dose = C_{x,t} \times DCF \times DR$$

Where:
$C_{x,t}$ - Concentration; Ci/L
DCF - Radionuclide Dependent, from ICRP 72; mrem/Ci
DR - Drinking Water Rate; L/year

[186] US DOE, 1982
[187] Estimated from Figure 2.3 HydroGeoLogic, Inc., Prepared for US NRC, 1991
[188] Estimated from Figure 2.3 HydroGeoLogic, Inc., Prepared for US NRC, 1991
[189] US DOE, 1982
[190] US DOE and NYSERDA, 1996
[191] Ibid
[192] US DOE and NYSERDA, 1996
[193] ICRP, 1996
[194] US EPA, 1997

We used Crystal Ball 7.2 (Decisioneering, Inc.) to run a Monte Carlo probability statistical analysis for the dose calculations at Frank's Creek. The analysis was run for 2,000 trials with the default seed value of 999. When multiple activities were available for a specific radionuclide a triangular distribution was defined based upon these values.

We assume that a fraction of 0.01 of the activity leaves the tank, SDA, and NDA and is carried through the groundwater, eventually reaching Buttermilk Creek.

$$C_{Buttermilk} = \left(\frac{0.01 \times A_{Tank}}{V_{Buttermilk}} \times e^{-\lambda t} \right) + \left(\frac{0.01 \times A_{SDA}}{V_{Buttermilk}} \times e^{-\lambda t} \right) + \left(\frac{0.01 \times A_{NDA}}{V_{Buttermilk}} \times e^{-\lambda t} \right)$$

Where:
A - Radionuclide Activity; Curies
$C_{Buttermilk}$ - Concentration in Buttermilk Creek - Curies/cubic feet
$V_{Buttermilk}$ - Volume of water flowing through Buttermilk Creek in one year; cubic feet

We accounted for retardation by only including activity for radionuclides whose travel time would equal less than 100 or 200 years when the groundwater velocity was divided by the corresponding retardation coefficient for each radionuclide. We used two different scenarios when modeling the dose calculations to people that might drink water from Buttermilk Creek, Cattaraugus Creek, and Lake Erie. In the first we assumed that a fraction of 0.01 of the original amount of waste was released only in the year 100, 1,000, 10,000, and 100,000 years following closure. The first scenario is more conservative in that it assumes that radioactive waste would still persist at the West Valley site 10,000 and 100,000 years into the future and becomes it assumes a one-time loss of radioactivity, as opposed to continual loss. In the second we assume that the NDA, SDA, and HLW tanks continuously released a fraction of 0.01 of the remaining radioactivity each year following 100 years after closure. For this period, since most of the radioactivity is released in the initial 1,000 years, the doses were calculated for the years 100, 200, 500, and 1,000.

For the first scenario, the following doses were calculated. The dose for Buttermilk Creek at 100 years has a mean of 0.2 mrem/year with a minimum of 0.04 mrem/year and a maximum of 0.4 mrem/year. The dose for Buttermilk Creek at 1,000 years has a mean of 22,100 mrem/year with a minimum of 21,300 mrem/year and a maximum of 23,100 mrem/year. The dose for Buttermilk Creek at 10,000 years has a mean of 3,110 mrem/year with a minimum of 2,920 mrem/year and a maximum of 3,370 mrem/year. The dose for Buttermilk Creek at 100,000 years has a mean of 240 mrem/year with a minimum of 230 mrem/year and a maximum of 260 mrem/year. Table 6 contains a breakdown of total dose from the HLW tanks, SDA, and NDA for each time period.

For the second scenario, the following doses were calculated. The dose for Buttermilk Creek at 100 years has a mean of 0.2 mrem/year with a minimum of 0.04 mrem/year and a maximum of 0.4 mrem/year. At 200 years the mean dose is 0.14 mrem/year with a minimum dose of 0.04 mrem/year and a maximum of 0.2 mrem/year. At 500 years the mean dose is 160 mrem/year with a minimum dose of 130 mrem/year and a maximum of

200 mrem/year. At 1,000 years the mean dose is 0.80 mrem/year with a minimum dose of 0.7 mrem/year and a maximum of 0.9 mrem/year. Table 7 contains a breakdown of total dose from the HLW tanks, SDA, and NDA for each time period.

We assume that the maximum concentration from Buttermilk Creek flows into Cattaraugus Creek and use the following equation to calculate the maximum possible concentration in Cattaraugus Creek. We further assume that the flow rate of the Cattaraugus Creek when it joins with the Buttermilk Creek is approximately 353 cubic feet per second.[195] The dose calculated for a Cattaraugus Creek receptor is calculated for the area close to where it joins with Buttermilk Creek.

$$C_{Cattaragus} = \frac{C_{Buttermilk} \times V_{Buttermilk}}{V_{Cattaraugus}}$$

We calculated two different scenarios when modeling the dose calculations to people that might drink water from Cattaraugus Creek. In the first we assumed that a fraction of 0.01 of the original amount of waste was released in the year 100, 1,000, 10,000, and 100,000 following closure. In the second we assume that the NDA, SDA, and HLW tanks continuously released a fraction of 0.01 of the remaining radioactivity each year following 100 years after closure. For this period, since much of the radioactivity would be released in the initial 1,000 years, the doses were calculated for the years 100, 200, 500, and 1,000.

For the first scenario, the following doses were calculated. The dose from Cattaraugus Creek at 100 years has a mean of 0.03 mrem/year with a minimum of 0.005 mrem/year and a maximum of 0.05 mrem/year. The dose for Cattaraugus Creek at 1,000 years has a mean of 2,880 mrem/year with a minimum of 2,770 mrem/year and a maximum of 3,010 mrem/year. The dose for Cattaraugus Creek at 10,000 years has a mean of 405 mrem/year with a minimum of 380 mrem/year and a maximum of 440 mrem/year. The dose for Cattaraugus Creek at 100,000 years has a mean of 31 mrem/year with a minimum of 29 mrem/year and a maximum of 33 mrem/year. Table 6 contains a breakdown of total dose from the HLW tanks, SDA, and NDA for each time period.

For the second scenario, the following doses were calculated. The dose for Cattaraugus Creek at 100 years has a mean of 0.03 mrem/year with a minimum of 0.005 mrem/year and a maximum of 0.05 mrem/year. At 200 years the mean dose is 0.02 mrem/year with a minimum dose of 0.005 mrem/year and a maximum of 0.03 mrem/year. At 500 years the mean dose is 21 mrem/year with a minimum dose of 17 mrem/year and a maximum of 26 mrem/year. At 1,000 years the mean dose is 0.10 mrem/year with a minimum dose of 0.09 mrem/year and a maximum of 0.12 mrem/year. Table 7 contains a breakdown of total dose from the HLW tanks, SDA, and NDA for each time period.

$$Collective\ Dose_{Lake\ Erie} = C_{Cattaraugus} \times DCF \times DR \times Population$$

The population doses for Lake Erie were calculated as described below. We conservatively assume that the concentration at this point is the one consumed by Lake

[195] US DOE and NYSERDA, 1996

Erie water users. We assume that the population is a triangular distribution with the minimum population of 350,000 people that was included in the 1996 DEIS and a maximum of 402,000 people as was included in the 2005 DEIS for the Sturgeon Point Treatment Plant (we did not include the population using water from the Van de Water Treatment Plant with a water intake on the Niagara River).

The flow rate of the Cattaraugus Creek discharging into Lake Erie (minimum of 250, mean of 750, and maximum of 1,587 cubic feet per second[196]) is greater than that utilized by both the Sturgeon Point Treatment Plant (106 cubic feet per second[197]). The flow rates of Cattaraugus Creek are from the US Geological Survey sampling point near Gowanda, which is in close proximity to the outfall into Lake Erie. The minimum, mean, and maximum rates come from the averages taken of the monthly averages from the year 1940 through the present.

In order to account for dilution we utilize a range, with a minimum, mean, and maximum of factors. We assume that the near-shore current has a minimum equivalent to the outflow of Cattaraugus Creek, a mean of 10,000 cubic feet second, and a maximum of 26,000 cubic feet per second. We use the ratio of the near-shore current to the outflow of Cattaraugus Creek for our maximum dilution factor. We use the ratio of the intake of the Sturgeon Point Treatment Plant (106 cubic feet per second) to the maximum outflow of Cattaraugus Creek for the minimum dilution factor. For the mean dilution factor we take the mean of two ratios: the ratio of the mean near-shore current to the mean outflow of Cattaraugus Creek and the ratio of the Sturgeon Point intake flow rate to the mean outflow of Cattaraugus Creek. The calculations are an underestimate in that they do not consider the accumulation of radionuclides in the lake or a large storm event, such as a "first flush" storm, as discussed in Appendix A.

We do not presume that any of the radionuclides entering the water treatment plant are filtered out, although this may occur, resulting in a lower dose. A 2001 study in Sweden found that uranium, thorium (except 232), plutonium, and polonium were all greatly reduced after treatment with precipitation, rapid-filtration, and slow filtration. The removal efficiency for uranium appears to be dependent upon pH level. Cesium, radium, and strontium were not reduced by filtration.[198] According to Joshi it is thought that americium and plutonium are primarily removed in the filtration process because of their ability to easily hydrolyze and due to their strong affinity for particulate matter. The report by Joshi also concurs that radionuclides such as strontium-90, a shorter-lived radionuclide, will largely pass through the filtration process without being removed and will reach water users.[199, 200] The floc/sludge that is contaminated during the filtration process must eventually be disposed of, presenting a further source of radioactive

[196] USGS, 2008
[197] Erie County Water Authority, 2006
[198] Gafvert, T, C Ellmark, and E Holm, 2002
[199] Joshi, SR,1988a
[200] Joshi, SR, 1988b

materials. Water taken into the Sturgeon Point Water Treatment Plant is cleaned through the following steps.[201]

- Passing through a screen to remove debris
- The addition of polyaluminum chloride, a coagulant to produce a by-product of floc
- Passing through flocculation basins to enlarge the floc
- Passing through a sedimentation basin where the floc is settled out and removed
- Filtration through sand, gravel, coal, and anthracite to remove remaining particles
- And finally with the addition of chlorine to kill germs

A 1997 article by Raghu et al. discussed the possibility of mixing sedimentation residuals from the Sturgeon Point Water Treatment Plant with natural top soil to produce fill for land application.[202] This is of particular importance because floc at this plant will contain accumulated radionuclides. While this is the current state of water treatment plants, we cannot predict the technologies used in or existence of future water treatment plants. EDTA is also within the SDA, and so its release in conjunction with the radionuclides may aid some radionuclides in passing through the treatment processes. Given that the US EPA recommends that institutional controls not be assumed to exist longer than 100 years, we do not utilize a reduction factor for water going through the treatment plant.

We used two different scenarios when modeling the dose calculations to people that might drink water from Lake Erie. In the first we assumed that a fraction of 0.01 of the original amount of waste was released in the year 100, 1,000, 10,000, and 100,000 years in the future. In the second we assume that the NDA, SDA, and HLW tanks continuously release a fraction of 0.01 of the remaining radioactivity each year following 100 years in the future. For this period, since most of the radioactivity is released in the initial 1,000 years, doses were calculated for the years 100, 200, 500, and 1,000.

For the first scenario, the following doses were calculated. Population doses are presented with person-rem units, these are a measurement of the collective dose in rem that a specific population is exposed to over a certain time period. The units represent the product of the average dose per person times the number of people exposed. We also calculated the latent cancer fatalities (LCF) by multiplying the person-rem dose by 0.0005[203]. The LCF is an estimated number of cancer fatalities expected to occur from radiation exposure in a given population. In our calculations the LCF values, unless specified otherwise, only pertain to the cancer fatalities that would occur as a result of radiation population dose in the specified year. The Lake Erie population doses and LCFs can be found in Table 8. The calculated mean population dose at 100 years would be 0.25 person-rem with a minimum of 0.01 person-rem and a maximum of 8 person-rem (Figure 23). The LCF range for that time is 0.000004-0.004. The calculated mean dose at 1,000 years is 28,700 person-rem with a minimum of 2,710 person-rem and a maximum of 1,260,000 person-rem (Figure 24). The LCF range for that time is 1.4-628. The calculated

[201] Erie County Water Authority, 2006
[202] Raghu, D, HN Hsieh, SC Basim, and M Morgan, 1997
[203] US DOE and NYSERDA, 1996

mean population dose at 10,000 years is 4,040 person-rem, with a minimum of 370 person-rem and a maximum 170,000 person-rem (Figure 25). The LCF range for that time is 0.2-85. The calculated mean population dose at 100,000 years is 3,010 person-rem, with a minimum of 28 person-rem and a maximum of 13,200 person-rem (Figure 26). The LCF range for that time is 0.01-7.

For the second scenario, the following doses were calculated. The calculated mean population dose at 100 years would be 0.25 person-rem with a minimum of 0.01 person-rem and a maximum of 8 person-rem (Figure 27). The LCF range for that time is 0.000004-0.004. The calculated mean dose at 200 years is 0.2 person-rem with a minimum dose of 0.01 person-rem and the maximum of 9 person-rem (Figure 28). The LCF range for that time is 0.000005-0.004. The calculated mean dose at 500 years is 200 person-rem with a minimum dose of 19 person-rem and the maximum is 8,710 person-rem (Figure 29). The LCF range for that time is 0.01-4. The calculated mean dose at 1,000 years is 1 person-rem with a minimum dose of 0.1 person-rem and the maximum is 41 person-rem (Figure 30). The LCF range for that time is 0.00005-0.02. Table 9 contains a breakdown of total dose from the HLW tanks, SDA, and NDA for each time period.

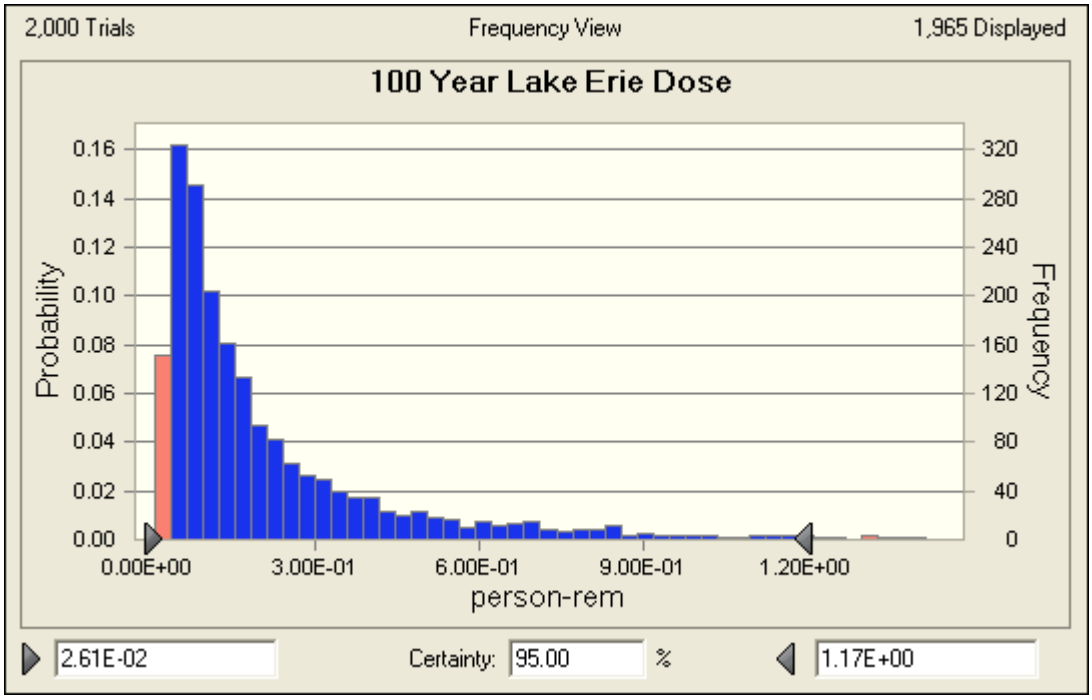


Figure 23. Lake Erie Population Dose to Sturgeon Point Water Users at 100 Years

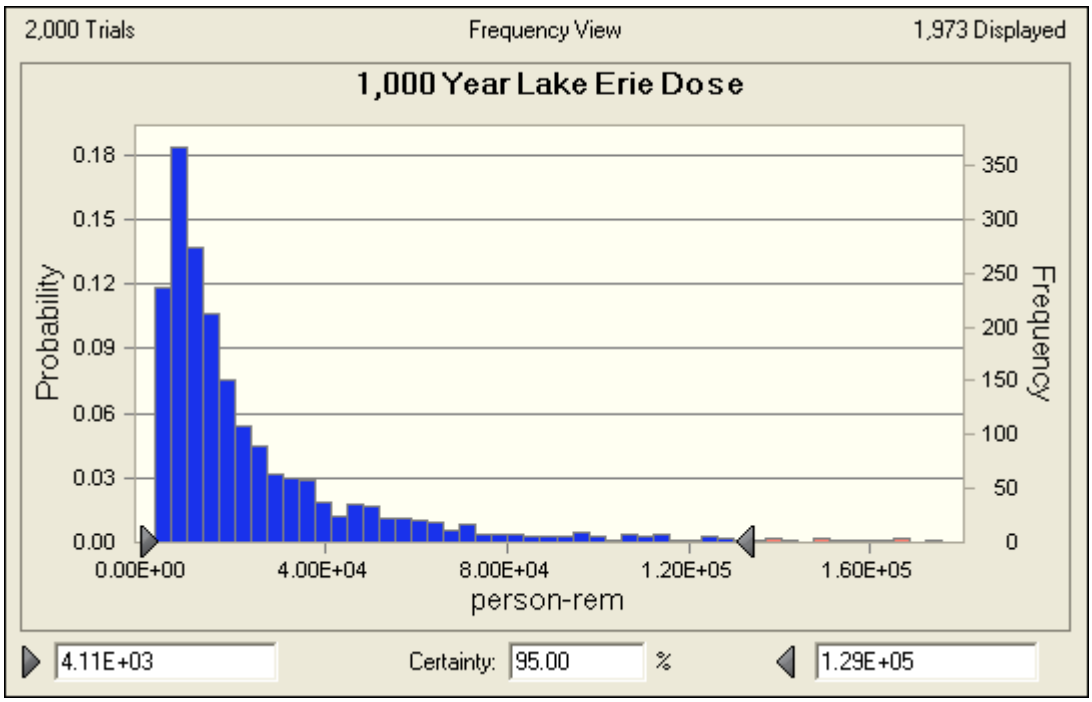


Figure 24. Lake Erie Population Dose to Sturgeon Point Water Users at 1,000 Years

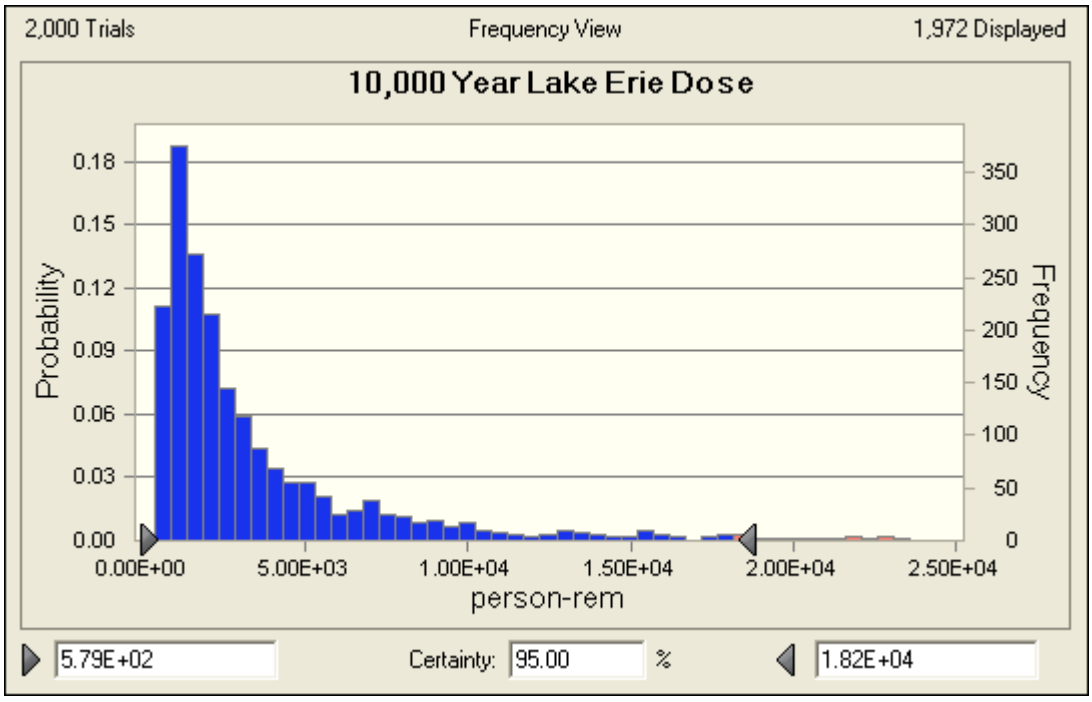


Figure 25. Lake Erie Population Dose to Sturgeon Point Water Users at 10,000 Years

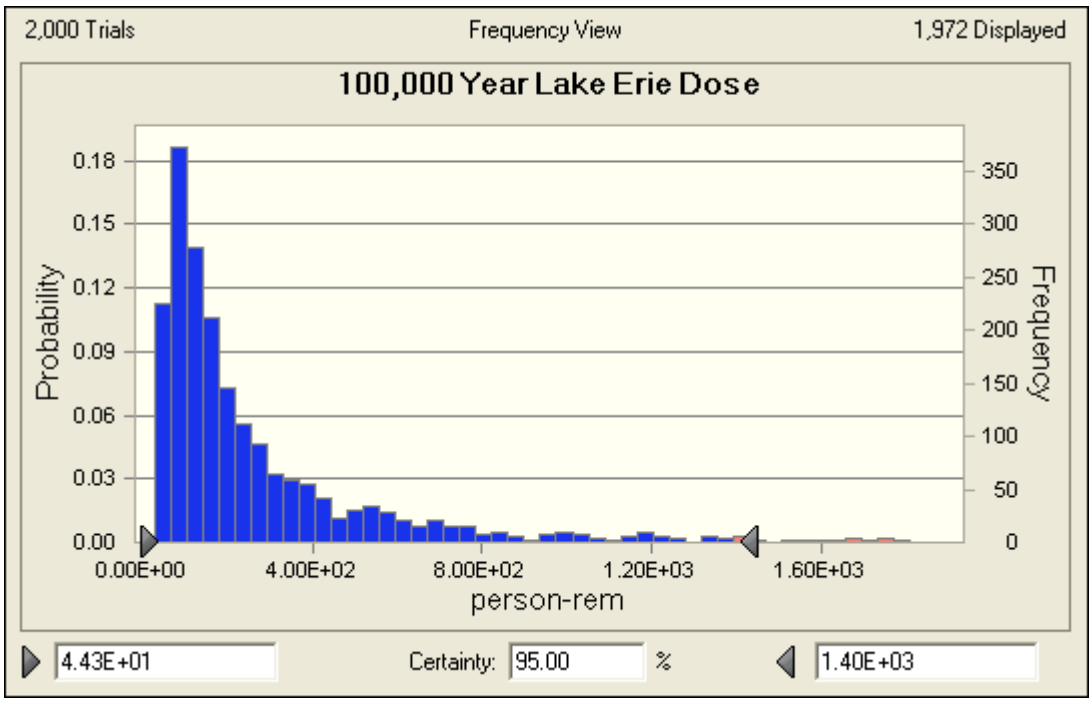


Figure 26. Lake Erie Population Dose to Sturgeon Point Water Users at 100,000 Years

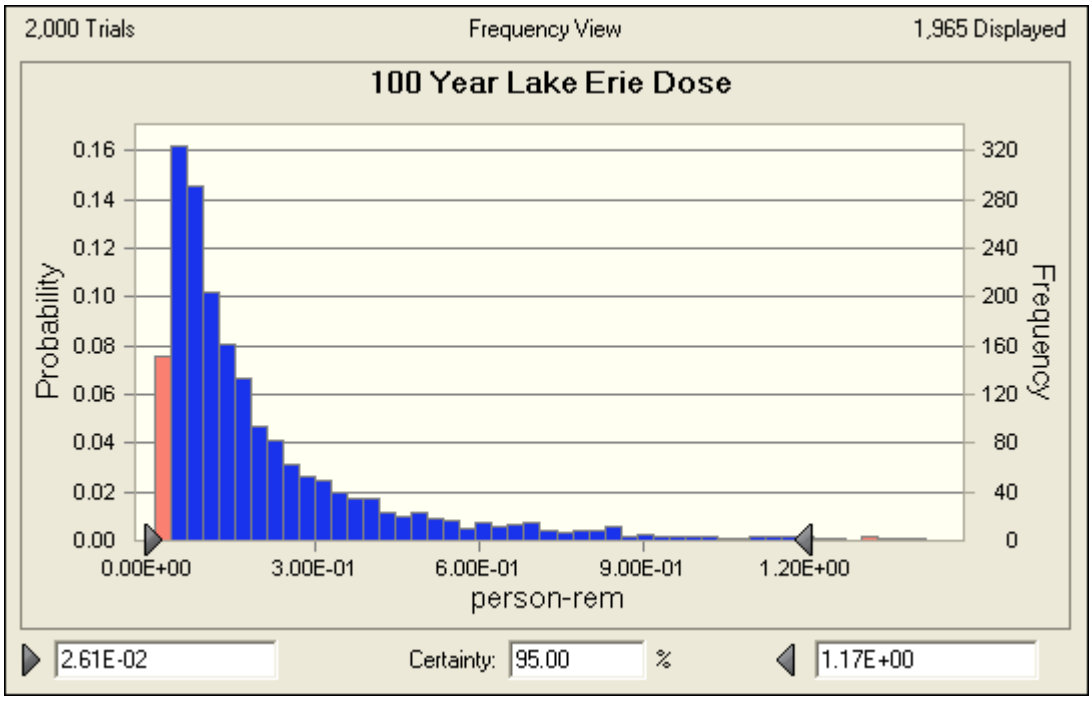


Figure 27. Lake Erie Population Dose to Sturgeon Point Water Users 100 Years After Continuous Release Beginning in 2108

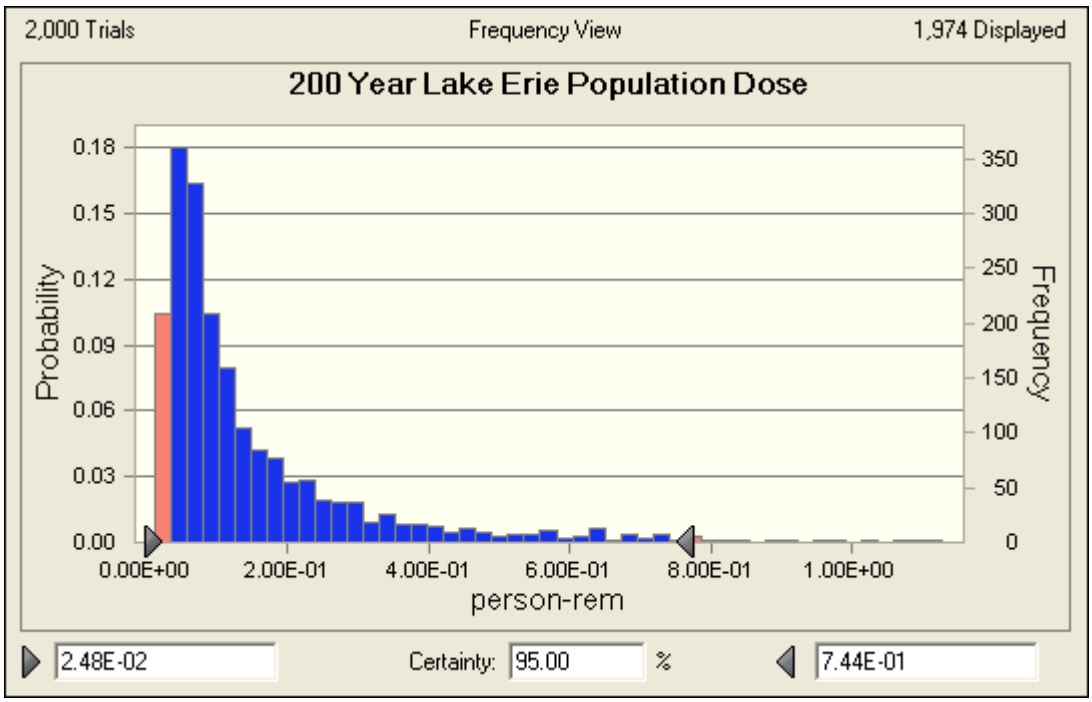


Figure 28. Lake Erie Population Dose to Sturgeon Point Water Users 200 Years After Continuous Release Beginning in 2108

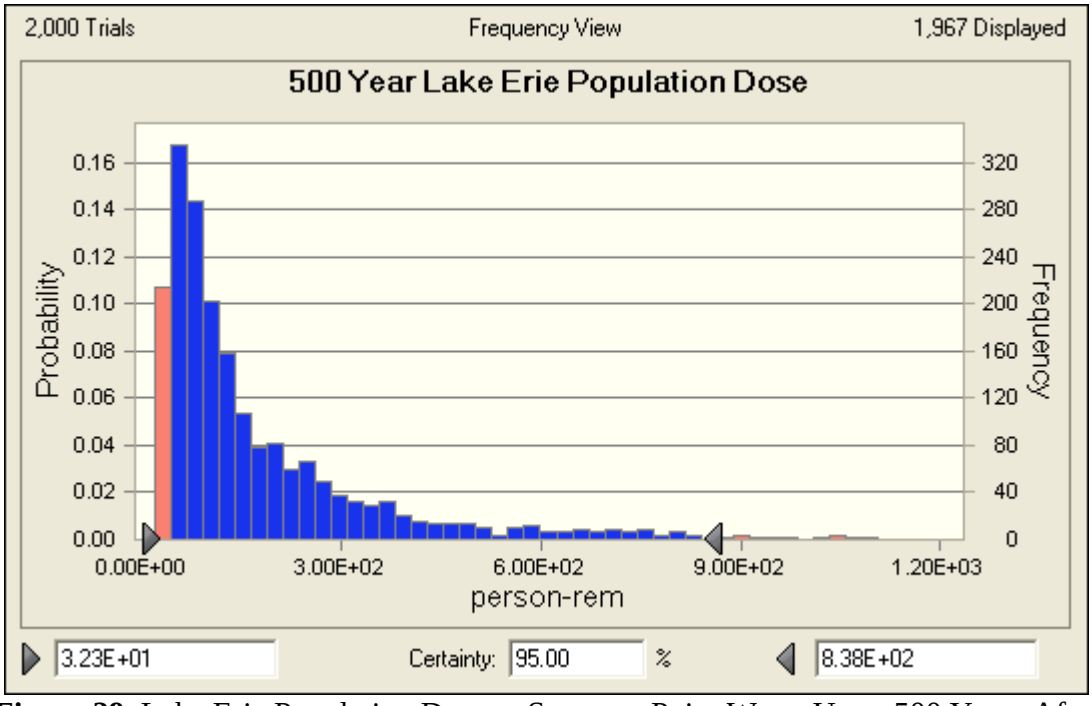


Figure 29. Lake Erie Population Dose to Sturgeon Point Water Users 500 Years After Continuous Release Beginning in 2108

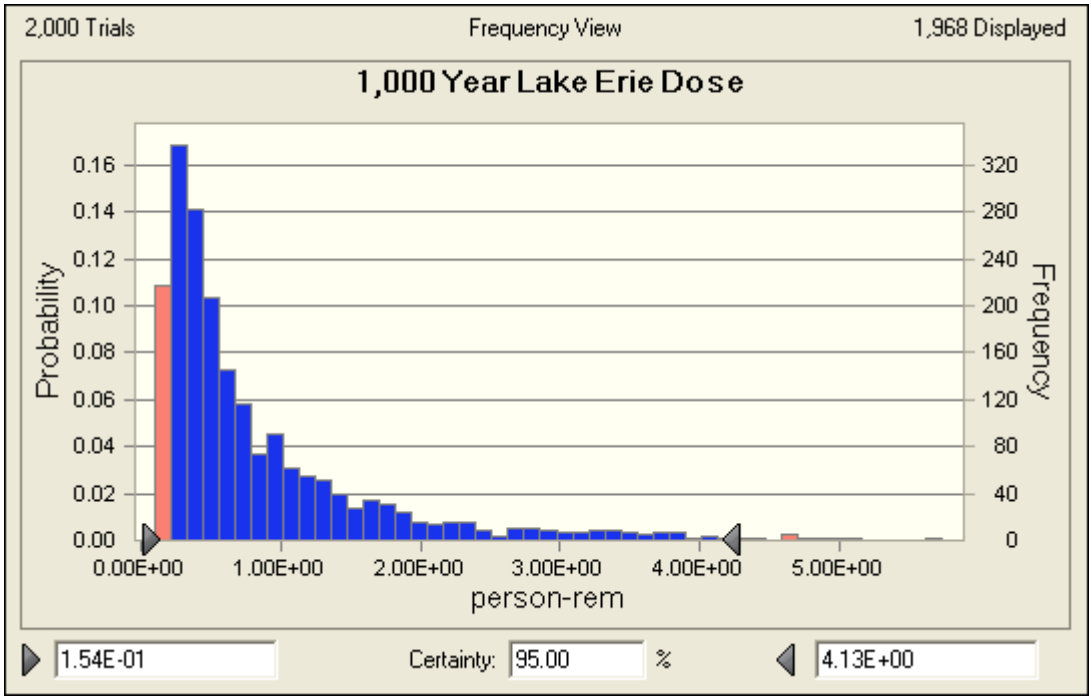


Figure 30. Lake Erie Population Dose to Sturgeon Point Water Users 1,000 Years After Continuous Release Beginning in 2108

The total Sturgeon Point population dose from Lake Erie through 1,000 years based on our assumptions is within the range of 12,890 - 334,320 person-rem at the 5th and 95th-percentile range (Figure 31). We calculated this by plotting the population doses at 100, 200, 500, and 1,000 years assuming continuous release from the site and assuming that the change over the time periods was linear, and then finding the area below the curve for the period between 0 - 1,000 years. Following the LCF methodology presented in the 1996 DEIS, we assume the 0.0005 conversion factor for each person-rem[204], and find a total LCF range of 6 - 167. We also employ a methodology in which we assume a conversion factor of 0.001 for each person-rem; this yields a total LCF range of 13 – 334.

We provide both ranges of LCFs because at high acute doses the conversion factors recommended for the calculation of LCFs are doubled. BEIR VII employs a dose and dose rate effectiveness factor[205] (DDREF), lowering the risk to dose ratio at both the high end and at the low end by a factor of 1.5.[206] The theory, and it is just a theory, is that at the low end, cells may repair themselves. More recent Japanese atomic bomb survivor studies have found an increased excess relative risk at low doses.[207] In fact, the data show a statistically significant greater excess relative risk per Sv at lower doses than at higher doses. These results are consistent with the 15-country worker study.[208] Use of the DDREF at the low dose end runs counter to the Japanese bomb survivor data and is

[204] US DOE and NYSERDA, 1996
[205] DDREF is defined as the reduction in radiation cancer risk associated with low dose or low dose rates of radiation.
[206] National Academy of Sciences, 2005
[207] Pierce DA et al., 1996
[208] Cardis E et al., 2005

clearly wrong. Use of this hypothetical DDREF in BEIR VII reduces the risk to dose estimate. BEIR VII, on the other hand, dismisses the hormesis theory and does not yet recognize the clear epidemiological data from Japanese bomb survivors that the excess relative risk per Sv at low doses is greater than at high doses, and incorporated a DDREF factor.

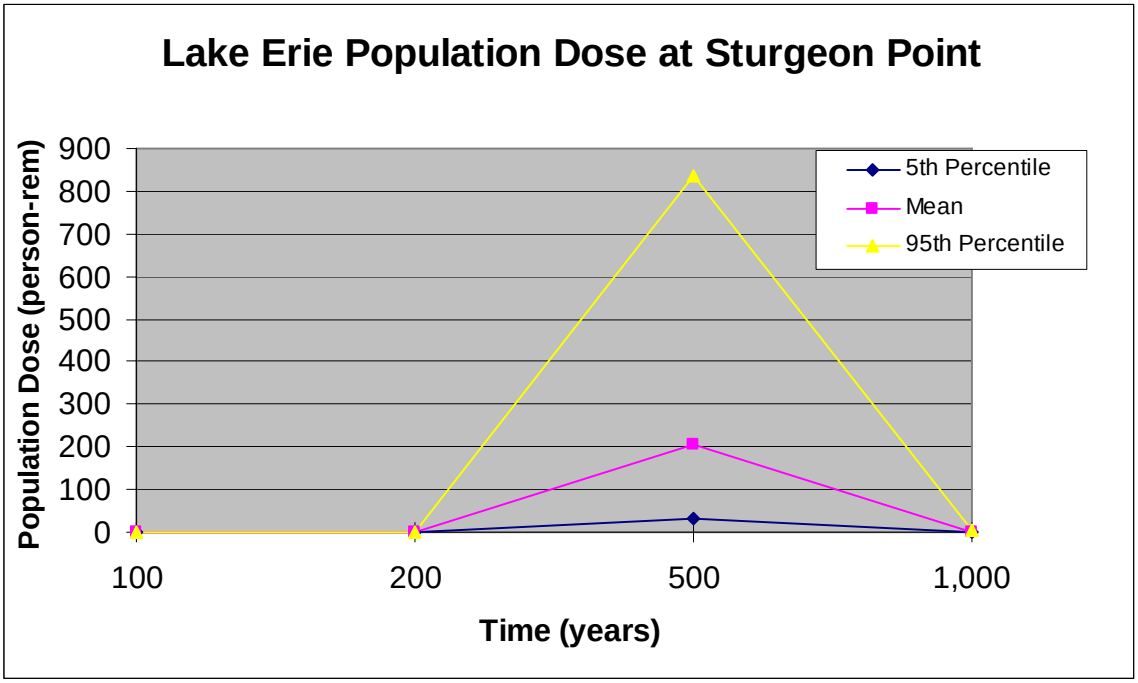


Figure 31. Lake Erie Population Dose (person-rem) to Sturgeon Point Water Users through 1,000 Years

These values, while calculated in a simplified manner to demonstrate the level of doses that could occur purely as a result of a leak during one year or continually over a period of 1,000 years. These doses are only based upon drinking contaminated water, and do not include the buildup of radionuclides that would occur over time or the consumption of contaminated fish. They do not include additional exposure pathways or diffusion related radionuclide migration. The results do clearly show the extreme risk is posed by in-place closure of the HLW tanks, SDA, and NDA as well as the need for release from cracking to be included in the final environmental impact statement.

Uncertainty

There are multiple uncertainties associated with these calculations as discussed below. It should be noted that these doses are not to serve as conclusive doses, but as evidence for why additional calculations should be included in the FEIS to include additional factors, such as high erosion rates, tank corrosion, vault cracking, and access to the public. The 2005 DEIS is woefully lacking in realistic assumptions.

These calculations are simplified based upon one dimensional input of contamination from one year at the HLW tanks, SDA, and NDA. These calculations do not include

transport of contamination due to diffusion through the concrete or vertical transport to the lower aquifer.

They calculated doses only include exposure from the ingestion of drinking water and do not include exposure resulting from irrigation or the ingestion of animal products, wildlife, and fish. In addition, they do not include the inhalation exposure one might receive when the creeks have minimal flow and soil containing radionuclides are raised as dust.

We make the assumption that 0.01 fraction is released from a vault crack each year. The actual released activity may be lower of higher, but based upon the 1982 FEIS, it is the best estimate for release through a vault crack that we have. As we do not have information on the amount of activity likely to be released from the NDA and SDA we assume that a fraction of 0.01 of the total activity in the NDA and SDA are released into the groundwater for one year. As is discussed earlier this value is uncertain and will in reality fluctuate greatly. The value used serves as an estimate of a potential future scenario. These values are meant to serve as an estimate of the potential contamination that will result from leaving the NDA and SDA in place. It is entirely possible that in the event of erosive forces and the breakdown of institutional controls that the amount of activity leaving the NDA and SDA will be much higher. In addition, the activity released during large storm events may also be much higher. These storm events will flush accumulated radionuclides in the streambeds into Lake Erie.

The dilution factors implemented are based on the best available information we have and serve to bound the risk to those drinking water from the Sturgeon Point Treatment Plant.

While we did not include a stochastic process within our calculations, it should be taken into account that the events leading to contamination from West Valley are stochastic and there is no one future scenario that will, with any great deal of certainty, occur. Thus the potential doses should be recognized to vary even more substantially than demonstrated in our calculations which used a range of values when possible.

Recommendations

We question the ability of the groundwater modeling in the 2005 DEIS to adequately describe potential radionuclide migration due to the sand lenses prevalently scattered throughout the site and changing hydrology as erosion transpires. One of the higher reported groundwater velocities should be used in this model to account for the discontinuities, which are often minimized in discussions of the local subsurface hydrology, within the aquifer. As is discussed in Appendix A, there are many volatile potential erosion and groundwater aspects (such as seeps) that cannot fully be modeled with any great accuracy for thousands of years. Appendix A states that erosive factors at the West Valley site include gulley head advancement, stream down-cutting, stream side cutting, landslides from stream down-cutting and side cutting, and sapping (when groundwater comes out of a slope causing erosion) Further forces may amplify erosion -

such as climate change, increased sapping, groundwater movement changes, deforestation, and increased impervious surface area.

We recommend that the doses considered in the final EIS be re-calculated to reflect reasonable erosion scenarios and realistic engineered barrier lifetimes. Engineered barriers (concrete walls, CLSM, grout, slurry walls, geomembranes, etc.) do not perform to the level anticipated, and their lifespan is insufficient to contain the long-lived radionuclides present in the tanks, SDA, and NDA. As is the case with both municipal and hazardous waste landfills, one of the primary ways of blocking an exposure pathway is to place an engineered barrier beneath the tanks and not just in the area above and surrounding it, although this was never done for the HLW tanks, SDA, or NDA.[209] Who will replace the barriers and maintain stringent erosion control at West Valley Nuclear Waste Site into perpetuity? What is the contingency plan for the inevitable failure of these barriers? What if failure occurs 500, 1,000, 5,000, 10,000, or even 50,000 years in the future; can a contingency plan even begin to include the tremendous unknowns that will exist at that point?

We must emphasize that the waste in the HLW tanks is high-level, and thus should not be disposed of via surficial burial, let alone in an area that will experience high erosion with runoff, groundwater, and surface water eventually traveling to Lake Erie. It is quite clear that when realistic erosion modeling and release pathways of the tanks, SDA, and NDA are considered that the risk over the long-term to receptors is significant and unacceptable.

Further calculations should be conducted to include the aforementioned factors. They should also include, not just diffusion through the CLSM and vault, but radionuclide activity release through cracks in the vault. It should be continued to assume that the tanks immediately fail given their life expectancy, which will be surpassed before any closure activities begin, and corrosion. The vaults have already experienced some cracking, and thus it should be assumed that radioactivity begins to escape through cracks, as well as via diffusion, soon after closure.

Radionuclides released from the low-level waste areas of West Valley Nuclear Waste Site have been detected in Lake Ontario, and are assumed to have traveled through Lake Erie to reach Lake Ontario.[210] In 1988 cesium-137 consistent with discharges from West Valley Nuclear Waste Site was detected in Lakes Ontario; a study found that the majority of the cesium-137 deposited in the sediments of Lake Ontario after flowing through Lake Erie and the Niagara River was from West Valley Nuclear Waste Site. Controlled releases of radioactive waste have occurred in the drainage system of West Valley Nuclear Waste Site; the average amount of strontium-90 released during 1969 through 1971 exceeded the US EPA's drinking water standard and the US NRC's technical specification.[211] Any release will reach these lakes and a large number of people, both Americans and Canadians, within the public that rely on the lake as their municipal water

[209] National Research Council, 2001
[210] Ahier, BA and BL Tracy, 1995
[211] Joshi, SR, 1988a

source. The location of West Valley Nuclear Waste Site makes it critical that the long-term impacts to the public are fully considered when choosing a final closure strategy.

We disagree with the redefinition of HLW in the tanks as WIR. Whereas HLW has to be disposed of at a safe geologic storage facility, WIR would be left on-site as a form of final disposal. The declaration process for WIR by evaluation and the risk assessment undertaken by DOE are linked, that is, the DEIS most coincidentally shows that re-labeling waste as WIR, is less costly and the health effects are magically reduced by this redefinition.

We recommend that Alternative 1 is selected from the 2005 DEIS. In-place closure of the HLW tanks or NDA and SDA is not appropriate. To ensure the safety of current and future residents in the area these tanks and disposal areas should be removed. The integrity of the vaults and tanks has been overstated since the beginning of their operation. In more recent documents past stress and damage to Tanks 8D-1 and 8D-2 and their associated vaults have been minimized and de-emphasized. In fact, if one were to only read recent documents from the 1990s and 2000s, a reader might not realize that the vaults are not level, have cracks, endured heavy stress prior to operation, and that the containment pan for Tank 8D-2 contains a leak in an unknown area. In addition, the removal of these tanks could serve as a step in the development of final disposal plans for the numerous underground HLW tanks within the US at Savannah River and Hanford. The removal and analysis of the activity remaining in the tanks would be instrumental in characterization of HLW remaining in tanks at both Savannah River and Hanford. Only Alternative 1 would also lead to the removal of buried waste in the SDA and NDA, which is imperative. Radioactive wastes cannot remain in these areas because it has and will continue to lead to groundwater contamination. Covering with a geomembrane followed by a multilayered barrier after 100 years, grout injection, or coverage with only a replaceable geomembrane are not acceptable final closure strategies.

The EPA and DOE have begun discussions on adding an additional preferred alternative to the DEIS. This alternative would involve removal of the process buildings, all structures (except for the HLW tanks), and contaminated soil on the North Plateau for unrestricted release or release with restrictions to achieve 25 mrem/year and management of the tanks and NDA with periodic reviews (likely on a five year cycle) to identify long-term technically and economically feasible solutions for implementation at a later date. This alternative would involve reducing the remaining liquid in the HLW tanks.[212, 213] This alternative is not acceptable; it does not offer a final closure solution for the HLW tanks or NDA. It allows for the tanks to be kept in the ground indefinitely because it is not a "final" solution. In the event that this modified alternative is utilized it is important to remember that no CLSM and grout would be added to the tanks to slow diffusion or leakage through the tank and vault into groundwater. The tanks have already reached or are approaching their life expectancy of 40 to 50 years and are corroding. The vaults were stressed prior to operation, contain cracks, and have likely experienced continuous stress

[212] US EPA, 2007
[213] US DOE, 2007a

by their tilted settled placement. As was discussed above it is our opinion that it is not acceptable to leave the tanks in place; they must be removed.

Although we disagree with both the 1996 and 2005 DEIS dose assumptions on several points, the doses calculated in both do exceed 25 mrem/year in several of the scenarios that we consider likely to occur (loss of institutional control and loss of erosion control). This especially apparent within the 1996 DEIS, and we consider some of the loss of institutional control scenarios as being extremely likely to occur. The addition of a release pathway through cracks in the CLSM, grout, and vaults of the HLW tanks would likely magnify the doses.

References

Ahier, BA and BL Tracy. 1995. Radionuclides in the Great Lakes Basin. Environmental Health Perspectives. Vol. 103, Supplement 9, pp: 89-101. December.

Battelle, Prepared for the US Department of Energy (DOE). 1979. Preliminary Environmental Implications of Alternatives for Decommissioning and Future Use of the Western New York Nuclear Services Center. BMI-X698(Rev.).

Bechtel SAIC Company. 2007. Recommended Values for HLW Glass for Consistent Usage on the Yucca Mountain Project. 000-00A-MGR0-00200-000-00A.

Bejaoui, S, J Sercombe, C Mugler, and H Peycelon. 2007. Modeling of Radionuclide Release from a Concrete Container. Transport in Porous Media. Vol. 69, No. 1. August.

Cardis, E et al. 2005. Risk of Cancer after Low Doses of Ionising Radiation : Retrospective Cohort Study in 15 Countries. British Medical Journal, June 29.

Chem-Nuclear Systems, Inc. 1991. Illinois Low-Level Radioactive Waste Disposal Facility. License Application to Illinois Department of Nuclear Safety.

Erie County Water Authority. 2006. Providing Water You Can Trust. Website URL: http://www.ecwa.org/brochures/Who%20We%20Are.pdf, Accessed April 2, 2008.

Gafvert, T, C Ellmark, and E Holm. 2002. Removal of Radionuclides at a Waterworks. Journal of Environmental Radioactivity. Volume 63 (2): 105-115.

Hemond, HF and EJ Fechner-Levy. 2000. Chemical Fat and Transport in the Environment. 2nd Edition. Academic Press: San Diego, CA.

HydroGeoLogic, Inc., Prepared for US DOE. 1991. Ground-Water Flow and Transport Modeling of the NRC-Licensed Waste Disposal Facility, West Valley, New York. NUREG/CR-5794.

Idaho National Engineering Laboratory, Prepared for US NRC. 1990. NUREG/CR-5542: Models for Estimation of Service Life of Concrete Barriers in Low-Level Radioactive Waste Disposal.

International Commission on Radiological Protection (ICRP). 2005. Low-Dose Extrapolation of Radiation Related Cancer Risk. ICRP Publication 99, Vol. 35, No. 4.

Joshi, S.R. 1988a. West Valley - Derived Radionuclides in the Niagara River Area of Lake Ontario. Water, Air, and Soil Pollution. Vol. 37, No 1-2, pp: 111-120. January.
Joshi, S.R. 1988b. West Valley Plutonium and Americium-241 in Lake Ontario Sediments off the Mouth of the Niagara River. Water, Air, and Soil Pollution. Vol. 42, pp: 159-168.

Lawrence Livermore Laboratory. 1978. Seismic Analysis of High Level Neutralized Liquid Waste Tanks at the Western New York State Nuclear Service Center, West Valley, New York. May.

McClure, LW, JC Henderson, and MR Elmore, for Jacobs Engineering Group Inc. and Pacific Northwest National Laboratory. 2002. Evaluation of West Valley High-Level Waste Tank Lay-Up Strategies.

National Academy of Sciences. 2005. Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2 (Committee of the Biological Effects of Ionizing Radiation), National Academy Press.

National Council on Radiation Protection and Measurements (NCRP). 2001. Evaluation of the Linear- Nonthreshold Dose-Response Model for Ionizing Radiation. NCRP Report No. 136.

National Institute of Standards and Technology, Prepared for US DOE. 1989. Service Life of Concrete, NUREG/CR-5466, NISTIR 89-4086.

National Research Council, Committee on the Management of Certain Radioactive Waste Streams Stored in Tanks at Three Department of Energy Sites. 2006. Tank Waste Retrieval, Processing, and On-Site Disposal at Three Department of Energy Sites: Final Report.

National Research Council. 2001. Research Needs for High-Level Waste Stored in Tanks and Bins at U.S. Department of Energy Sites.

New York State Energy Research and Development Authority (NYSERDA). 2004. West Valley Nuclear Service Center (The West Valley Site). Website URL: http://www.nyserda.org/programs/West_Valley/default.asp.

NYSERDA. 2003. Answer to Questions from Utah's DEQ Julie Silotti on the West Valley Site. 6/27/03.

Nuclear Fuel Services, Inc (NFS). 1979. West Valley Quarterly Report for the period of October 1, 1978 to December 31, 1978.

NFS. 1974. Supplement No. 12 to Safety Analysis Report. January 10.

NFS. 1964. Final Safety Analysis Report for the Spent Fuel Reprocessing Plant.

Nuclear and Radiation Studies Board. 2006. Tank Waste Retrieval, Processing, and On-site Disposal at Three Department of Energy Sites: Final Report.

Oak Ridge National Laboratory (ORNL), R. Clapp and S. Herbes. 1985. Research Plan for Investigating Radionuclide Migration at the West Valley Facility Disposal Area.

Oztunali, OI and GW Roles, Prepared for the US NRC. 1986. Update of Part 61 Impacts Analysis Methodology. NUREG/CR-4370. Volume 1.

Pacific Northwest National Laboratory. 2001. West Valley Tank 8D-1 and 8D-2 Inventory Estimation Methodology. July.

Pierce, DA, et al. 1996. "Studies of the Mortality of Atomic Bomb Survivors. Report 12, Part I. Cancer: 1950-1990," Radiation Research. Volume 146, p. 9.

Portland Cement Association. 2008. Concrete Basics: Controlled Low-Strength Material. Website URL: http://www.cement.org/basics/concreteproducts_clsm.asp.

Raghu, D, HN Hsieh, SC Basim, and M Morgan. 1997. Physical Characterization of Water Treatment Plant Residual and Top Soil Mixtures. Testing Soil Mixed With Waste or Reycled Materials, ASTM STP 1275, MA Wasemiller, KB Hoddincott, eds, American Society for Testing and Materials.

Sierra Club. 1979. Review of the Nuclear Regulatory Commission Seismic Study of the NFS Neutralized High Level Waste Tank.

US Department of Energy (US DOE). 2008. United States Department of Energy West Valley Demonstration Project: High Level Waste Tank. Website URL: http://www.wv.doe.gov/highlevelwastetank.htm.

US DOE. 2007a. Letter from F. Marcinowski to W. Mugdan with the US EPA. April 17.

US DOE. 2007b. Presentation at October 24, 2007 CTF Meeting. Enhancements to the Interim End State. October 24.

US DOE. 2007c. DOE News: West Valley Demonstration Project Achieves Milestone, 11,088th Low-Level Cemented Waste Drum Shipped Offsite. Website URL: http://www.emcbc.doe.gov/files/news/Press%20West%20Valley%20Waste%20Drums%20Jul07.pdf. Accessed March 5, 2008. July 2.

US DOE. 2006. West Valley Demonstration Project Waste Management Environmental Impact Statement, Supplement Analysis. Revised Final. DOE/EIS-0337-SA-01.

US DOE and New York State Energy Research and Development Authority (NYSERDA). 2005. Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center. DOE/EIS-0226-R.

US DOE and West Valley Nuclear Services Company (WVNSCO). 2002. High-Level Waste Tank Cleaning and Field Characterization at the West Valley Demonstration Project.

US DOE and NYSERDA. 1996. Draft Environmental Impact Statement for Completion of the West Valley Demonstration Project and Closure of Long-Term Management of Facilities at the Western New York Nuclear Service Center. DOE/EIS-0226-D.

US DOE. 1982. Final Environmental Impact Statement: Long-Term Management of Liquid High-Level Radioactive Wastes Stored at the Western New York Nuclear Service Center, West Valley. June.

US Environmental Protection Agency (EPA). 2007. Letter from W. Mugdan to F. Marcinowski of the US DOE. March 1.

US EPA. 2007. 3DFEMWATER/3DLEWASTE Release Notes. Website URL: http://www.epa.gov/ceampubl/gwater/femwater/fwtrreln.htm.

US EPA. 2001. EPA On-Line Tools for Site Assessment Calculation. Website URL: http://www.epa.gov/athens/learn2model/part-two/onsite/ard_onsite.htm. Accessed March 5, 2008.

US EPA. 2006. Regional Administrator Talking Points, West Valley Demonstration Project, June 15, 2006 Meeting. June 6.

US EPA. 2002. 40 CFR 191.

US EPA. 1997. Exposure Factors Handbook.

US EPA. 1993. 40 CFR 190. Subpart B.

US EPA. 1987. Federal Register Notice. Volume 52, Number 186, Page 36100. Sole Source Aquifer Determination, Cattaraugus Creek Basin Aquifer System in Cattaraugus, Erie, Wyoming, and Allegany Counties, New York.

US EPA. 1985. 40 CFR 191. Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes.

Unite States Geological Survey (USGS). 2008. USGS Surface-Water Monthly Statistics for New York: USGS 04213500 Cattaraugus Creek at Gowanda, NY. Website URL: http://waterdata.usgs.gov/ny/nwis/monthly. Website Accessed June 26, 2008.

United States Government Accountability Office (US GAO). 2001. Nuclear Waste: Agreement Among Agencies Responsible for the West Valley Site is Critically Needed. May. GAO-01-314.

US GAO. 1980. Further Analysis of Issues at Western New York Nuclear Service Center. EMD-81-5. October 23.

US GAO. 1980. Status of Efforts to Clean Up the Shut-Down Western New York Nuclear Service Center. EMD-80-69. June 6.

US GAO. 1977. Issues Related to the Closing of the Nuclear Fuel Services, Incorporated, Reprocessing Plant at West Valley, New York. EMD-77-27. March 8.

US Nuclear Regulatory Commission (NRC). 2008. 10 CFR 63.

US NRC. 2007. 10 CFR 60.

US NRC. 1992. 10 CFR 61. Licensing Requirements for Land Disposal of Radioactive Waste.

WVNSCO and Gemini Consulting Company. 2005. West Valley Demonstration Project, Residual Radionuclide Inventory Estimate for the Waste Tank Farm, Supplemental Report. February 7.

WVNSCO and Innovative Waste Solutions. 2002. A West Valley Demonstration Project Milestone - Achieving Certification to Ship Waste to the Nevada Test Site.

WVNSCO and the US DOE. 2000. Waste Removal from the West Valley Demonstration Project High-Level Radioactive Waste Storage Tanks. January.

WVNSCO. 1998. Supplement Analysis II of Environmental Impacts Resulting from Modifications in the West Valley Demonstration Project. DOE/EIS-0081 Supplement.

WVNSCO. 1996. Environmental Compliance at the West Valley Demonstration Project: The Vitrification Permitting Program. May.

Westinghouse Savannah River Company. 2001. Functions and Requirements for the Leak Mitigation System of the Savannah River Site Double Shell High Level Waste Tanks. WSRC-TR-2001-00438, Rev. 1.

Wikipedia. 2008. Portland Cement. Website URL: http://en.wikipedia.org/wiki/Portland_cement.

Wilson, MP. 2007. Erosion and Control of Erosion at the West Valley Nuclear Site. November.

Zimmerman, E. 1987. Affidavit, Civ Act No 86-1052 c., January 20, 1987.

Table 1. Fuels Processed at WVDP[1]

Campaign	Source	Metric Ton Uranium (MTU)	Total Plutonium (kilograms)	Burnup (MWD/MTHM)
1	N-Reactor	19.7	1.7	75
2	N-Reactor	28.8	2.3	75
3	N-Reactor	46.7	50.9	1,287
4	Dresden 1	50	191	8,500
5	Yankee Rowe	49.8	285.1	11,200
6	N-Reactor	26.6	52.6	2,700
7	N-Reactor	26.1	47.4	2,700
8	N-Reactor	42.4	75.4	2,700
9	N-Reactor	38.8	79.1	2,850
10	N-Reactor	55.3	115.7	2,870
11[2]	Indian Point 1	16.5	--	13,650
12	N-Reactor	48.9	102.5	2,850
13	Yankee Rowe	19.6	175	20,500
14	N-Reactor	30.3	--	Unirradiated
15	Dresden 1	21.5	104.6	10,900
16	Indian Point 1	15.6	107.6	15,794
17	Yankee Rowe	9.3	95.6	24,381
18	Pathfinder	9.6	7.1	2,231
19	Big Rock Point	18.4	72.8	9,212
20	Indian Point 1	7.6	68.1	23,455
21	N-Reactor	15.8	25.4	2,868
	BoNus Superheater	1.7	0.9	1,552
22	BoNus Boiler	2.4	4	3,230
23	Humboldt Bay	20.8	87.2	10,466
24	Yankee Rowe	9.5	95.7	23,653
25	C-V Tube Reactor	3.5	11.6	9,783
26	Big Rock Point	5.8	27.9	13,567
27	SEFOR	--	95.5	--
TOTAL		**641**	**1,983**	

Notes:

1 - WVNSCO and Gemini Consulting Company. 2005. West Valley Demonstration Project, Residual Radionuclide Inventory Estimate for the Waste Tank Farm Supplemental Report.

2 - The value for MTHM from this campaign is for metric tons uranium plus thorium.

Table 2. Summary of High Level Waste Tank Inventory

Radionuclide	Half-Life (years)	1979[1]	Decayed to 2005[2]	2% of 2008 Value	20% of 2008 Value	1982[3,4]	Decayed to 2005[2]	2% of 2008 Value	20% of 2008 Value
H-3	12.32								
C-14	5,730								
Co-60	5.27								
Sr-90	28.9	7.70E+06	4.13E+06	8.26E+04	8.26E+05	6.60E+06	4.29E+06	8.57E+04	8.57E+05
Y-90	0.01	7.70E+06	4.13E+06	8.26E+04	8.26E+05	6.60E+06	4.29E+06	8.57E+04	8.57E+05
Zr-93	1,530,000					2.50E+02	2.50E+02	5.00E+00	5.00E+01
Nb-93m	16.13					2.40E+02	1.11E+02	2.22E+00	2.22E+01
Tc-99	211,100								
Ru-106	1	6.90E+04	1.03E-03	2.06E-05	2.06E-04	1.00E+02	3.82E-04	7.65E-06	7.65E-05
Rh-106	hours	6.90E+04				1.00E+02	0.00E+00	0.00E+00	0.00E+00
Pd-107	6,500,000					6.00E+00	6.00E+00	1.20E-01	1.20E+00
Cd-113m	14.1								
Sb-125	2.76					6.00E+03	6.52E+01	1.30E+00	1.30E+01
Sn-126	100,000					4.00E+01	4.00E+01	8.00E-01	8.00E+00
Sb-126	0.03					4.00E+01	1.38E-158	2.75E-160	2.75E-159
Sb-126m	0.03					4.00E+01	1.05E-179	2.11E-181	2.11E-180
I-129	15,700,000								
Cs-137	30.07								
Ce-144	1.00					1.10E+01	4.21E-05	8.41E-07	8.41E-06
Pr-144	1.44					1.10E+01	1.90E-03	3.80E-05	3.80E-04
Pm-147	2.62					6.00E+04	5.17E+02	1.03E+01	1.03E+02
Sm-151	90.00					2.00E+05	1.74E+05	3.48E+03	3.48E+04
Eu-152	13.52					4.10E+02	1.63E+02	3.26E+00	3.26E+01
Eu-154	8.59					1.30E+05	3.04E+04	6.09E+02	6.09E+03
Ra-226	1,602								
Ac-227	21.77								
Ra-228	6.70								
Th-229	7,340								
Pa-231	32,760								
Th-232	14,050,000,000								
U-232	68.9								
U-233	159,200								
U-234	245,500								
U-235	703,800,000					8.00E-02	8.00E-02	1.60E-03	1.60E-02
Np-237	2,144,000	2.33E+02	2.33E+02	4.66E+00	4.66E+01	2.30E+01	2.30E+01	4.60E-01	4.60E+00
U-238	4,468,000,000					8.20E-01	8.20E-01	1.64E-02	1.64E-01
Pu-238	88					1.50E+03	1.30E+03	2.60E+01	2.60E+02
Np-239	0.01					2.20E+02	0.00E+00	0.00E+00	0.00E+00
Pu-239	24,100	1.69E+03	1.69E+03	3.38E+01	3.38E+02	1.80E+03	1.80E+03	3.60E+01	3.60E+02
Pu-240	6,500	2.00E+03	1.99E+03	3.98E+01	3.98E+02	9.70E+02	9.68E+02	1.94E+01	1.94E+02
Pu-241	14	2.30E+05	6.34E+04	1.27E+03	1.27E+04	7.00E+04	2.87E+04	5.74E+02	5.74E+03
Am-241	432.2	1.43E+04	1.37E+04	2.74E+02	2.74E+03	2.00E+04	1.94E+04	3.89E+02	3.89E+03
Am-242, -242m	141	6.84E+02	6.02E+02	1.20E+01	1.20E+02	3.60E+02	3.30E+02	6.59E+00	6.59E+01
Am-243	7,370	4.71E+02	4.70E+02	9.40E+00	9.40E+01	2.20E+02	2.20E+02	4.39E+00	4.39E+01
Cm-243	29.1	3.37E+02	1.81E+02	3.63E+00	3.63E+01				
Cm-244	18.1	3.03E+04	1.12E+04	2.24E+02	2.24E+03	8.80E+03	4.42E+03	8.84E+01	8.84E+02
Cm-245	8,500	2.70E+01	2.69E+01	5.39E-01	5.39E+00	1.00E+00	9.99E-01	2.00E-02	2.00E-01
Cm-246	4,730	4.40E+00	4.38E+00	8.77E-02	8.77E-01				
Total Rare Earths		1.69E+06	1.69E+06	3.38E+04	1.69E+06				
Other Fission Products		2.40E+03	2.40E+03	4.80E+01	2.40E+03				
TOTAL ACTIVITY		**1.75E+07**	**1.00E+07**	**2.01E+05**	**3.36E+06**	**1.37E+07**	**8.84E+06**	**1.77E+05**	**1.77E+06**

Notes:

1 - Battelle, Prepared for US DOE. 1979. Preliminary Environmental Implications of Alternatives for Decommissioning and Future Use of the Western New York Nuclear Services Center. BMI-X698(Rev.).

2 - Calculated using radioactive decay equation of $A = A_0 e^{-\lambda t}$, where λ is equal to $Ln(2)/t_{1/2}$

3 - US DOE. 1982. Final Environmental Impact Statemetn for Long-Term Management of Liquid High-Level Radioactive Wastes Stored at the Western New York Nuclear Service Center, West Valley. DOE/EIS-0081.

4 - The 1982 inventory of radionuclides was estimated as of 1987.

5 - US DOE and NYSERDA. 1996. Draft Environmental Impact Statement for Completion of the West Valley Demonstration Project and Closure of Long-Term Management of Facilities at the Western New York Nuclear Service Center. DOE/EIS-0226-D.

6 - The 1996 DEIS inventory of radionuclides was estimated as of 2000.

7 - US DOE and NYSERDA. 2005. Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center. DOE/EIS-0226-R.

Table 2. Summary of High Level Waste Tank Inventory - Continued

Radionuclide	Half-Life (years)	Tank 8D-1			Tank 8D-2			Tank 8D-3	Tank 8D-4		
		1996 DEIS[5]	Decayed to 2005[2,6]	2005 DEIS[7]	1996 DEIS[5]	Decayed to 2005[2,6]	2005 DEIS[7]	2005 DEIS[7]	1996 DEIS[5]	Decayed to 2005[2,6]	2005 DEIS[7]
H-3	12.32				1.00E+00	7.55E-01			1.00E-02	7.55E-03	
C-14	5,730			2.00E-02	4.00E+00	4.00E+00	2.70E-03	1.50E-05	2.00E-02	2.00E-02	1.00E-02
Co-60	5.27				6.00E+00	3.11E+00			7.00E-05	3.63E-05	
Sr-90	28.9	4.00E+02	3.55E+02	2.30E+03	2.00E+05	1.77E+05	3.40E+04	7.80E-01	9.00E+02	7.98E+02	5.00E+03
Y-90	0.01										
Zr-93	1,530,000										
Nb-93m	16.13										
Tc-99	211,100			5.40E+00	5.00E+01	5.00E+01	2.90E+00	1.50E-02	3.00E-01	3.00E-01	2.90E-01
Ru-106	1										
Rh-106	hours										
Pd-107	6,500,000										
Cd-113m	14.1				4.00E+01	3.13E+01			3.00E-04	2.35E-04	
Sb-125	2.76				2.00E+01	5.69E+00			4.00E-05	1.14E-05	
Sn-126	100,000				3.00E+00	3.00E+00			2.00E-03	2.00E-03	
Sb-126	0.03										
Sb-126m	0.03										
I-129	15,700,000			6.80E-03	1.00E-02	1.00E-02	3.80E-03	1.90E-05	2.00E-06	2.00E-06	3.20E-03
Cs-137	30.07	2.00E+05	1.78E+05	2.50E+05	2.00E+05	1.78E+05	8.60E+04	1.10E-01	1.00E+03	8.91E+02	2.20E+03
Ce-144	1.00										
Pr-144	1.44										
Pm-147	2.62										
Sm-151	90.00										
Eu-152	13.52										
Eu-154	8.59				1.00E+03	6.68E+02			1.00E+01	6.68E+00	
Ra-226	1,602				5.00E-06	4.99E-06					
Ac-227	21.77				2.00E-01	1.71E-01			1.00E-03	8.53E-04	
Ra-228	6.70				2.00E-02	1.19E-02			1.00E-04	5.96E-05	
Th-229	7,340				6.00E-03	6.00E-03			3.00E-05	3.00E-05	
Pa-231	32,760				5.00E-01	5.00E-01			2.00E-03	2.00E-03	
Th-232	14,050,000,000				5.00E-02	5.00E-02			3.00E-04	3.00E-04	
U-232	68.9			6.00E-01	2.00E-01	1.90E-01	1.20E-01	4.50E-03	6.00E-05	5.71E-05	1.90E-01
U-233	159,200			2.60E-01	3.00E-01	3.00E-01	5.90E-02	2.10E-03	8.00E-05	8.00E-05	4.40E-02
U-234	245,500			1.00E-01	1.00E-01	1.00E-01	2.20E-02	7.70E-04	6.00E-05	6.00E-05	3.20E-03
U-235	703,800,000			3.40E-03	3.00E-03	3.00E-03	1.10E-03	2.30E-05	2.00E-07	2.00E-07	1.40E-04
Np-237	2,144,000			2.30E-02	7.00E-01	7.00E-01	5.00E-01	2.70E-04	4.00E-03	4.00E-03	1.20E-02
U-238	4,468,000,000			3.10E-02	3.00E-02	3.00E-02	5.20E-03	2.00E-04	8.00E-06	8.00E-06	1.00E-04
Pu-238	88	8.00E+01	7.69E+01	5.60E+00	2.00E+02	1.92E+02	1.50E+02	1.00E-02	1.00E+00	9.61E-01	2.00E+01
Np-239	0.01										
Pu-239	24,100	2.00E+01	2.00E+01	1.50E+00	5.00E+01	5.00E+01	3.60E+01	2.70E-03	3.00E-01	3.00E-01	6.40E-01
Pu-240	6,500			1.10E+00	4.00E+01	4.00E+01	2.60E+01	1.90E-03	2.00E-02	2.00E-02	3.20E-01
Pu-241	14	6.00E+02	4.68E+02	4.40E+01	2.00E+02	1.56E+02	7.40E+02	9.10E-02	1.00E+01	7.81E+00	1.50E+01
Am-241	432.2			3.80E-01	2.00E+03	1.98E+03	3.80E+02	3.20E-02	8.00E+00	7.94E+00	2.70E+00
Am-242, -242m	141										
Am-243	7,370										
Cm-243	29.1			1.10E-03	3.00E+00	2.66E+00	3.60E+00	9.70E-05	2.00E-02	1.78E-02	5.00E-02
Cm-244	18.1			5.00E-02	2.00E+02	1.65E+02	8.00E+01	4.40E-03	1.00E+00	8.26E-01	1.30E-01
Cm-245	8,500										
Cm-246	4,730										
Total Rare Earths											
Other Fission Products											
TOTAL ACTIVITY		**2.01E+05**	**1.79E+05**	**2.52E+05**	**4.04E+05**	**3.59E+05**	**1.21E+05**	**1.05E+00**	**1.93E+03**	**1.71E+03**	**7.24E+03**

Notes:

1 - Battelle, Prepared for US DOE. 1979. Preliminary Environmental Implications of Alternatives for Decommissioning and Future Use of the Western New York Nuclear Services Center. BMI-X698(Rev.).

2 - Calculated using radioactive decay equation of $A = A_0 e^{-\lambda t}$, where λ is equal to $Ln(2)/t_{1/2}$

3 - US DOE. 1982. Final Environmental Impact Statemetn for Long-Term Management of Liquid High-Level Radioactive Wastes Stored at the Western New York Nuclear Service Center, West Valley. DOE/EIS-0081.

4 - The 1982 inventory of radionuclides was estimated as of 1987.

5 - US DOE and NYSERDA. 1996. Draft Environmental Impact Statement for Completion of the West Valley Demonstration Project and Closure of Long-Term Management of Facilities at the Western New York Nuclear Service Center. DOE/EIS-0226-D.

6 - The 1996 DEIS inventory of radionuclides was estimated as of 2000.

7 - US DOE and NYSERDA. 2005. Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center. DOE/EIS-0226-R.

Table 3. Estimated Activities in the SDA and NDA[1, 2]

Radionuclide	1996 DEIS - SDA (Curies)	2005 DEIS - SDA (Curies)	1996 DEIS - NDA (Curies)	2005 DEIS - NDA (Curies)
H-3	1.60E+03	4.13E+04	1.00E+04	6.49E+01
C-14	2.70E+02	3.06E+02	6.00E+02	5.17E+02
Fe-55	--	1.86E+02	--	--
Co-60	1.60E+04	5.33E+03	3.00E+04	2.97E+04
Ni-59	--	8.00E+02	--	--
Ni-63	--	2.07E+04	--	--
Sr-90	3.10E+04	1.75E+02	2.90E+04	2.88E+04
Y-90	--	1.75E+02	--	--
Tc-99	1.00E+01	1.49E+00	1.00E+01	1.02E+01
Cd-113m	--	--	3.00E+00	5.82E+00
Sn-126	6.00E-02	--	3.00E-01	4.90E-01
Sb-125	1.00E-03	--	7.00E+02	4.20E+01
I-129	4.00E+00	3.32E+00	1.00E-02	2.15E-02
Cs-137	4.00E+04	1.46E+04	4.70E+04	3.68E+04
Ba-137m	--	1.38E+04	--	--
Eu-154	7.00E+03	--	2.00E+02	2.22E+02
Ra-226	9.00E-01	2.73E+01	1.00E-05	4.07E-06
Ac-227	--	--	2.00E-02	5.34E-02
Ra-228	--	--	1.00E-03	8.73E-03
Th-229	--	--	1.00E-02	3.42E-02
Pa-231	--	--	3.00E-02	8.31E-02
Th-232	--	--	3.00E-03	8.90E-03
U-232	1.70E+00	--	4.00E+01	5.25E+00
U-233	6.00E+00	2.46E+00	5.30E+01	1.13E+01
U-234	1.50E+00	9.75E+01	2.50E+01	5.77E-01
U-235	4.00E-01	3.53E+00	5.00E-01	1.20E-01
Th-234	--	1.92E+02	--	--
Pa-234m	--	1.92E+02	--	--
Np-237	4.00E-02	--	2.00E-01	1.60E-01
U-238	8.00E-01	1.92E+02	5.00E+00	1.46E+00
Pu-238	3.10E+04	2.65E+04	7.50E+03	3.79E+02
Pu-239	1.70E+02	1.84E+02	2.60E+03	5.79E+02
Pu-240	9.50E+01	1.09E+02	1.50E+03	3.99E+02
Pu-241	3.10E+04	3.89E+03	2.10E+04	1.54E+04
Am-241	1.40E+02	4.39E+02	1.00E+03	1.78E+03
Cm-243	5.00E-01	--	3.00E-01	5.87E-01
Cm-244	6.00E+00	--	4.60E+01	1.71E+01
TOTAL	**1.583E+05**	**1.292E+05**	**1.51E+05**	**1.15E+05**

Notes:

1 - US DOE and NYSERDA. 1996. Draft Environmental Impact Statement for Completion of the West Valley Demonstration Project and Closure of Long-Term Management of Facilities at the Western New York Nuclear Service Center. DOE/EIS-0226-D.

2 - US DOE and NYSERDA. 2005. Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center. DOE/EIS-0226-R.

Table 4. Weight of CLSM versus PUREX Waste in Tank 8D-2

	Tank 8D-2		Vault	Density (pound/cubic feet)	Weight (pounds)
	Volume (gallons)	Volume (cubic feet)	Volume (cubic feet)		
CLSM	750,000 [1]	100,260	158,737 [2]	90 - 125 [3]	13,957,974 - 19,386,075
PUREX Waste	750,000	100,260	--	52 [4]	5,213,542

$$Mass = Volume \times Density$$

Notes:

CLSM - Controlled Low Strength Material

1 - Volume taken from: US DOE and NYSERDA. 2005. Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center. DOE/EIS-0226-R.

2 - Volume based on vault dimensions from: US DOE and NYSERDA. 2005. Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center. DOE/EIS-0226-R.

3 - CLSM density taken from: Portland Cement Association. 2008. Concrete Basics: Controlled Low-Strength Material.

4 - PUREX waste density taken from: Westinghouse Savannah River Company and Savannah River Technology Center. 2003. PUREX Waste Solidification.

Table 5. Predicted Doses from the 1996 and 2005 DEIS Reports

	1996 DEIS			2005 DEIS			
Receptor	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**
Buttermilk Creek (mrem/yr)							
Normal Scenario							
SDA	0.8	0.08	1	0.7	0.7	0.7	0.51
NDA	0.02	0.00044	0.04	0.11	0.11	0.11	0.077
HLW Tanks	541	4700	45,000	--	0.00029	0.00029	6.5
Erosion - Favorable Case							
SDA	--	--	--	16	16	16	16
NDA	--	--	--	16	16	16	16
HLW Tanks	--	--	--	--	--	--	--
Loss of Erosion Control/Best Estimate Case							
SDA	67,000	67,000	--	52	52	52	52
NDA	9,400	9,400	--	50	50	50	50
HLW Tanks	--	--	--	--	0	0.000003	0.000003
Erosion Collapse/Unfavorable Case							
SDA	280,000	280,000	330,000	3,700	3,700	3,700	3,700
NDA	47,000	47,000	47,000	960	960	960	960
HLW Tanks	--	--	--	--	0	0.00004	0.00004
Cattaraugus Creek (mrem/yr)							
Normal Scenario							
SDA	0.1	0.1	--	0.15	0.15	0.15	0.096
NDA	0.003	0.005	--	0.054	0.054	0.055	0.05
HLW Tanks	71.9	--	--	--	0.000054	0.000054	1.3
Erosion - Favorable Case							
SDA	--	--	--	4	4	4.1	4.1
NDA	--	--	--	7	7	6.9	6.9
HLW Tanks	--	--	--	--	--	--	--
Erosion - Best Estimate Case							
SDA	--	--	--	13	13	13	13
NDA	--	--	--	20	20	20	20
HLW Tanks	--	--	--	--	1	0.8	0.8
Erosion - Unfavorable Case							
SDA	--	--	--	1,400	1,400	1,400	1,400
NDA	--	--	--	340	340	340	340
HLW Tanks	--	--	--	--	15	15	15
Seneca Nation of Indians (mrem/yr)							
Normal Scenario							
SDA	0.2	0.3	--	0.25	0.25	0.25	0.15
NDA	0.007	0.01	--	0.14	0.14	0.14	0.13
HLW Tanks	126	--	--	--	0.000084	0.000084	1.8
Erosion - Favorable Case							
SDA	--	--	--	8	8	7.8	7.8
NDA	--	--	--	17	17	17	17
HLW Tanks	--	--	--	--	--	--	--

Table 5. Predicted Doses from the 1996 and 2005 DEIS Reports

	1996 DEIS			2005 DEIS			
Receptor	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**
Erosion - Best Estimate Case							
SDA	--	--	--	24	24	24	24
NDA	--	--	--	48	48	48	48
HLW Tanks	--	--	--	--	2	2	2
Erosion - Unfavorable Case							
SDA	--	--	--	3,400	3,400	3400	3400
NDA	--	--	--	750	750	750	750
HLW Tanks	--	--	--	--	34	34	34
Resident Farmer Intruder (mrem/yr)							
Normal Scenario							
SDA	--	310,000	44,000,000	960	960	5,200	5,200
NDA	--	6,500,000	570,000,000	890	890	130,000	130,000
HLW Tanks	89,000,000	1,100,000,000	--	--	9.1	9.1	5,500,000
Direct Intrusion							
SDA	--	--	--	43	43	41,000	41,000
NDA	--	--	--	2,800	2,800	3,100,000	3,100,000
HLW Tanks	--	--	--	--	9	8.8	80,000
Construction Intruder[1] (mrem/yr)							
SDA	NA	260	2,600	38	38	7,100	7,100
NDA	NA	410,000	4,100,000	32	32	30,000	30,000
HLW Tanks	--	--	--	--	210	210	1,000
Drilling Intruder[1] (mrem/yr)							
SDA	0.09	0.56	27	38	38	7,100	7,100
NDA	0.05	2.1	21	32	32	30,000	30,000
HLW Tanks	0.4	--	--	--	210	210	1,000
Immediate Construction/Drilling Intruder (mrem/yr)							
SDA	--	--	--	43	43	41,000	41,000
NDA	--	--	--	190	190	2,800,000	2,800,000
HLW Tanks	--	--	--	--	210	210	3,400
Discovery Intruder (mrem/yr)							
SDA	--	26,000	260,000	--	--	--	--
NDA	--	7,000	70,000	--	--	--	--
HLW Tanks	--	8,000	80,000	--	--	--	--
Recreational Hiker Intruder (mrem/yr)							
Erosion - Favorable Case							
SDA	--	--	--	13	13	13	13
NDA	--	--	--	25	25	25	25
HLW Tanks	--	--	--	--	--	--	--

Table 5. Predicted Doses from the 1996 and 2005 DEIS Reports

	1996 DEIS			2005 DEIS			
Receptor	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**
Erosion - Best Estimate Case							
SDA	--	--	--	19	19	19	19
NDA	--	--	--	43	43	43	43
HLW Tanks	--	--	--	--	4	3.8	3.8
Erosion - Unfavorable Case							
SDA	--	--	--	300	300	300	300
NDA	--	--	--	2,900	2,900	2,900	2,900
HLW Tanks	--	--	--	--	10	9.6	9.6
Population Dose - Lake Erie Water Users							
Normal Scenario							
Collective Dose (person-rem)							
SDA	0.06	0.08	0.079	16	16	16	12
NDA	0.002	0.000035	0.0032	2.7	2.7	2.7	2
HLW Tanks	43.1	371	3,500	--	0.0074	0.0074	160
Latent Cancer Fatalities (Unitless)							
SDA	9.00E-07	0.00004	0.00004	--	--	--	--
NDA	3.20E-05	0.000000017	0.0000016	--	--	--	--
HLW Tanks	0.02	0.19	1.8	--	--	--	--
Loss of Erosion Control							
Collective Dose (person-rem)							
SDA	5,300	5,300	--	--	--	--	--
NDA	743	743	--	--	--	--	--
Latent Cancer Fatalities (Unitless)							
SDA	3	3	--	--	--	--	--
NDA	0	0	--	--	--	--	--
Erosion Collapse							
Collective Dose (person-rem)							
SDA	22,000	22,000	26,000	--	--	--	--
NDA	3,700	3,700	3,700	--	--	--	--
Latent Cancer Fatalities (Unitless)							
SDA	11	11	13	--	--	--	--
NDA	2	2	2	--	--	--	--
Total Population Dose - Lake Erie Water Users (person-rem)							
Erosion - Favorable Case	--	--	--	760	790	760	790
Erosion - Best Esimate Case	--	--	--	2,600	2,700	2,600	2,700
Erosion - Unfavorable Case	--	--	--	120,000	120,000	120,000	120,000

Note:

1 - The higher of the construction or drilling intruder dose was included in the 2005 DEIS.

Table 6. Predicted Doses (mrem/year) to Offsite Populations

100 Years				
	SDA	**NDA**	**HLW Tanks**	**Total**
Buttermilk Creek	0	0	0.04 - 0.36	0.04 - 0.36
Cattaraugus Creek	0	0	0.005 - 0.05	0.005 - 0.05
1,000 Years				
	SDA	**NDA**	**HLW Tanks**	**Total**
Buttermilk Creek	16,245	4,573	485 - 2,318	21,303 - 23,136
Cattaraugus Creek	2,112	595	63 - 301	2,770 - 3,010
10,000 Years				
	SDA	**NDA**	**HLW Tanks**	**Total**
Buttermilk Creek	325	2,508	55 - 535	2,920 - 3,370
Cattaraugus Creek	42	326	11 - 70	380 - 440
100,000 Years				
	SDA	**NDA**	**HLW Tanks**	**Total**
Buttermilk Creek	61	159	6 - 36	230 - 260
Cattaraugus Creek	8	21	0.7 - 5	30 - 33

Table 9. Predicted Doses (mrem/year) to Offsite Populations

Table 7. Predicted Doses (mrem/year) to Offsite Populations

100 Years				
	SDA	**NDA**	**HLW Tanks**	**Total**
Buttermilk Creek	0	0	0.04 - 0.36	0.04 - 0.36
Cattaraugus Creek	0	0	0.005 - 0.05	0.005 - 0.05
200 Years				
	SDA	**NDA**	**HLW Tanks**	**Total**
Buttermilk Creek	0.005	0.01	0.04 - 0.2	0.05 - 0.2
Cattaraugus Creek	0	0	0.005 - 0.03	0.005 - 0.03
500 Years				
	SDA	**NDA**	**HLW Tanks**	**Total**
Buttermilk Creek	20	101	14 - 79	135 - 200
Cattaraugus Creek	3	13	1.8 - 10.2	18 - 26
1,000 Years				
	SDA	**NDA**	**HLW Tanks**	**Total**
Buttermilk Creek	0.08	0.56	0.06 - 0.3	0.70 - 0.93
Cattaraugus Creek	0.01	0.07	0.01 - 0.04	0.09 - 0.12

Note:

These doses are calculated from releases via groundwater beginning in 2108.

Table 8. Predicted Population Doses for Sturgeon Point Lake Erie Water Users

	SDA (person-rem)	NDA (person-rem)	HLW Tanks (person-rem)	Total (person-rem)	LCF
100 Years	0 - 0	0 - 0	0.01 - 8	0.01 - 8	0.000004 - 0.004
1,000 Years	2,010 - 907,000	566 - 255,000	87 - 94,400	2,700 - 1,256,400	1.4 - 628
10,000 Years	40 - 18,100	311 - 140,000	16 - 12,900	367 - 170,000	0.2 - 85
100,000 Years	8 - 3,430	20 - 8,860	1 - 871	28 - 13,161	0.01 - 7

Table 9. Predicted Population Doses for Sturgeon Point Lake Erie Water Users

	SDA (person-rem)	NDA (person-rem)	HLW Tanks (person-rem)	Total (person-rem)	LCF
100 Years	0 - 0.001	0 - 0.0002	0.01 - 8	0.01 - 8	0.000004 - 0.004
200 Years	0 - 0.4	0 - 0.8	0.01 - 7	0.01 - 9	0.000005 - 0.004
500 Years	3 - 984	13 - 4,870	3 - 2,860	19 - 8,714	0.01 - 4
1,000 Years	0.01 - 3.80	0.07 - 27	0.01 - 10	0.1 - 41	0.00005 - 0.02

Note:
These doses are calculated from release beginning in 2108.