ABSTRACT
The performance objectives of the U. S. Department of Energy’s National Nuclear Security Administration Nevada Operations Office (NNSA/NV) Low-level Radioactive Waste (LLW) disposal facilities located at the Nevada Test Site transcend those of any other radioactive waste disposal site in the United States. Situated at the southern end of the Great Basin, 244 meters (800 feet) above the water table, the Area 5 Radioactive Waste Management Site (RWMS) has utilized a combination of engineered shallow land disposal cells and deep augured shafts to dispose a variety of waste streams. These include high volume low-activity waste, classified radioactive material, and high-specific-activity special case waste. Fifteen miles north of Area 5 is the Area 3 RWMS. Here bulk LLW disposal takes place in subsidence craters formed from underground testing of nuclear weapons. Earliest records indicate that documented LLW disposal activities have occurred at the Area 5 and Area 3 RWMSs since 1961 and 1968, respectively. However, these activities have only been managed under a formal program since 1978. This paper describes the technical attributes of the facilities, present and future capacities and capabilities, and provides a description of the process from waste approval to final disposition. The paper also summarizes the current status of the waste disposal operations.

WASTE MANAGEMENT

Introduction
In 1978, the U. S. Department of Energy (USDOE) and its Nevada Operations Office (NVO) established a managed LLW disposal project at the Nevada Test Site (NTS). Two sites, that were already accepting limited amounts of on-site generated waste for disposal and off-site generated Transuranic Waste for interim storage, were selected to house the disposal facilities. In those early days, the sites, located about 24 kilometers (15 miles) apart, afforded the NVO the opportunity to use at least two alternative technologies to effectively manage its disposal cost. The Area 5 RWMS uses engineered shallow-land burial cells to dispose packaged waste while the Area 3 RWMS uses subsidence craters formed from underground testing of nuclear weapons for the disposal of packaged and unpackaged bulk waste.

Authorization Basis
The Areas 3 and 5 RWMSs are categorized as radiological facilities. The authorization to operate the
RWMSs is based on a variety of documents which may include but are not limited to Integrated Safety Management System Description, Activity Agreements, Real Estate and Operating Permit, appropriate Safety Analysis documentation, Execution Plans, Environmental Impact Statement, Health and Safety Plan, and procedures. A Disposal Authorization Statement (DAS) was received in October 1999 for Area 3. In October 2000, the NVO Manager approved the NTS Integrated Closure and Monitoring Plan as well as the Performance Assessment and Composite Analysis Maintenance Plan as required by the Area 3 DAS. A DAS for Area 5 was received in December 2000. The Area 3 and 5 RWMSs received initial determination of acceptability from U. S. Environmental Protection Agency (EPA) pursuant to the CERCLA Off-Site Rule, in July 1998. The determination of continued acceptability is evaluated annually.

Physical/Technical Attributes
The NTS is a federally owned facility located on the southern end of the Great Basin in south central Nevada. It consists of approximately 3,561 square kilometers (1,375 square miles) and is surrounded by the Nellis Air Force Range and areas controlled by the Bureau of Land Management. Manned guard gates control access to the NTS. The two disposal facilities are inside the boundaries of the NTS and are located 24 kilometers (15 miles) (Area 5) and 48 kilometers (30 miles) (Area 3) north of the main access gate. Remoteness to populated areas is a key feature that enhances the site characteristics. The closest populated area to either disposal facility is the small town of Indian Springs, NV located 55 kilometers (34 miles) to the southeast. Las Vegas, the closest major population, is approximately 105 kilometers (65 miles) southeast.

The Area 5 RWMS is located in the southeastern section of the NTS in Frenchman Flat, within a topographically closed basin where all surface water drains into a playa. The facility is sited on a coalesced alluvial fan, south of the Massachusetts Mountains. The water table is 244 meters (800 feet) beneath the facility. Site characterization studies show that there is no aerially distributed recharge to the aquifer in the vicinity of the RWMS. In fact, hydrogeologic testing in bore holes show that in approximately the upper 46 meters (150 feet) of the vadose zone, the movement of moisture is upward (negative water potentials).

The Area 3 RWMS is located approximately 24 kilometers (15 miles) north of the Area 5 RWMS in the Yucca Flat basin, another closed basin where all surface drainage terminates in a playa at the south end of the basin. The water table is 488 meters (1,600 feet) beneath this facility. Both facilities receive on average 10-15 centimeters (4-6 inches) of precipitation annually.

Measurements at meteorological stations show that annual potential evaporation exceeds precipitation by greater than a factor of 14, and a moisture deficient state is maintained in the surface soils. The Nevada Test Site Waste Acceptance Criteria (NTSWAC) limits the amount of free liquids the waste can contain to one percent of the volume of the waste in a container. This equates to approximately 2 liters (one-half gallon) in a 208 liters (55 gallon) drum or 32 liters (eight gallons) in a 1.2x1.2x2.1 meter (4'x4'x7') box. The adequacy of these limits was verified in the Area 5 RWMS Performance Assessment (PA). In the PA, no credit was given for the packaging of the waste. All waste and radionuclide inventories were assumed to be available to the transport process immediately upon final closure of each cell. A bounding scenario in the PA model assumed uniform closure cap subsidence to a
depth of 1.8 meters (six feet) below grade, three successive 200 year flood events which filled the 1.8 meters (six foot) subsidence depression and then infiltrated the ponded water into the waste. Even under these extreme conditions, the disposal site did not exceed the regulated performance objectives.

**Acceptance Process**
The NTSWAC establishes the standard and requirements that generator sites must meet in order to receive approval to ship radioactive waste to the NTS. The NTSWAC covers the generator waste certification program, characterization of the waste, traceability, waste forms, and packaging and transfer of the material. The Radioactive Waste Acceptance Program (RWAP) personnel maintain the NTSWAC. The RWAP personnel review the generator’s program and documentation to verify the generator sites capability to develop and maintain a NTSWAC compliant program. Waste profiles are reviewed, biennial program audits, annual assessments and periodic surveillances are conducted to verify and validate the Generators Waste Management Programs. RWAP personnel can recommend the suspension of a generator program and/or waste stream that was found to be noncompliant or falls below standards described in the NTSWAC. In addition to the reviews by RWAP staff, the actual waste shipment and containers are inspected upon arrival at the RWMS facilities to verify items such as placards, manifests, marking and labeling, and container integrity.

**Disposal Process**
Both RWMSs are shallow-land disposal facilities, but there are differences between the sites. Area 5 has 296 hectares (732 acres) available for disposal of LLW. Current operations use 37 hectares (92 acres) of this total acreage, although expansion beyond this area is in process. Here, engineered disposal cells are used for disposition of waste. These cells are planned, designed and constructed to fit within the existing fenced area. At Area 5, LLW, NVO in-state generated mixed low-level waste (MLLW), radioactively contaminated regulated asbestos, and classified LLW are disposed. High specific activity LLW was disposed in Greater Confinement Disposal (GCD) bore holes, however this disposal option is not currently being used. Additionally, there are facilities for the storage, characterization, and certification of Transuranic Waste.

The disposal cells at Area 5 are excavated, and consequently are more expensive to develop than the subsidence craters used at Area 3. The Area 5 disposal space has historically been reserved for conventionally packaged waste in containers such as steel drums and 1.2x1.2x2.1 meter (4’x4’x7’) or 0.6x0.6x2.1 meter (2’x4’x7’) wooden and steel boxes. On occasion, other container sizes are accepted on a case-by-case basis, such as the regulated asbestos cell which accepts 2.4x2.4x6.1 meter (8’x8’x20’) cargo containers.

All packages accepted for disposal at Area 5 are required to meet the rigid U. S. Department of Transportation performance based packaging requirements. With the exception of cargo containers, the NTSWAC requires all boxes to meet a 16,113-kilograms/square meter (3,300-pound/square foot) compressive strength test. This provides a factor of safety for the workers. The waste packages are stacked one upon the other in a stair step configuration, until the stack is four feet below the top of the cell walls. Because these packages can weigh as much as 4090 kilograms (9,000 pounds) each, there is the potential for the bottom box in the stack having to support in excess of 27,273 kilograms (60,000
pounds) of loading. Thus, strength criteria in conjunction with the stacking configuration ensure a secure work platform for the waste handling crew. Process safety is taken seriously, as the disposal operations have been accident free for more than six years.

The Area 3 RWMS covers 49 hectares (120 acres). Area 3 disposes waste in subsidence craters formed from underground testing of nuclear weapons instead of conventional engineered cells. The criterion used for choosing these craters was that the emplacement of the nuclear device had to have been above the water table. This criterion was chosen to ensure that no preferential pathway would be available to the underlying aquifers. These disposal cells are considerably less expensive to develop than the Area 5 cells because the waste is disposed in existing subsidence craters. The disposal process also differs significantly here. Small packages such as boxes and drums are replaced with larger bulk sized packages such as the previously mentioned cargo containers, large pieces of equipment, super sacks or soils in lined dump trailers, referred to as “burrito wraps.” Instead of stacking the waste in a single monolith configuration, waste is disposed in a layer-cake geometry with each layer of waste covered by a layer of compacted soil ranging from 0.3-0.9 meters (1-3 feet) in depth.

Disposal Access
The NTS RWMS currently receives LLW from 22 generators including: Aberdeen Proving Grounds; Allied Signal; Bechtel Jacobs, Oak Ridge National Laboratory; Bechtel Nevada; Boeing North American-Rocketdyne; British Nuclear Fuels Limited, Inc., Oak Ridge National Laboratory; Fernald Environmental Management Project; General Atomics; Idaho National Engineering and Environmental Laboratory; International Technology Corporation, Las Vegas; Lawrence Livermore National Laboratory; Lovelace Respiratory Research Institute; Mound Plant; Paducah Gaseous Diffusion Plant; Pantex Plant; Princeton Plasma Physics Laboratory; RMI; Rocky Flats Plant; Sandia National Laboratories/California; and Sandia National Laboratories/New Mexico; Savannah River Site; and West Valley Demonstration Project.

The Waste Management Programmatic Environmental Impact Statement Record of Decision for disposal of LLW and MLLW, issued on February 25, 2000, identified NTS as one of two regional disposal sites. It is anticipated during fiscal year 2002 that at least one new generator (Idaho National Engineering and Environmental Laboratory) will receive approval to ship LLW to NTS. Only NVO in state generated MLLW is currently accepted. However, NVO anticipates being operationally ready to accept MLLW from off-site generators in 2002.

Present And Future Capabilities For Waste Disposal
The current Area 5 RWMS inventory of disposal cells is 23; not including the GCD bore holes. These range in size from 25-345 meters (83 to 1,133 feet) long, 9-102 meters (30 to 336 feet) wide, and 4-15 meters (12 to 48 feet) deep. The total disposed volume of waste in these cells is over 244,000 cubic meters (8.6 million cubic feet). Available open capacity in the fenced 37 hectares (92 acre) compound at Area 5, in existing cells, is approximately 137,657 cubic meters (5.9 million cubic feet). This includes the 20,000 cubic meters (706,000 cubic feet) being proposed for MLLW disposal. One new cell with a capacity of 28,317 cubic meters (1,000,000 cubic feet) has been constructed in the expansion area north of this fenced compound. No master plan currently exists for the layout of future
cells across the total 296 hectares (732 acres). However simple calculations based upon existing
inventory for the 37 hectares (92 acres) show that the current capacity averages 4,572 cubic meters per
0.4 hectares (161,000 cubic feet of waste per acre) of available ground. Extrapolation of this calculation
for the total 296 hectares (732 acres), taking no credit for future technology such as deeper cells, shows
the total capacity of Area 5 RWMS is about 3,337,194 cubic meters (118 million cubic feet).

The Area 3 RWMS includes a total of seven craters, representing five cells, designated for disposal
operations. The current inventory of disposed waste at the Area 3 RWMS is approximately 379,478
cubic meters (13.4 million cubic feet). Open capacity available in the two developed cells is estimated
to be approximately 189,662 cubic meters (6.7 million cubic feet). The two remaining craters, which at
the present time are assumed to be individual cells, represent an estimated combined available future
capacity of 203,000 cubic meters (7.2 million cubic feet).

In the five year period covering fiscal years 1997 through 2001, the NTS has received on average 643
shipments of LLW representing 21,096 cubic meters (745,000 cubic feet) of waste annually from as
many as 21 waste generators. This volume of waste has been transported, received, and disposed
safely with minimal risk to the general public, the workers at the disposal facility or the environment. A
Conservative calculation of total remaining disposal capacity at the NTS is about 3,727,360 cubic
meters (132 million cubic feet). This does not consider expansion into undesignated land surrounding the
Area 5 RWMS or the inclusion of additional subsidence craters adjacent to the Area 3 RWMS.

The question of when NTS may reach its disposal capacity is dependent on the volume of waste
received. Using 22,655 cubic meters (800,000 cubic feet) of waste received per year it will take
approximately 156 years for the NTS RWMSs to reach capacity. Knowing that the waste volumes in
the future will diminish as DOE completes the cleanup of the weapons complex and that the 156-year
estimate does not include expanding into undesignated areas or future technology, NTS capacity is
virtually unlimited.

**Conclusion**

The years of experience in waste management programmatic assessments and disposal operations, in
conjunction with remoteness of the location, superior physical attributes (depth to groundwater, arid
environment) establish NTS as one of the nations premier LLW disposal facilities. The issuance of the
Waste Management Programmatic Environmental Impact Statement for LLW, and an available capacity
of over 3.7 million cubic meters (130 million cubic feet), make the NTS LLW disposal facilities a
keystone in the efforts to clean up and close the DOE sites across the complex, especially for those sites
that are unable to dispose LLW at onsite facilities or unable to access a commercial facility.

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