Commercial Low-Level Radioactive Waste Disposal In South Carolina

A Publication of the South Carolina Department of Health and Environmental Control

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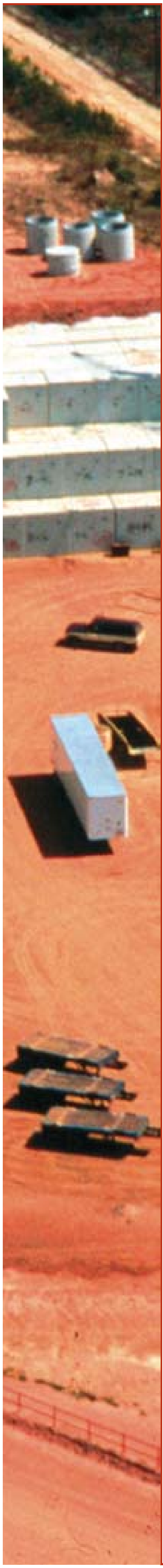

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I. INTRODUCTION

The disposal of commercial low-level radioactive waste (LLRW) in South Carolina began in 1971. That year, **Chem-Nuclear Systems, LLC (CNS)**, now a wholly owned subsidiary of **EnergySolutions**, applied for and was issued a South Carolina Radioactive Materials License. The license authorized the operation of a shallow land disposal facility in Barnwell County. CNS has been the sole operator of the Barnwell facility since that time. The facility occupies about 235 acres, deeded to the State of South Carolina by CNS. Through a formal agreement administered by the State Budget and Control Board, the state in turn has leased the land, as required by state law, to CNS for disposal operations. When the Barnwell facility is eventually closed, it will revert to state control. Although the Barnwell LLRW is located near the Savannah River Site—a major federal nuclear facility owned by the U.S. Department of Energy—the two facilities are separate and unrelated.

The U.S. Nuclear Regulatory Commission (NRC) delegated radioactive material licensing authority to South Carolina and other states through a formal agreement under Section 274(B) of the federal **Atomic Energy Act of 1954** (PDF). Regulatory control of the Barnwell facility operation is provided by the Infectious and Radioactive Waste Section of the S.C. Department of Health and Environmental Control (DHEC), Division of Waste Management (DWM). This regulatory authority is derived from the South Carolina **Atomic Energy and Radiation Control Act, Section 13-7-40, 1976 S.C. Code of Laws**, (as amended). The state's regulations for radiation control were promulgated pursuant to this legislation. Department **Regulation 61-63**, Radioactive Materials (Title A), and corresponding **Regulation 61-83, Transportation of Radioactive Waste Into or Within South Carolina**, define the state's requirements for the licensing of facilities possessing radioactive materials. The regulations also provide statutory authority to enforce conditions of issued licenses as necessary to ensure public health and safety. This authority includes the regulation of commercial low-level radioactive waste disposal, radioactive waste processing facilities and the customers of these activities.

This publication is intended to inform citizens of the characteristics of low-level radioactive waste, and its management and disposal. Information concerning waste types, packaging, transportation and environmental impacts of the disposal site also are presented. A more detailed description of DHEC's role in LLRW management is presented for the purpose of further defining the state's responsibilities.

Timeline

1969	License application submitted by CNS to store radioactive waste.
1971	CNS entered into a 99 year lease agreement with the S.C. Budget and Control Board to lease a 17.2 acre plot of land to bury radioactive waste–License amended to allow disposal of radioactive waste.
1976	Lease agreement amended expanding the leased area to its present 235 acres.
1980	Annual volume reaches 2.4 million cubic feet–Low Level Waste Policy Act was passed by Congress.
1981	Annual volume restricted to 1.2 million cubic feet by Governor Riley.
1985	Amendments to the Low-Level Waste Policy Act were passed by Congress.
1994	Site closes to all but Southeast Compact states.
1995	Site reopens to all states except North Carolina–$235 per cubic foot tax established–South Carolina withdrew from the Southeast Compact.
1996	Disposal technology changed from shallow land disposal to engineered below-grade vaults for all classes of waste.
2000	Governor Jim Hodges signs the Atlantic Compact Act, which provides for South Carolina to join the Northeast Compact and allowing receipt of out-of-compact waste through June 2008; CNS application for license renewal; CNS submitted Environmental Radiological Perfromance Verification (ERPV) Report demonstrating the future performance of the site after closure.
2001	Blue Ribbon Panel Report provided recommendations for improvements for documenting the findings in the ERPV.
2003	CNS revised ERPV Report to address the recommendations of the Blue Ribbon Panel; Public Notice of Proposed License Renewal and Public Hearing Schedule; Public Hearing of the draft license.
2004	Department approval of the license renewal; License renewal challenged by the Sierra Club; Six phases (96) acres of site closure completed with the installation of impermeable, synthetic trench caps.
2005	S.C. Administrative Law Court (ALC) final order and decision to sustain Department approval of the license renewal; CNS to perfom studies as ordered by the ALC; ALC order denying motion by Sierra Club for reconsideration and to alter or amend ALC initial decision.
2006	Sierra Club appealed ALC decision to the DHEC Board; decision pending.

II. HISTORY

Chem-Nuclear Systems (CNS) has operated the low-level radioactive waste disposal site in Barnwell County near the town of Snelling without interruption since operations began in 1971. CNS initially was licensed by South Carolina in 1969 to store radioactive waste while reviews were being performed to license

Rad Bits

The state of South Carolina has regulated the Barnwell disposal site since its opening in 1971.

Rad Bits

Due to radioactive decay, approximately one-third of the total radioactivity disposed of at the Barnwell disposal site over the years remains.

the facility for disposal of LLRW. After the reviews were completed, the license was amended in 1971 to allow shallow land disposal of radioactive waste. Since the initial opening of the Barnwell facility, increased use of waste volume reduction techniques has resulted in higher levels of radioactivity per storage container. In response, the disposal technology originally utilized has been enhanced to include the use of concrete vaults.

On April 21, 1971, CNS entered into a 99-year agreement, with the South Carolina Budget and Control Board to lease a 17.2 acre plot of land. This land previously had been purchased and deeded to the state by CNS for the purpose of radioactive waste burial. The lease agreement was amended on April 6, 1976. The amendment expanded the leased area to its current 235 acres. The lease expires in 2075. In addition to the lease agreement, two trust funds, administered by the state and financed through volume-based waste disposal surcharges, were created. The Decommissioning Trust Fund was established to provide funds for site stabilization prior to closure. The Long Term Care Fund will be used for care and monitoring of the site after closure. For each cubic foot of waste received for disposal at the site, an amount of money is paid into each respective fund. In addition, the funds accrue interest.

As one of six commercially operated U.S. disposal sites in the 1970s, the Barnwell facility received its proportionate share of the nation's waste. But by 1979, three of the six sites had closed, and the Barnwell facility was receiving three-fourths of the nation's waste (2.2 million cubic feet per year). In 1981, a waste acceptance limit of 1.2 million cubic feet per year (about 163,000 55-gallon drums) was imposed by the state. Table I shows the volumes and activities of waste received at the Barnwell site since it began operation.

Through the years, 115 acres have been developed for disposal. Of this total,105 acres have been used, with 10 acres remaining as of June 2005. For more information, download the (PDF) **CNS June 2005 Closure Plan**. This equates to a remaining capacity of approximately 2.5 million cubic feet of waste. The remaining capacity after FY 2008 will be approximately 2.3 million cubic feet.

In 1980, Washington, Nevada, and South Carolina were the only states with operational LLRW disposal facilities. The respective governors of these states

TABLE 1

Barnwell Disposal Facility LLRW Activity and Volume Inventory

Year	Volume (cubic feet)	Disposed Activity (curies)
1971	50,219.34	212,412.03
1972	159,933.47	19,787.39
1973	599,886.28	52,650.97
1974	624,759.44	22,103.10
1975	643,564.44	19,418.68
1976	1,393,587.55	89,911.80
1977	1,636,425.12	395,713.76
1978	2,220,519.72	636,857.82
1979	2,238,322.13	314,938.44
1980	2,444,810.72	143,495.36
1981	1,543,287.67	183,744.31
1982	1,228,200.83	273,961.56
1983	1,240,688.21	383,450.25
1984	1,231,715.28	385,079.07
1985	1,214,422.99	460,600.25
1986	1,053,791.68	116,108.01
1987	958,275.82	211,098.07
1988	931,974.01	219,033.83
1989	1,103,299.56	725,163.57
1990	788,031.90	443,594.19
1991	789,681.85	611,535.76
1992	828,720.34	815,944.28
1993	605,443.07	611,784.73
1994	733,931.04	735,298.41
1995	484,994.32	168,982.13
1996	325,870.60	455,214.79
1997	222,269.48	102,624.48
1998	195,684.08	356,205.46
1999	166,435.79	326,428.52
2000	118,001.14	701,871.12
2001	109.591.83	482,590.37
2002	52,163.23	135,037.82
2003	71,416.22	608,147.43
2004	57,241.56	336,221.29
2005	42,784.98	517,638.39
Total	27,995,870.23	12,072,674.25*

* Total manifested activity of radionuclides in waste.
(The decay corrected radioactivity is approximately 3 million curies.)

wanted the rest of the country to share the burden of LLRW disposal. As a result of efforts primarily by the National Governor's Association, Congress passed the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1980 (Public Law 99-240) which set forth responsibility for managing and disposing of radioactive waste in each of the 50 states. Consequently, regional compacts (see Figure 1) were established among various states. Under the compacts, a host state is designated to operate a disposal facility for a fixed period of time. Currently, the Barnwell site operates as the regional facility for the Atlantic Compact, and the Hanford facility, located in the state of Washington, operates as the regional facility for the Northwest Compact. The disposal facility in Nevada was closed in December 1992.

The lack of progress in site development among regional compacts resulted in the **amendment of the LLRWPAA in 1985** (PDF). This amendment replaced the LLRWPAA of 1980 and created milestones for disposal facility development and penalties for failure to achieve reasonable progress within an established schedule. States with operating disposal facilities were allowed to deny access to states and compact regions that failed to meet scheduled siting requirements.

South Carolina was initially affiliated with the Southeast Compact. The state withdrew in July of 1995 because North Carolina, the next designated host state for the Southeast Compact, failed to comply with milestones set forth in the LLRWPAA. Under the LLRWPAA, North Carolina was supposed to find a suitable site to replace the Barnwell facility, but that didn't happen. From 1995 until 2000 the Barnwell facility was open for use by all states except North Carolina, the Southeast Compact host state. In 2000, Governor Jim Hodges, signed the Atlantic Compact Act, which provided for South Carolina to join the Northeast Compact. It also allowed receipt of out-of-compact waste only through June 2008.

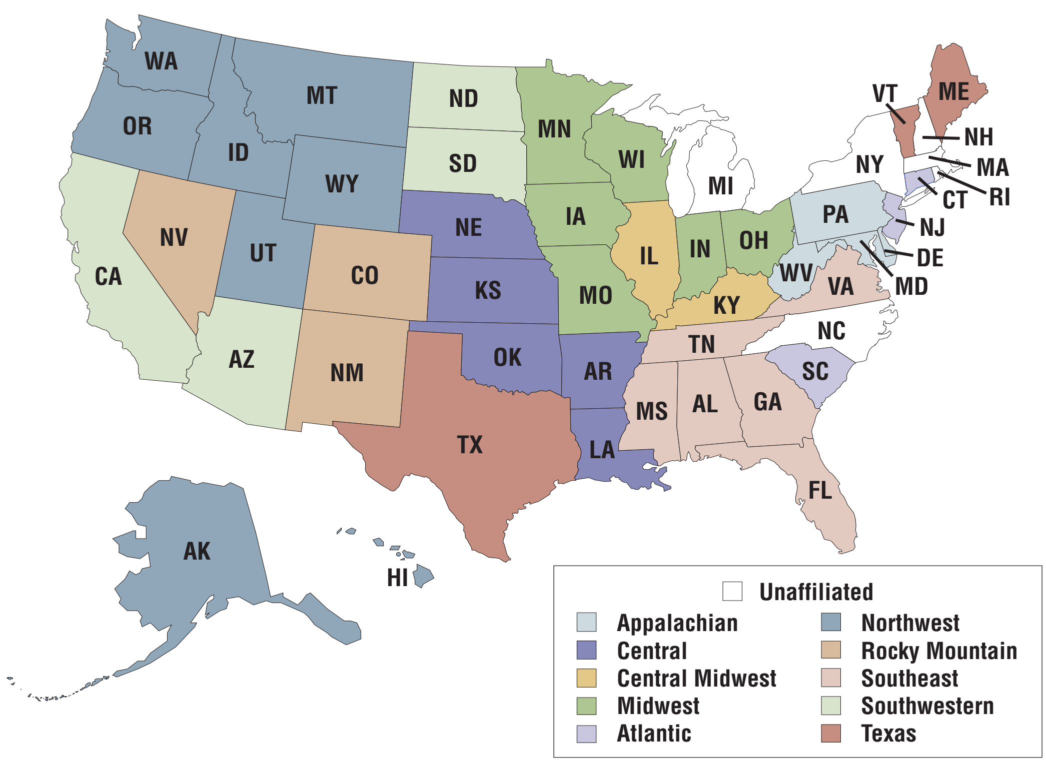
The Atlantic Compact Act (PDF) provided a schedule for reduced waste volume receipts from 2001 through 2008 (see Table 2). It also provided that the Budget and Control Board would set the disposal rates and that Chem-Nuclear would be reimbursed for their operating costs. It provided a 29 percent profit margin on some of these costs. The difference in the amount of money collected and what is paid to Chem-Nuclear for operating the site is used by the state for funding education. According to the Budget and Control Board, $94.4 million in Barnwell site revenues have been used for education from Fiscal

Rad Bits

There are currently three active commercial disposal sites in the U.S. that accept LLRW. They are located in the states of South Carolina, Washington, and Utah.

FIGURE 1

Low-Level Radioactive Waste Compacts



Rad Bits

The annual radiation dose the average american receives from diagnostic x-rays is about 40 mrem, while the average annual dose received from nuclear power and radioactive fallout is about 1 mrem.

Year 2001 through Fiscal Year 2006. CNS currently receives low-level waste primarily from generators located in the eastern half of the United States, though some waste is received from western states. CNS customers range from nuclear power plants and industries, which generate several thousand cubic feet annually, to small research facilities and businesses, which generate less than 100 cubic feet annually. To retain disposal priviledges, all generators must follow stringent regulations, license conditions, and site disposal criteria imposed by the state and CNS.

III. RADIATION PRINCIPLES

Radiation is energy, and it's been around for billions of years. Radioactive materials (called radioisotopes or radionuclides) and the radiation they produce are everywhere. They are in soil, water and light. Thanks to evolution, humans have developed a level of tolerance to the radiation found naturally in the everyday environment. However, exposure to higher than normal tolerance levels can be harmful to health.

Not all radiation is the same. Non-ionizing radiation is a low energy form of radiation. It comes from visible light, infrared heat, radio waves, microwaves, electric power lines, cell phones, and ultraviolet (UV) light. The non-ionizing radiation from these sources can make atoms vibrate, but it lacks the energy to chemically alter them. Microwave ovens, for example, use radiation from microwaves to heat the water in food by making the water molecules vibrate.

A second type of radiation, called ionizing radiation, is much more energetic. It can alter the

TABLE 2

Atlantic Compact Act Annual Volume

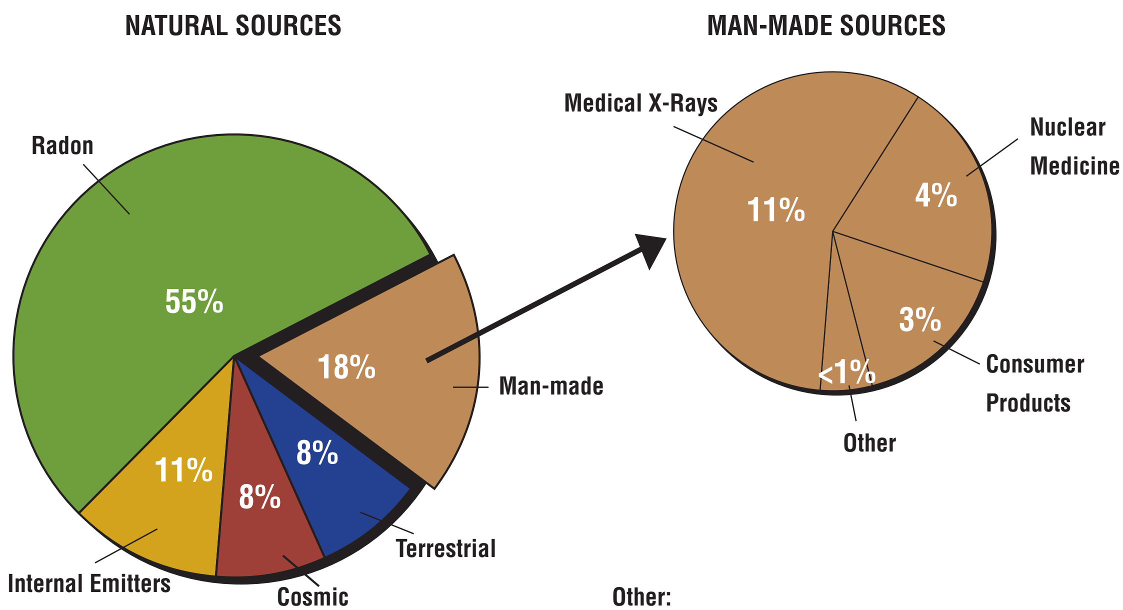
Fiscal Year*	Maximum Allowed Volume (cubic feet)
2000/2001	160,000
2001/2002	80,000
2002/2003	70,000
2003/2004	60,000
2004/2005	50,000
2005/2006	45,000
2006/2007	40,000
2007/2008	35,000

South Carolina Fiscal Year: July 1 - June 30

FIGURE 2

Radiation Exposure in the United States (Percentage of Total Effective Dose)

Based on an average annual effective dose equivalent of 3.6 mSv (360 mrem) and a ground level radon concentration of about 40 Bqm^{-3} (1pCi/l)



Other:

Occupational	0.3%	Nuclear Power	0.1%
Fallout	0.3%	Miscellaneous	0.1%

structure of the atoms it penetrates. It does this by knocking the atom's electrons out of orbit. This causes atoms to become positively charged, or ionized. The change can damage whatever material the radiation is penetrating, including human tissue. Sources of ionizing radiation include cosmic rays from the sun and stars, radon gas, x-rays, and uranium and other naturally occurring radioactive materials in rocks and soil. Ionizing radiation can take two diffferent forms - electromagnetic waves or particles.

Ionizing radioisotopes are unstable atoms. Their ratio of neutrons to protons is out of balance. A radioisotope will try to stabilize itself by decaying, and as it does so, it throws off energy in the form of ionizing radiation. The rate of decay is known as a radioisotope's half-life. Half-life is the time required for a radioisotope to lose 50 percent of its original activity. If a radioisotope has a half life of six hours, for example, then after six hours one-half of the radioactive atoms would have decayed and been transformed into different isotopes. Some radioisotopes take only seconds to decay; others take billions of years.

Much of the ionizing radiation released through radioactive decay is emitted in the form of relatively slow moving alpha particles and fast moving beta particles. Both are most dangerous to humans when ingested or inhaled. Ionizing radiation is also released as electromagnetic waves, including highly penetrating gamma rays. Gamma rays can pass completely through the human body, but they lose most of their energy in 6 inches of lead or 3 feet of concrete. X-rays, which are also electromagnetic waves, are not as penetrating as gamma rays and can be blocked by several millimeters of lead (1/10 of an inch).

In addition to natural sources of radiation, there are man-made (anthropogenic) radioisotopes. These radioisotopes are created when neutrons are released during nuclear fission or when a neutron collides with a nucleus during a nuclear reaction. Because neutrons have a neutral charge, they are easily absorbed by other atoms, which creates new radioisotopes. Manmade radioisotopes account for the bulk of low level radioactive waste generated in this country.

The biological effect of radiation on the human body depends on the **dose**, or amount of radiation absorbed by, or passed through it. For example, the average annual radiation exposure to a typical non-radiation worker from all sources has been estimated to be about 0.35 **R** or **rem** (Roentgen Equivalent Man). In addition to the REM, radiation exposure can also be expressed using the metric or international unit term **Seivert (Sv)**. This average annual level of radiation exposure is attributed primarily to natural sources such as cosmic and radon gas. During an average lifetime, this level of radiation exposure has an unquantifiable effect, if any, on humans. Federal and state regulations allow a total annual occupational exposure of 5.0 rem (0.05 Sv). However, typical worker exposures in power reactors, medical facilities and manufacturing seldom exceed 0.3 rem (0.003 Sv) per year.

TABLE 3
Typical LLRW Isotopes and Corresponding Half-Lives

Isotope	Half Life
Cobalt-60	5.3 years
Cesium-137	30 years
Hydrogen-3 (Tritium)	12.4 years
Iodine-131	8.0 days
Nickel-63	96 years

Although the effect of large acute radiation exposures can be detrimental to health, when used safely, radiation can be very beneficial to society. The radioactive waste disposed of at the Barnwell facility is a by-product of these beneficial uses such as electricity production, manufacturing, medical diagnosis, cancer therapy and scientific research. Radiation exposure to the public due to activities associated with the Barnwell facility has been minimal and well within regulatory limits for its workers.

IV. LOW-LEVEL RADIOACTIVE WASTE (LLRW)

LLRW can best be described by what it is not. It is not High Level Radioactive Waste (HLRW) or Transuranic Waste (TRU). HLRW consists mostly of spent nuclear fuel and processing residues from nuclear fuel reprocessing. TRU primarily contains man-made radioisotopes that have atomic weights greater than that of uranium. Both HLRW and TRU remain radioactive for thousands or millions of years. The U.S. Department of Energy is responsible for developing disposal facilities for these wastes (e.g.

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Radioactive half-life is the time it takes for half the activity of a radioactive material to decay. For example, if you start with 10 Curies of Cesium-137, 30 years later only 5 Curies of activity will remain.

Rad Bits

More than 50 various facility and operations inspections are performed at the Barnwell Facility each year by DHEC staff.

Yucca Mountain in Nevada and the Waste Isolation Pilot Project (WIPP) Facility in New Mexico).

The Barnwell facility does not accept any HLRW or TRU waste. Also, not all LLRW is acceptable at the Barnwell facility. Only LLRW wastes that primarily contain radioisotopes having relatively short half-lives (a few decades) are accepted for disposal. After 25 years, only 25 percent of the radioactivity disposed of at the facility will remain due to radioactive decay. After 100 years, the radioactivity decreases to 10 percent.

Another source of radioactive waste is derived from naturally occurring radioactive material (NORM). Sources of NORM include radioactive elements in rocks, soil, groundwater, radon gas and its decay progeny in the air we breathe. NORM wastes result when a natural source of radiation is condensed from a raw material through various industrial activities. Examples of NORM waste generated as a by-product include the following: residue solids from mining and associated refining activities, coal ash, oil production equipment and bottled spring water processing residue. Although large concentrations of NORM are not routinely accepted at the Barnwell facility, some small discrete medical sources are occasionally permitted for disposal.

LLRW is further characterized for the purpose of disposal through the use of a waste classification system. This system is based on concentrations of specific radionuclides as defined by federal regulations. Three classes, A, B and C, are used to describe specific activity limits for packaging and final disposition. Class A waste is the least restrictive classification in terms of handling, packaging and disposal requirements. Currently, Class A waste accounts for about 50 percent of the waste received by volume, and Class B and Class C wastes comprise the other 50 percent of the waste volume. Class B and C wastes are higher in specific activity, and, as such, these waste classifications require additional stabilization through solidification, encapsulation or specification packaging. Also, higher radiation levels associated with these waste classes require additional safety precautions to protect site workers. Any LLRW with specific activity greater than the Class C limit is not generally acceptable for disposal at Barnwell. Greater than Class C wastes are currently stored at the site of origin and will eventually be disposed of at a federal HLRW repository.

Class A waste is usually in the form of Dry Active Waste or DAW. This waste class can include the following: paper, clothing, tools, laboratory glass, soil, wood, metal, dewatered concentrates and ion-exchange resins. Due to the high costs of interim storage and disposal, DAW is routinely the subject of various management and volume reduction techniques including compaction and incineration.

Low activity commercial reactor steam generators placed among disposal vaults for burial.

Ion exchange resins, usually in the form of very small beads, are composed of organic substances which attract and physically capture certain radionuclides. Specialized equipment containing ion exchange resin is used in commercial power reactors to clean contaminated water. The resulting contaminated resins are dewatered to meet disposal facility requirements and placed in liners or high integrity containers. In some cases, resin and other forms of LLRW are solidified in some type of approved binder in lieu of dewatering.

Class B and C wastes may include some of the same physical characteristics of Class A waste. However, the most common waste forms of these classifications include: activated metal components, ion exchange media and mechanical filters. Activated metal components result primarily from commercial power reactor operation. Stable elements within these power reactor components become radioactive due to neutron and photon bombardment. Mechanical filters of various sizes and configurations collect and condense radioactive contaminants and as a result possess a high specific activity per unit volume. The solid form of these wastes combined with specification packaging and enhanced disposal techniques make it possible for their safe disposal at the Barnwell facility.

Recently, some commercial power reactors have been decommissioned. Instead of generating more waste through the disassembly of large secondary reactor components, these components, such as steam generators, have been disposed of as one large package. Their low specific activity precludes disposal by conventional means. The potential high cost of decontaminating these components makes enhanced shallow land disposal a more viable option.

V. ENHANCED SHALLOW LAND BURIAL CONCEPT

Selection of a low-level radioactive waste disposal site is contingent upon many factors. Desirable physical characteristics include minimal surface water sources; a geology that can be characterized, modeled, analyzed, and monitored; groundwater at a sufficient depth so that it does not intrude into the waste; low frequency of tectonic processes (earth quakes and faulting); and low rates of erosion, landsliding, or weathering.

Shallow land burial of LLRW has been one of the traditional methods for disposal for many years. This disposal technique places wastes below the land surface, but above the water table. At the Barnwell facility, trenches are excavated in clay-rich soils. The soil is characteristic of the so-called Hawthorne Formation, a near surface geologic formation in the area. Soil characteristics are an important factor in choosing LLRW burial sites. The soil of the Hawthorne formation tends to reduce groundwater movement, which serves to slow the movement of radionuclides. LLRW containers are entombed in concrete vaults placed in the trench. Each trench, when completed, is capped with an impermeable synthetic cover that minimizes water infiltration. The technology associated with this type of disposal has advanced markedly in the past 10 to 15 years. Before this type of disposal practice was widely used, much of the commercial and government LLRW generated in the United States was disposed of in the ocean off the coasts of Maryland and California. This practice was suspended in the early 1970s in the United States, after more disposal options on land had been established.

Although suitable sites from a technical standpoint are available in the eastern half of the United States, public sentiment combined with legal obstructions

Rad Bits

Trenches at the Barnwell facility are not simply "holes in the ground"; they are engineered and constructed to meet specific performance requirements and are inspected by DHEC and CNS many times during and after construction.

FIGURE 3

Primary South Carolina LLRW Generators

NOTE: Savannah River Site, located in Barnwell and Aiken Counties, does not ship LLRW to the CNS disposal facility.

1 – Catawba Nuclear Station
2 – Chem-Nuclear Systems, LLC
3 – Clemson University
4 – H.B. Robinson Nuclear Station
5 – Unitech
6 – Medical University of South Carolina
7 – RWE Nukem
8 – Oconee Nuclear Station
9 – Transnuclear
10 – University of South carolina
11 – V.C. Summer Nuclear Station
12 – Westinghouse - Columbia

Rad Bits

All trenches have engineered drainage systems designed to keep water away from waste packages.

have delayed attempts to develop new LLRW disposal facilities. Specific characteristics of the Barnwell facility are discussed in more detail in the following section.

VI. CNS' BARNWELL, SOUTH CAROLINA LLRW DISPOSAL FACILITY

The CNS Low-Level Radioactive Waste Management Facility is located in Barnwell County near the town of Snelling. Figure 2 illustrates the location of the waste management facility as well as the location of primary LLRW generators in the state. The site is accessible from S.C. Highway 64. It encompasses an area of about 235 acres adjacent to the U.S. Department of Energy's Savannah River Site (SRS) and the decommissioned Allied General Nuclear Services, Barnwell Fuel Recycling Plant. CNS is licensed by DHEC to handle, process, store and dispose of LLRW. CNS is required to pay an annual licensing fee that helps offset the expense of regulatory activities.

The radioactive material license is administered by the DHEC Bureau of Land and Waste Management's Division of Waste Management. The license (see attachments) establishes regulatory conditions and procedures with which CNS must comply regarding waste acceptance criteria, site construction, maintenance, environmental monitoring, stabilization and closure. Administration of the license includes daily inspection of transportation and burial activities by a permanent on-site inspector. Routine (weekly) visits are performed by the Division's engineering and health physics staff who provide oversight of disposal operations, continuing construction activities and overall site performance.

The license is renewed every five years. During the licensing renewal process, waste acceptance criteria, site procedures and overall site performance are reviewed. If needed for regulatory compatibility, amendments are made to license conditions or modifications to site operational procedures are implemented. The CNS license was renewed in March 2004, but was appealed. During this appeals process, CNS is allowed to continue to operate the facility in accordance with the existing license.

FIGURE 4

Trench Preparation

NOTE: Drawing is not to scale.

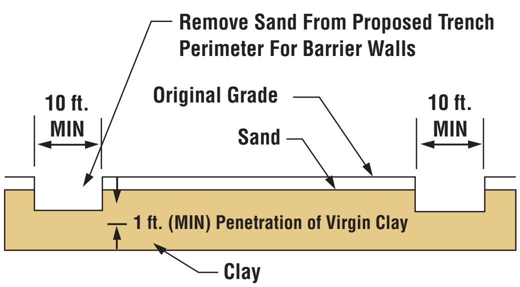
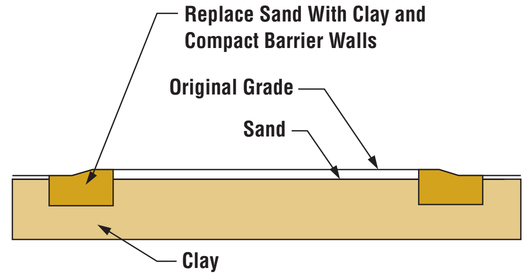


FIGURE 5

Trench Preparation

NOTE: Drawing is not to scale.



Enhanced shallow land burial at the Barnwell facility involves the construction of trenches. Individual trench construction is based largely on the geology and hydrology of the area of interest. The Barnwell facility, which is underlain by sediments of the Atlantic Coastal Plain, is overlain by a 4-6 foot layer of sandy loam that is not suitable for waste burial. Lower soils typically consist of stratified clay, silt, sand and limestone. Some areas of the site have been precluded from trench construction. The soil in which the trenches are located is mainly clay, providing low infiltration rates for surface water and slow ground water movement. The elevation of the water table varies over the site, with the highest elevations occurring at the northern boundary. The water table varies mainly in relation

A typical B/C Trench under construction.

to the surface slope, and lies 30 to 50 feet below the surface. Allowable trench bottom elevations are dependent on the maximum historically measured water table elevation in the trench vicinity. A minimum allowable separation (at least 5 feet) between the trench bottoms and the water table is an important element of trench construction.

The current Class A waste trench is approximately 1,000 feet long, 300 feet wide and 30 feet deep. Typical Class B/C waste trenches are approximately 600 feet long, 50 feet wide and 20 feet deep. Current slit trenches are approximately 300 feet long, 10 feet wide and 20 feet deep. Slit trenches at the Barnwell facility contain the higher Class C concentrations of LLRW. These wastes are usually comprised of activated metal components. The deep narrow trench aids in minimizing exposure to workers during package off-loading operations.

A hydrogeologic characterization of the area is completed and presented to DHEC for approval prior to trench construction. Upon approval, the trench is excavated by removing the top layer of sand and fill from the area. A compacted clay backfill is installed which will form trench barrier walls. The trench is then excavated to the desired length and depth. Upon completion of the trench, a ramp is constructed at the low end to allow access for transport vehicles. In addition, the trench bottom is sloped, A drainage and sump system is installed that allows for environmental monitoring of any accumulation of water through the use of standpipes. All aspects of trench construction are inspected by division engineers and CNS staff to ensure construction accuracy including: bottom elevation, slope surveys, drain construction, wall construction, floor buffer sand and proper water drainage. A standard Class A trench is illustrated in Figure 3.

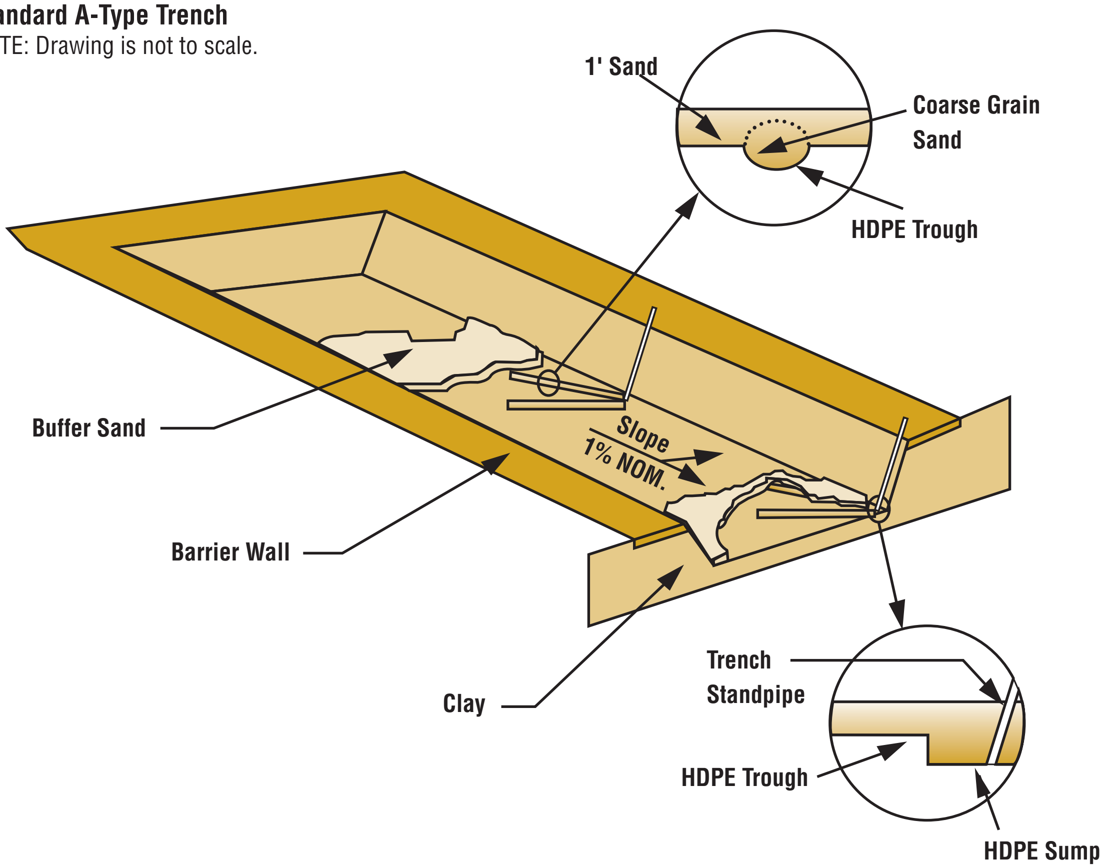
An active Slit Trench with disposal vault in place.

Rad Bits

The Barnwell disposal facility is the only commercial LLRW disposal site that uses concrete vaults as structural overpacks for all classes of LLRW.

FIGURE 6

Standard A-Type Trench
NOTE: Drawing is not to scale.



Rad Bits

CNS samples approximately 200 monitoring points each quarter to assess environmental compliance.

A Slit Trench disposal vault and lifting device.

Cylindrical B/C Trench disposal vaults in an active trench. Vaults are immediately backfilled to fill void spaces and reduce radiation exposure.

A typical configuration of cylindrical and rectangular A Trench disposal vaults. The vaults are configured to ensure trench cap structural integrity and to reduce radiation exposure to workers during LLRW off-loading activities.

Type B/C trenches are constructed much like the Class A trench with the exception of the access ramp. Wastes are placed into trenches by cranes to minimize worker dose and hazards to workers. Slit trenches also share the same initial construction phases in that barrier walls are formed prior to the actual trench being dug. Excavation is performed using a backhoe and proceeds in stages of about 125 feet to assure the structural integrity of the trench wall and to minimize sloughing. Sand is added in 1 to 3 foot depths to provide drainage.

The use of vaults helps to ensure that the engineered cap is well supported and enhances the long-term performance of the various LLRW containers placed within. The vaults are engineered to support the weight of waste and vaults stacked up to three high, as well as the backfill soil, heavy equipment and the trench cap.

Three types of concrete vaults are used at the Barnwell facility. Rectangular vaults are normally used for wastes packaged in metal boxes and drums. The size of the rectangular vaults is about 10 feet by 10 feet on the sides by 11 feet tall. Cylindrical vaults are normally used for wastes packaged in metal cylindrical liners, high integrity containers (HIC's) and drums. The cylindrical vaults are about 8 feet in diameter and 9 feet tall. Vaults used in slit trenches are about 17 feet long by 5 feet wide by 4 ½ feet tall. The nominal thickness of the vault walls is 8 inches.

TABLE 4

Enhanced Trench Caps

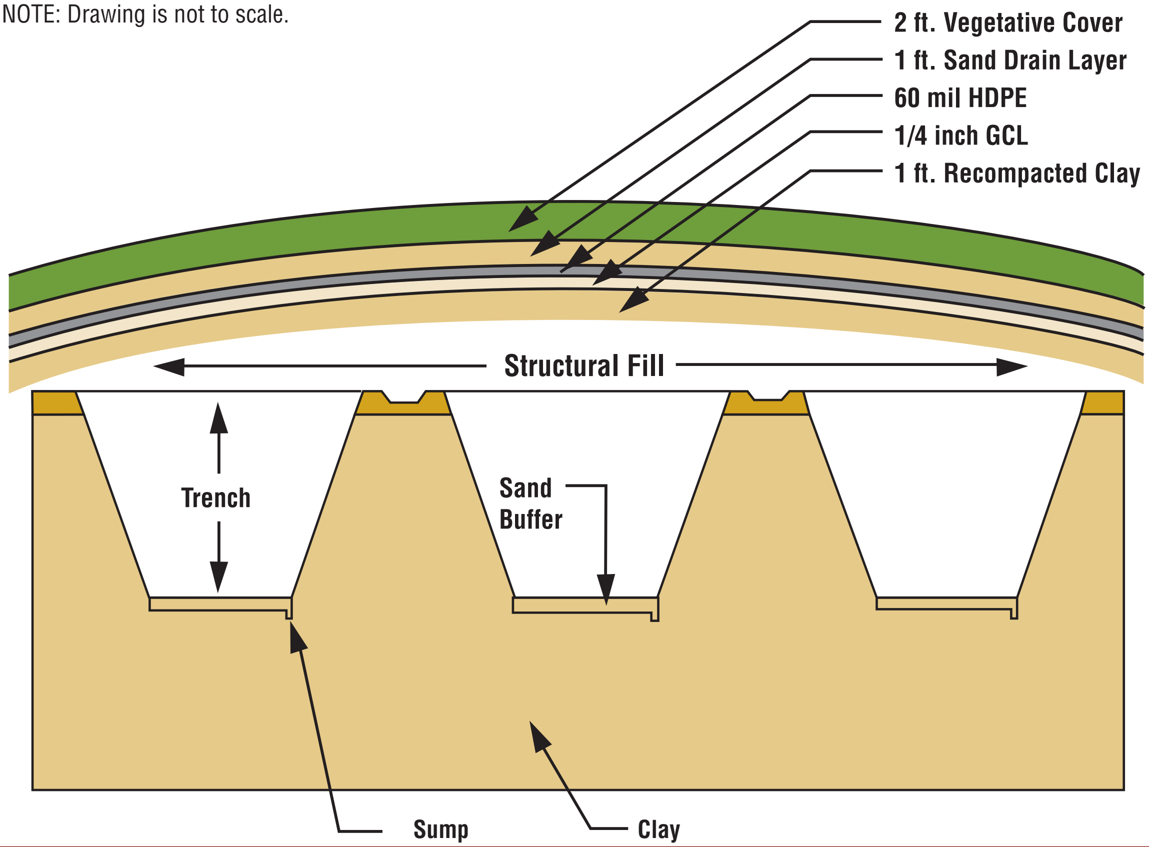
Phase	Date Completed	Area (acres)	Approximate Cost ($ in Millions)
I	Jan-92	12.50	1.70
II	Feb-94	8.00	1.40
III	July-95	26.00	4.10
IV	May-97	22.50	3.00
V	Aug-98	10.00	1.65
VI	May-04	17.00	2.90
TOTAL		96.00	14.75

As waste packages are placed in the trench vaults and the vaults are closed, as much sandy clay as possible is added as backfill material to fill voids between the vaults. This process continues from one end to the other as the trench is filled. A temporary compacted clay cap is then installed over the completed trench. This mitigates infiltration of surface

FIGURE 7

Enhanced Cover Construction Details

NOTE: Drawing is not to scale.



water to the trench contents until the enhanced cap is installed. Various species of grass may be planted on the temporary trench cap to help control erosion.

Finally, enhanced caps are placed over completed groups of trenches in "phases." To date, six "phases" have been completed. Table 3 provides more detailed information about this important project. Prior to closure of the facility, the entire area used for disposal will have been capped.

These caps are designed to virtually eliminate water infiltration through the trenches. As illustrated in Figure 4, the enhanced cap consists of a compacted clay layer that is a minimum of 1 foot thick, a geosynthetic clay liner (GCL), a 60 mil high density polyethylene (HDPE) liner, a sand drain layer, and a sandy topsoil layer. The sand drain layer combined with the contoured compacted clay structural fill promotes the lateral movement of water from the tops of the filled trenches. The sandy topsoil provides a plant growth medium. The HDPE and GCL liners provide a double barrier to prevent water percolation to the filled trenches. Should the HDPE liner fail, the GCL liner is designed to seal the rupture.

VII. ENVIRONMENTAL MONITORING

Chem-Nuclear is responsible for environmental monitoring at the site. However, DHEC also collects and analyzes environmental samples for comparison and verification of the sample analysis results submitted to DHEC by Chem-Nuclear.

CNS' Program

CNS' environmental monitoring program is similar to DHEC's in that samples are collected and analyzed from wells, surface water, air, soil, sediment, vegetation and thermos-luminescent dosimetry TLDs. Samples of all types are collected on-site, in the administrative area, and off-site.

The most extensive monitoring is performed on groundwater. Monitoring wells have been established to examine the various water bearing zones underlying the site. Water samples are analyzed for radiological and nonradiological contamination. Water elevations also are measured for use in estimating the elevation

Rad Bits

High Integrity Containers (HIC'S) used for waste transportation and disposal are required to withstand rigorous testing including a 30 foot drop onto an essentially unyielding surface and they are designed to contain the waste for 300 years.

Rad Bits

The existence of strict federal and state regulations and CNS' history of exceptional regulatory compliance have been instrumental in assuring the environment is not negatively impacted.

of the water table surfaces beneath the site. There are more than 150 wells in the site environmental monitoring program, including U.S. Geological Survey (USGS) test wells, CNS wells and privately owned potable water supplies. Surface water is sampled both on and off-site. On-site surface water is accumulated in large holding ponds near the west boundary fence and the east side of the site. The ponds are sampled regularly and analyzed for radionuclides. Samples also are taken from nearby surface water sources.

DHEC's Program

Water samples from on-site boundary and offsite monitoring wells are collected by CNS with oversight from DHEC and split. The samples are analyzed for gross alpha and beta concentrations, tritium, and specific gamma isotopes on a quarterly basis. The monitoring wells are sampled at frequencies ranging from quarterly to annually.

Environmental sampling is performed not only as a monitoring function of the disposal facility, but also to establish a baseline body of data for comparison should circumstances dictate a need for concern.

VIII. SAFETY AND SECURITY

Safety at the Barnwell disposal facility is provided by the site's radiation safety officer (RSO) and associated Health Physics, Regulatory Affairs and supervisory staff. The radiation safety officer develops, establishes and implements safety procedures that all personnel must follow. Periodic training of site personnel is conducted and documented to assure compliance with all applicable work procedures.

CNS and DHEC personnel closely observe use of equipment during construction and off-loading operations. Strict adherence to established safety policies is mandated by DHEC and CNS. Health and safety procedures are enforced by CNS Health Physics (HPs) personnel. The HPs are present whenever radioactive material is handled or transferred, and they perform surveys on all incoming and outgoing vehicles. In addition, HPs enforce site radiological control policy by restricting access to certain areas as necessary and controlling trench operations. DHEC's resident on-site inspector, in addition to DWM central office staff, also ensures compliance with all health and safety requirements.

Security at the site is controlled through a number of mechanisms including the use of fences, locks, cameras and security officers. The CNS Security Department consists of personnel trained to South Carolina law enforcement standards. Each officer also is trained in basic first aid and emergency response procedures. The mission of these officers is to safeguard against unauthorized entry into the site and unauthorized removal of radioactive material from the site. They control access to the administrative area and to the disposal area. Following the terrorists events of September 11, 2001, DHEC required that CNS review their security and make necessary improvements to prevent access by terrorists to licensed radioactive material at the site. In December 2005, additional specific security requirements were added to the disposal site license. Security details are controlled similarly to safeguard information and are provided only to individuals with a need to know.

IX. QUALITY ASSURANCE

All workmanship at the disposal site requires quality control. Quality Assurance (QA) and other CNS staff provide additional oversight pertaining to construction, incoming transportation vehicles, site equipment and actual waste disposal. Inspectors document and maintain records of all quality control inspections. The quality assurance program is proactive, and input on procedures and safety is actively solicited from the facility staff through scheduled safety meetings and other internal programs.

X. LOW-LEVEL WASTE DISPOSAL PACKAGE HANDLING

The handling procedures of various packages require different approaches based on container type and varying dose rates. Various types of equipment are maintained permanently at the disposal facility to facilitate ease of off loading operations. Metal drums and boxes are transported mainly in closed vans and on flatbed trucks. Upon receipt and inspection, most drums and boxes are removed by forklift and placed in trench vaults by crane. Carbon steel liners and high integrity containers (HICs) are usually transported within specialized casks on flatbed trailers. Transportation casks provide radiation shielding from the higher radiation doses associated

Transport Vehicle in position for removal of LLRW container prior to disposal in a B/C Trench.

High Integrity Container of Class A LLRW being placed in a cylindrical disposal vault.

with these types of packages. Both liners and HICs are equipped with a disposable sling, cable, or other approved lifting device that can easily be attached and removed from a crane's lifting device. HICs and liners are removed directly from the transport vehicle and placed in trench vaults. Radiation exposure to site workers is controlled by HPs at each trench using shipment paperwork, radiation work permit protocols, and direct radiation measurement through survey instruments and personal dosimetry.

Slit trench shipments and large reactor components are less common packages and require special handling. Slit trench shipments involve packages that are classified as Class C waste and have high radiation exposure rates. Due to these high exposure rates, heavy shielding, specialized offloading procedures and remote operations are required for disposal. Backfilling over slit trench shipments begins immediately after package placement to reduce radiation exposure at the trench. Large reactor components also are accepted for disposal at the Barnwell facility. These components include steam generators (heat exchangers), pressurizers and reactor vessels. The components contain low overall specific activity and are disposed of in an active Class A Trench. The main challenge for successful disposal of these components is the use of adequate heavy transport vehicles and competent specialists required for interstate transportation. Coordination and planning between CNS, state, federal and utility representatives is essential.

XI. DHEC'S ROLE IN LLRW DISPOSAL

Licensing

After thorough review of CNS's application, DHEC issued a radioactive material license (South Carolina Radioactive Material License #097) to the company in 1970 for the purpose of LLRW storage. Additional amendments to this license resulted in the disposal operation that continues today. The continued successful licensing of the Barnwell LLRW Disposal Facility requires thorough review and knowledge of current federal regulations, site characteristics and applicable operational procedures. Every five years CNS is required to renew their license in its entirety. Upon receipt of the license renewal application, all aspects of facility operation are subject to review and revision. View a (PDF) copy of the current **operating license for the Barnwell facility**.

Permitting

Prior to a generator shipping LLRW to the Barnwell facility, an application for a **South Carolina Radioactive Waste Transport Permit** (PDF) must be obtained and submitted for DHEC review and acceptance. The permits are valid for the calendar year in which they are issued. Before the permit is issued, the shipper must deposit and maintain with DHEC a cash or corporate surety bond in the amount of $500,000 or provide to DHEC satisfactory evidence of liability insurance of $500,000 per occurrence and $1 million aggregate, or as otherwise provided by state law. The shipper certifies that it will comply with all applicable state or federal laws, licenses, or license conditions and disposal facility requirements.

Rad Bits

DHEC's resident inspector at the Barnwell disposal facility performs inspections of every waste shipment that comes to the facility.

Rad Bits

All shipments of radioactive waste to the Barnwell Facility are inspected to insure that regulatory radiation exposure limits are not exceeded.

In addition, a permit fee is assessed based on a classification system defined by the generator's projected waste disposal volume. The DWM maintains a staff of permitting specialists who review application information, confirm evidence of adequate liability insurance and issue permits.

Engineering

The DWM maintains a staff of environmental engineering associates to perform technical and licensing reviews, and it provides weekly inspections of disposal facility operations. Overall site condition, drainage, construction and disposal activities are included in the scope of these inspections. All inspections of the site are documented. Upon submittal, the DWM engineering staff reviews all site construction plans and activities prior to and during implementation. This includes oversight of trench construction, site stabilization operations and surface water management. CNS procedures are reviewed periodically. A physical copy of all CNS procedures and policies is maintained at the DWM offices. These documents are subject to review and revision as deemed necessary. Review of environmental sample analysis data is performed, documented and interpreted for compliance.

Inspections

The DWM maintains a staff of health physicists who ensure that waste shipments comply with all applicable regulations, laws and licensing conditions through inspection of all incoming waste shipments. A resident inspector is assigned to the Barnwell facility.

As each transport arrives, the resident inspector checks the vehicle for compliance with U.S. Department of Transportation and state regulations. At the same time, inspections are conducted for packaging, radiological exposure, content and shipping environment. This assures compliance with applicable regulations and site criteria. A physical inspection of the packaging is usually performed. At the direction of the state inspector, inspections of the contents of the waste disposal package may also be performed. Visual inspections of shipping casks are performed to ensure proper installment of the attachment cables (tie downs), rain cover, impact limiter and associated bolts.

Radiological compliance inspections are performed by surveying the outer surfaces and cab of each vehicle with a Geiger-Mueller (GM) survey meter, commonly known as a "Geiger Counter." This instrument detects radiation and approximates the exposure rate. Any measurements approaching regulatory limits are re-surveyed using an ion chamber type survey instrument. This instrument gives a qualitative exposure rate as it relates to absorbed dose. In addition to radiological surveys, wipe tests are performed on the vehicle surfaces and packaging to confirm the absence of significant removable contamination.

DHEC inspector performs radiological survey of transport vehicle upon receipt at the Barnwell facility.

Shipping papers of incoming LLRW shipments are meticulously reviewed by the DWM inspector and CNS staff. Specific activity, weight, physical and chemical forms and other defining parameters are compared with the shipper's stated radiation levels and radionuclide composition. If any discrepancies are suspected, packages can be physically inspected to determine compliance with waste acceptance criteria. For example, manifested waste data is closely monitored to determine if liquids may be present. If liquids are suspected, the package in question may be placed in the site liner punch. The liner punch system uses a series of hydraulic rams to puncture the package and remove and collect any liquid for measurement. Once a package has undergone the inspection process and has been determined to be in compliance, it is properly sealed and disposed of. DHEC and the waste generator are notified if a shipment discrepancy is found during an inspection.

Random physical inspections of packages also are performed on a fixed schedule by CNS with the DWM inspector usually present. CNS is required

Hydraulic Liner and Drum puncture equipment is utlized to assure that no excessive liquids are present within waste packaging.

by regulation to inform DHEC of waste shipment discrepancies observed during the course of disposal operations.

In addition to transportation inspection activities, the DWM performs unannounced, semi-annual inspections of the entire site and disposal operation. The inspection encompasses a thorough audit of all aspects of CNS' radioactive material license requirements and their compliance with applicable regulations. CNS personnel are observed performing their respective responsibilities to ensure that all health and safety practices are followed. Radiological monitoring of open trenches is closely observed to assure minimal radiation exposure to both workers and the environment. The license inspection is documented, and any deficiencies are brought to the attention of CNS management for their response and follow-up.

Compliance

The DWM administers the enforcement of regulations applicable to CNS and LLRW generators. Violations of transportation regulations and site waste acceptance criteria are documented by the inspector, and enforcement actions are taken. In the case of serious violations, a monetary penalty and/or suspension of a waste generator's transportation permit may be imposed. A waste generator found to be in violation of applicable regulations is afforded an opportunity to observe questionable packages prior to any enforcement actions. In addition, after a penalty is assessed, an appeal process can be initiated through application within a specified time. Regardless of severity level, all transportation and waste acceptance criteria violations require some response from the responsible party to assure DHEC that corrective measures have been instituted to preclude repeat violations.

CNS, as a radioactive materials licensee, has a documented history of exceptional regulatory compliance. The overall safe operation of the site has been commended repeatedly by the state's Department of Labor. This is not to imply that no infractions of applicable regulations have occurred in the past, just that the significance of cited discrepancies has been minor. CNS's radioactive material license subjects them to the same enforcement system used for other DHEC licensees.

XII. ENVIRONMENTAL IMPACT

Performance criteria for LLRW disposal facilities are detailed in state and federal regulations. To demonstrate that the Barnwell disposal facility will continue to meet regulatory standards for performance, assessments are performed and reviewed by DHEC.

In 2000, Chem-Nuclear prepared and submitted to DHEC the **Environmental Radiological Performance Verification of the Barnwell Waste Disposal Facility (ERPV)** (PDF) . This performance assessment was prepared at the direction of DHEC with consultation from the U.S. Nuclear Regulatory Commission. DHEC formed a Blue Ribbon Panel of national experts to assist in the review of the ERPV. The ERPV demonstrated that the disposal site will meet the performance objectives in the regulation during operations and after closure.

The U.S. Nuclear Regulatory Commission performed a study in 1981 for DHEC, **Environmental Assessment for the Barnwell Low-Level Waste Disposal Facility, NUREG-0879, Pub. 1982** (PDF). CNS performed an independent study at about the same time. The results of the two assessments are very compatible, finding little reason for concern over significant radionuclide migration to existing drinking water supplies. In addition, the U.S. Geological Survey has spent years studying the site's geohydrological conditions and have concluded that the site is adequate for the disposal of LLRW.

The effects to air quality in the area have been determined to be negligible. Radiological air monitoring is performed by CNS both on- and off-site. The main concern of air quality impacts involve non-radiological fugitive dust and gaseous pollutants. These are often the result of the dirt roads used on-site, trench construction, and capping activities. CNS's operation modes have kept these impacts to a minimum.

Direct exposure from gamma radiation is highest in the immediate area of the open trenches. The trenches are posted radiation areas, and site access is restricted. The direct radiation levels at the site boundary are monitored continuously using TLDs. TLD analysis results indicate that the actual radiation dose to any member of the public is well below regulatory limits.

The exposure pathways that may potentially occur after closure of the Barnwell facility are release of material into the groundwater and inadvertent intrusion into the waste. Subsidence of a trench could allow some release of radioactive material to the air, but this is unlikely due to the enhanced permanent caps and maintenance, which will continue during the institutional control period. Groundwater migration of radionuclides is probably the most likely of off-site release possibilities. However, due to the enhanced capping currently employed, this would be an unlikely event.

In 1978, during routine groundwater monitoring, tritium was detected in monitoring wells at the Barnwell facility. Tritium is a radioactive form of hydrogen. It migrates by replacing ordinary hydrogen in a water molecule. Tritium has moved with the groundwater away from the disposal area. Various remediation efforts were made during the 1980s, but were not completely successful. Since 1987, CNS has implemented a field and environmental monitoring program aimed at identifying the extent of tritium movement.

During 1991, CNS installed the first enhanced trench cap over 12.5 acres of completed trench area suspected of being the tritium source. The cap was designed to eliminate virtually all rainfall infiltration and thereby reduce further tritium migration from these early trenches. Current environmental monitoring data has indicated that water infiltration has been successfully mitigated in this particular completed trench area. The success of this initial enhanced capping project led to its continued application on-site. So far, approximately 80 percent of the disposal area has been capped.

XIII. LLRW TRANSPORTATION IMPACT

The Barnwell disposal facility is accessed only by highway. Some large reactor components have been transported to locations near the facility by rail and barge, but have been transferred to heavy haul vehicles prior to arriving for disposal. There are many individual carriers of LLRW. All must comply with the state and federal regulations pertaining to the shipment of radioactive materials.

The effects to the general population from the transportation of LLRW have been found to be negligible. Although radiation exposure is measurable on the external surfaces of LLRW transport vehicles, the minimal time spent in the vicinity and the relative distance of the public from these vehicles during travel negates any measurable exposure one might receive.

Only a few accidents involving LLRW shipments have occurred in the past, but no injuries or fatalities have been induced by the radioactive material. There has not been a release of radioactive material from a LLRW shipment involved in an accident in South Carolina to date. The only impact of these shipments is increased truck traffic on certain roads, causing increased deterioration and maintenance costs. However, road use taxes paid by carriers help offset these factors.

XIV. THE FUTURE

DHEC has planned carefully for the continued maintenance of the Barnwell facility after its closure and decommissioning. Decommissioning and long term maintenance care funds have been established with the State Budget and Control Board and are on deposit with the state treasurer. These are dedicated funds that are invested and accrue interest. They will be used to provide expertise, equipment, environmental monitoring, maintenance and security.

FIGURE 8

Expected Decay Schedule

Barnwell Disposal Site

Perpetual care of the site will be performed by the State of South Carolina for a period of several hundred years, after which time the area may be released for use. In the interim, however, the area could have limited use by the state.

During the early 2000's, approximately $75 million was removed from the long term maintenance care fund by the S.C. General Assembly. Commitments to repay the fund were included, along with acknowledgement that the state would be responsible for the amount of money removed from the fund. **In 2005, the legislature returned approximately $25 million to the fund** (PDF).

Prior to releasing the site, all equipment will either be decontaminated as necessary or disposed of. The area will be graded so that water continues to drain away from the trenches to minimize erosion. CNS also must supply documented proof that all trench bottoms are above the water table taking into account seasonal fluctuations and extreme events. A passive site security system will remain in effect and must require minimum maintenance.

Upon final closure of the facility, DHEC will oversee the decommissioning and final site stabilization. The land will be stabilized according to a pre-developed plan drafted by CNS and approved by DHEC. The plan must incorporate schedules for closure, estimated costs for passive maintenance of buffers and trench caps and an environmental monitoring plan. The final draft must be submitted no later than one year prior to closure.

V. SUMMARY

The regulatory control that DHEC exercises at the Barnwell facility is broad, and the authority is shared, to a lesser extent, by such agencies as the U.S. Nuclear Regulatory Commission and the U.S. Department of Transportation. By working with these agencies and CNS, a comprehensive shipment inspection program has been implemented, long-term environmental monitoring programs continue, and internal controls within the company have been established to make disposal of LLRW as safe as possible. The evolution of commercial LLRW management has developed markedly within the commercial nuclear industry. Similar to the evolution of manned flight, the discovery of radiation and knowledge of its risks and beneficial applications have been understood by man less than 100 years. While far from being perfected, techniques for the safe use of radioactive materials and the associated management of LLRW have evolved and continue to improve.

This publication is intended to familiarize the reader with commercial low-level radioactive waste disposal in South Carolina. DHEC realizes that the public may have questions or concerns that may have not been addressed herein. If further information is needed, we ask members of the public to write to the Director, Division of Waste Management, Bureau of Land and Waste Management, S.C. Department of Health and Environmental Control, 2600 Bull Street, Columbia, SC, 29201.

Glossary

A

Activity–The rate of transformation (or "disintegration" or "decay") of radioactive material. The units of activity are the Curie (Ci) and the Becquerel (Bq).

Agreement State–A state which has entered into an agreement with the U.S. Nuclear Regulatory Commission (NRC) in which the Commission relinquishes regulatory control over certain activities involving the use of radioactive materials in the state. South Carolina is an Agreement State and therefore exercises regulatory authority over the Barnwell disposal facility within the guidelines of applicable federal regulations and state statutes.

ALARA–(acronym for "as low as reasonably achievable") Making every reasonable effort to maintain exposures to radiation as far below the dose limits as practical. This important principle is practiced at the Barnwell disposal facility and throughout the nuclear industry.

Alpha Particle– A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. An alpha particle is essentially two protons and two neutrons. Alpha particles travel short distances and can be stopped by a sheet of paper due to their relatively large size.

Atom–The smallest particle of an element that can not be divided or broken up by chemical means. It consists of a central core called the nucleus which contains protons and neutrons. Electrons revolve in orbits surrounding the region of the nucleus.

B

Background Radiation–Radiation that occurs naturally in the environment. Background radiation, also called natural radiation, consists of cosmic radiation from outer space, radiation from the radioactive elements in rocks and soil, and radiation from radon and its decay products in the air we breathe. The average background radiation level across the U.S. is about 350 mRem.

Beta Particle–A negatively charged particle that is emitted by certain radioactive atoms. It is essentially an electron that has been ejected from an atom.

C

Calibration–The check or correction of the accuracy of a measuring instrument to insure proper operational characteristics.

Carrier–Private companies which transport low-level radioactive wastes to the Barnwell disposal facility. All LLRW entering the Barnwell facility for disposal is transported by specialized trailers, flatbed trucks or closed vans.

Cask–A heavily shielded container used to store and/or transport radioactive materials. Lead and steel are common materials used in the manufacture of casks.

Contamination, radioactive–The presence of unwanted radioactive material on the surface of or within structures, areas, objects or personnel.

D

Decay, radioactive–The decrease in the amount of any radioactive material with the passage of time due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation or rays.

Decay Product or "Daughter" Product–The nuclide produced by the transformation of a radioactive nuclide.

Decontamination, radioactive–The reduction or removal of contaminating radioactive material from a structure, area, object or person. Decontamination may be accomplished by 1) treating the surface to remove or decrease the contamination, or 2) letting the material stand so that the radioactivity is decreased as a result of radioactive decay.

Disposal Vault–Engineered concrete containers used to provide structural stability for waste disposal containers and to support the weight of the engineered trench caps.

Dose, radiation–A generic term that denotes the quantity of radiation (or energy) absorbed by living tissue.

E

Electron–A negatively charged particle found in the region outside the nucleus of an atom. Electrons are in constant motion and are several thousand times smaller than protons and neutrons.

G

Gamma Ray or Gamma Radiation–High energy, short-wavelength electromagnetic radiation emitted from the nucleus of an atom. Gamma ray emission frequently occurs along with the emission of alpha or beta particles. Gamma rays are very penetrating and are best stopped or shielded by dense materials such as lead or uranium. They are identical to x-rays, but originate specifically in the nucleus instead of the atom in general.

Geiger Mueller Counter–One of several types of instruments that detects and measures ionizing radiation. Also called a Geiger Counter or G-M Counter.

H

Half-life–The time taken for one half the activity of a radioactive material to decay. Half-lives can range from seconds to billions of years depending on the radionuclide.

High-Density Polyethylene (HDPE)–A type of strong plastic used as the primary barrier for prevention of water infiltration into completed trenches.

I

Ionization Chamber–One of several types of instruments that detects and measures ionizing radiation.

Ionizing Radiation–Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions (charged particles). Examples: alpha particles, beta particles, gamma rays, x-rays, and neutrons.

Isotope–One of two or more atoms with the same number of protons, but different numbers of neutrons in their nuclei. Thus, carbon-12 (6 protons + 6 neutrons), carbon-13 (6 protons + 7 neutrons), and carbon-14 (6 protons + 8 neutrons) are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have similar chemical properties, but often have different physical properties. In this example, carbon-14 is radioactive, but the other two are stable.

M

Mil–Unit of measurement used to define thickness. A mil is equal to one thousandth of an inch.

Millirem–A unit for measuring absorbed doses of radiation. It is equal to one thousandth of a rem.

N

Neutron–An uncharged particle about the same size as a proton that can be found in the nucleus of atoms.

Non-ionizing Radiation–Radiation that is not capable of producing ions. Examples: radio waves, visible light rays, UV rays.

Naturally Occurring Radioactive Material (NORM)–A radiation source that occurs naturally in the environment. NORM can be found in rock and soil formations. The most common form of NORM that impacts public health is in the form of radon gas and its decay products in the air we breathe.

P

Proton–A particle having a positive electrical charge found in the nucleus of atoms. It is about the same size as a neutron.

R

Radiation–Emission or propagation of energy in the form of rays or waves.

Radionuclide–A general term referring to any known radioactive isotope.

Rem (Roentgen Equivalent Man)–A unit for measuring absorbed doses of radiation, equivalent to one roentgen of x-rays or gamma rays. The comparable S.I. unit (System International) is the Sievert.

S

Sievert–A unit for measuring absorbed doses of radiation, equivalent to one roentgen of x-rays or gamma rays. The comparable English unit is the rem.

Standpipe–A pipe placed vertically in the trench sumps and extending above the trench cap that facilitates collection of water samples. These samples are then analyzed for radiological and non-radiological contaminants.

Sump–A low-lying area in the bottom of the trench, accessed by standpipes, that serves as a collection point for the trench drainage system.

T

Thermoluminescence Dosimeter (TLD)–A crystalline material which, when heated after having been exposed to radiation, emits light in proportion to the radiation dose previously received. Lithium fluoride chips are used at the Barnwell facility to measure ambient gamma exposure.

W

Waste, radioactive–Solid, liquid and gaseous materials from nuclear operations that are radioactive, or become radioactive, for which there is no further use. Wastes are classified as high-level (spent nuclear fuel), transuranic (waste containing primarily radioactive elements heavier than uranium) or low-level (all other radioactive waste).