Sealed Source Disposal and National Security – Problem Statement and Solution Set

Deliverable (Part 1) of the Removal and Disposition of Disused Sources Focus Group of the Radioisotopes Subcouncil of the Nuclear Government and Sector Coordinating Councils

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Foreword

The closure of the low-level radioactive waste disposal site in Barnwell, South Carolina in July 2008 to out-of-compact waste, coupled with other challenges to the disposition of low-level radioactive waste, has increased concerns in the public and private sectors about the security of disused radioactive sealed sources without a disposal pathway. During their service lives, radioactive sealed sources provide numerous essential and beneficial medical, industrial, and research applications. After their service lives have ended, these radioactive sealed sources make up less than 1% of all low-level radioactive waste (LLRW) by volume and activity. However, due to their highly concentrated activity and their portability, some of these sources could be used—either individually or in aggregate—in radiological dispersal devices commonly referred to as "dirty bombs." Thousands of radioactive sealed sources each year become disused. However, as of July 2008, only 14 states have access to disposal facilities for sealed sources classified as LLRW.

In response to these concerns, the Nuclear Government Coordinating Council (NGCC) and Nuclear Sector Coordinating Council (NSCC), through the Department of Homeland Security's Nuclear Critical Infrastructure Protection Advisory Council (CIPAC), created the Removal and Disposition of Disused Sources Focus Group ("Focus Group") in February of 2009. The objective of the public and private sector collaboration in the Focus Group is to fully characterize the challenge, develop a consensus problem statement, explore medium and long-term solutions, and recommend to the NSCC and NGCC a messaging strategy for communicating with the appropriate stakeholders to implement a solution. This whitepaper serves as the first part of that deliverable. It includes a consensus view of the scope and character of the challenge, a consensus problem statement, and a consensus determination of options from which specific solutions can be further explored and identified. The Focus Group will continue its work in the coming months to accomplish the second part of the deliverable—explore potential solutions to the problem and a messaging strategy for use by the NSCC-NGCC.

This paper is intended not only to inform the NSCC and NGCC, but also to be used as a communication tool for those seeking to engage public and private stakeholders about the sealed source disposal challenge and potential solutions. It represents a consensus view of Focus Group participants, but does not necessarily reflect their respective agencies' or organizations' positions.

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Removal and Disposition of Disused Sealed Sources Focus Group

In September 2008, the Department of Homeland Security (DHS), under the auspices of the Nuclear Critical Infrastructure Partnership Advisory Council (CIPAC), facilitated a public and private sector Sealed Source Security Workshop. Workshop participants, including Federal, State, local, and private sector stakeholders, identified the lack of a commercial disposal pathway for disused radioactive sealed sources, a subset of Low-Level Radioactive Waste (LLRW), as a potential national security concern.

In December 2008, the Nuclear Government Coordinating Council (NGCC) created a Removal and Disposition of Disused Sources Focus Group ("the Focus Group") within the CIPAC framework in order to more fully characterize the issue, explore potential solutions, and to recommend to the NGCC a messaging strategy for communicating with the appropriate stakeholders to implement a solution. This whitepaper serves as the first part of that deliverable.

The Focus Group has met on a monthly or semi-monthly basis since February 2009 and has included members of the NSCC and NGCC, as well as subject matter experts (SMEs) from across the radioactive sealed source stakeholder community, including manufacturers, distributors, users, storage and disposal companies, regulators, other Federal and State officials, and LLRW compact members. This whitepaper represents a consensus view of these participants, but does not necessarily reflect their respective agencies' or organizations' positions. The Focus Group participants are listed in Appendix A.

In addition to ensuring that sealed sources have commercial disposal access, there are a number of further considerations that are important to the safety and security of radioactive sealed sources that are beyond the scope of this Focus Group. These considerations include transportation limitations (including a shortage of available transportation packages for some sources), financial considerations for disposal, security in storage, import and export controls, and alternative technologies.

Radioactive Sealed Sources: What They Are and What They Are Not

- Radioactive sealed sources **are** the discrete, often encapsulated radioactive materials used in many applications, such as blood and food irradiators, well-logging devices, and moisture density gauges.
- Radioactive sealed sources **are not** items such as pieces of radioactive reactor components, radioactively contaminated clothing and equipment, or spent nuclear fuel.
- Sealed sources comprise less than 1% by volume and activity of all LLRW.

Radioactive Sealed Sources and Low-Level Radioactive Waste

Radioactive sealed sources are widely used for a variety of essential medical, industrial, and research purposes. Table 1 on the next page describes common medical and industrial uses of radioactive sealed sources. When these sources come to the end of their service lives, many are classified as LLRW. Most LLRW *by volume* is comprised of objects containing relatively low level of radioactive material from nuclear facilities (such as pieces of radioactive reactor components and radioactively contaminated clothing and equipment). In contrast, radioactive sealed sources are generally small capsules or manufactured items that contain relatively high concentrations of radioactivity.

Due to the small size and high radioactivity of some commonly used sealed sources, they are of particular concern from a public health, safety, and national security standpoint. If used—either individually or in aggregation—in a radiological dispersal device (RDD) or "dirty bomb", these sources could cause billions of dollars worth of contamination and result in serious health consequences for exposed individuals.[1] In addition, these sources, if misplaced or improperly removed from their shielding, mistakenly melted into scrap metal, or otherwise breached or damaged, could cause millions of dollars worth of contamination damage or cause serious burns and high radiation doses to exposed individuals.[2]

Table 1. Widely Used Radioactive Sealed Sources

Device	Radionuclide	Typical Activity in Curies (Ci) Range	IAEA Source Category[a]	Waste Class[b]
Panoramic irradiators used to irradiate single-use medical devices and products, cosmetics, food, and plastics.	Cobalt-60	150,000 - 5,000,000	1	B
Self-shielded irradiators/blood-tissue irradiators.	Cesium-137	2,500-42,000	1,2	B, C, GTCC
	Cobalt-60[c]	1,500-50,000	1	
Gamma knife (fixed, multibeam teletherapy).	Cobalt-60	4,000-10,000	1	B
Teletherapy, which uses radiation directed at a human or animal body to treat many serious diseases, most notably cancer.	Cesium-137	500-1,500	2	B, C
	Cobalt-60	1,000-15,000	1	
Calibration sources, generally used to calibrate various radiation measuring and monitoring instruments	Americium-241	1-25	2,3,4	A, B, C, GTCC
	Cesium-137	1.5-14,000	1,2,3,4	
	Cobalt-60[c]	0.55-16,000	1,2,3,4	
	Plutonium-239/ Beryllium	2-25	2,3	
	Strontium-90	0.05-2	4	
Industrial radiography widely used in the chemical, petrochemical, and building industries for radiographic inspection of pipes, boilers, and structures where consequences of failure can be severe.	Cesium-137	5-12	3	A, B, C, GTCC
	Cobalt-60[c]	11-330	2	
	Iridium-192	5-290	2,3	
	Selenium-75	80	2	
	Thulium-170	20-200	4	
	Ytterbium-169	2.5-20	3,4	
Fixed industrial gauges (level, dredger, conveyor, blast furnace, and spinning pipe) used for a wide variety of industrial and manufacturing purposes, primarily to monitor production processes.	Cesium-137	0.1-40	2,3,4	A, B, C, GTCC
	Cobalt-60[c]	0.1-20	2,3,4	
	Plutonium-238	20	2	
	Californium-252	0.034	4	
	Krypton-85	0.05-1	5	

1. Cousins, Tom and Barbara Reichmuth, "Preliminary Analysis of the Economic Impact of Selected RDD Events in Canada", presentation at the CRTI Summer Symposium 2007, Gatineau, Quebec, 11-14 June 2007 (CRTI 05-0043RD). Luna, Robert E., H. Richard Yoshimura and Mark S. Soo Hoo, *Survey of Costs Arising From Potential Radionuclide Scattering Events*, paper presented at the Waste Management Forum, Phoenix, AZ, February 24-28, 2008, available at http://www.energy.ca.gov/nuclear/yucca/documents/AG-155-2007-005295.pdf. Reichmuth, B., S. Short, and T Wood, *Economic Consequences of a Rad/Nuc Attack: Cleanup Standards Significantly Affect Cost,* Richland, WA: Pacific Northwest National Laboratories, 2005 (PNNL-SA-45256). Sheely, Kenneth, NNSA Associate Assistant Deputy Administrator, Global Threat Reduction Initiative, testimony before the House Committee on Homeland Security, Subcommittee on Emerging Threats, Cybersecurity, and Science and Technology, available at http://www.nnsa.energy.gov/news/print/2541.htm.

2. Charles D. Ferguson, Tahseen Kazi, Judith Perera, *Commercial Radioactive Sealed Sources: Surveying the Security Risks*, Center for Non-Proliferation Studies Occasional Paper No. 11, 2003, page 23, available at http://www.ead.anl.gov/pub/doc/rdd.pdf). International Atomic Energy Agency, *Reducing Risks in the Scrap Metal Industry: Radioactive Sealed Sources*, IAEA/PI/A.83 / 05-0951, 2005, page 5, available at http://www.iaea.org/Publications/Booklets/SealedRadioactiveSources/pdfs/handout_scrap.pdf.

Table 1. Widely Used Radioactive Sealed Sources (cont.)

Device	Radionuclide	Typical Activity in Curies (Ci) Range	IAEA Source Category[a]	Waste Class[b]
Well-logging sources used for characterizing subsurface properties such as density and moisture percentages. Most commonly associated with oil and mineral exploration.	Americium-241/ Beryllium	0.5-20	2,3,4	A, B, C, GTCC
	Californium-252	0.027-1.61	3,4	
	Cesium-137	0.5-20	3,4	
	Cobalt-60[c]	1-20	2,3	
	Plutonium-238/ Beryllium	5-70	2,3	
	Radium-226	20	2	
	Tritium	1-20	5	
Brachytherapy (high, medium and low dose rate), which uses either beta or gamma sources to irradiate tumors over a very small area and thickness of tissues.	Cobalt-60[c]	1-20	2,3	A, B,C, GTCC
	Cesium-137	0.1-8	3,4,5	
	Iridium-192	0.02-15	3,4,5	
	Radium-226	0.005-0.05	4,5	
	Iodine-125	0.005-1.3	4,5	
	Gold-198	0.08	4	
	Californium-252	0.083-0.54	3,4	
	Strontium-90	0.02-0.12	4,5	
	Ruthenium/ Rhodium-106	0.00022-0.0006	5	
	Palladium-103	0.03-0.0056	5	
Cardiac pacemakers.	Plutonium-238	2.9-8	3	B, C GTCC
Research reactor startup sources.	Americium-241/ Beryllium	2-5	3	B, C, GTCC
Static eliminators used in the production of paper, textiles, plastic and electrical circuits. They are particularly useful in hazardous areas where electrical devices cannot be used.	Americium-241/ Beryllium	0.03-0.11	4	A, B, C, GTCC
	Polonium-210	0.03-0.11	4	
Portable gauges (moisture and density) used in the field at construction sites and on farms. The gauges are typically used to determine the moisture and density of a material such as soil or asphalt.	Americium-241/ Beryllium	0.01-3	3,4,5	A, B, C, GTCC
	Cesium-137	0.008-0.011	5	
	Radium-226	0.002-0.005	5	
	Californium-252	0.00003-0.00007	5	

a The International Atomic Energy Agency (IAEA) categorization system is based on “the potential for radioactive sources to cause deterministic health effects. This potential is due partly to the physical properties of the source, especially its activity, and partly to the way in which the source is used.” See, IAEA Safety Guide No. RS-G-1.9, Categorization of Radioactive Sources 2005, Annex I, page 37, available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1227_web.pdf.

b Refers to Nuclear Regulatory Commission’s (NRC’s) classification of LLRW for land disposal found in 10 CFR Part 61. Activity per unit mass or volume classification limits are related to relative hazard and necessity for waste isolation. Class A represents the least hazard, Class B represents a greater hazard, and Class C the greatest hazard appropriate for near surface disposal. Waste with an activity concentration Greater-Than-Class-C (GTCC) must be disposed of in a geologic repository unless NRC approves an alternate disposal site.

c There are no limits established for cobalt-60 in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 2 in 10 CFR § 61.55 determine the waste to be Class C independently of these nuclides.

Sealed Source Security

Due to the potential public health, safety, and national security concerns of lost or stolen sealed sources, the sealed source community—including sealed source manufacturers, distributors, and users, Federal, State, and local officials, and those involved in the radioactive waste storage and disposal industry—encourages sealed source users to permanently dispose of sources that are no longer in use and cannot be recycled. The Interagency Radiation Source Protection and Security Task Force's ("Task Force") *2006 Report to Congress and the President* ("Task Force Report") notes that "holding a source in storage longer than 24 months usually indicates the lack of a strategy to use or dispose of the source."[3]

The Task Force has also described the potential risk posed by a lack of sealed source disposition options. The Task Force Report notes that "either a lack of legal disposal path or high costs because of a lack of adequate disposal options is causing some licensees to store their unused or unwanted sources until the disposal situation improves. Providing adequate disposal for these sources will have a much greater effect on reducing the total risk of long-term storage (by reducing the number of sources in long-term storage) than any additional changes to the storage requirements."[4] In addition, reducing the number of sources in storage will reduce the number of storage locations, thereby decreasing the number of attractive targets for those who seek to illegitimately procure a sealed source for malicious purposes.

Finally, the Task Force Report notes that "lifecycle management of risk-significant radioactive sources is key to preventing sources from becoming abandoned, lost, or diverted for malicious use,"[5] and the Government Accountability Office (GAO) has noted that "domestic and international experts contend that the lack of disposal availability for unwanted sealed radiological sources makes them more vulnerable to abandonment, misplacement, and theft that would pose a safety and security risk."[6]

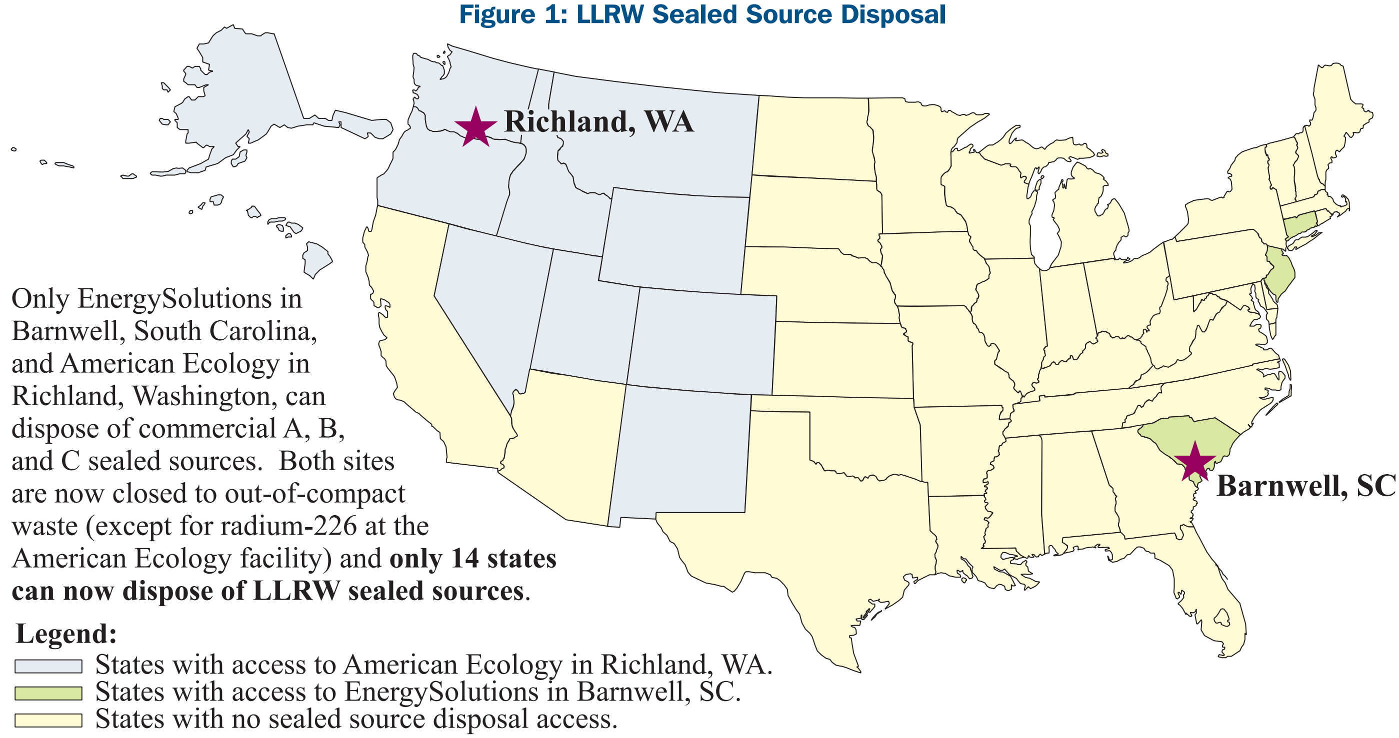
Current Challenges to Sealed Source Disposal

The Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA), which amended the *1980 Low-Level Radioactive Waste Policy Act,* assigned separate responsibilities to the states and the federal government for disposal of low-level radioactive waste. Under the *LLRWPAA*, States are responsible for providing disposal for Class A, B, and C low-level radioactive waste[7] in a facility licensed by either the NRC or an Agreement State.[8] The Department of Energy (DOE) is responsible for disposal of "greater- than-class C" (GTCC) low-level radioactive waste.[9]

As an incentive for states to manage LLRW waste on a regional basis, Congress consented in the *Omnibus Low-Level Radioactive Waste Interstate Compact Consent Act* (a part of *LLRWPAA*) to interstate agreements, known as compacts, and granted the compacts the authority to exclude LLRW from states outside of their compacts. The Atlantic Compact,

3. *Report of the Radiation Source Security and Protection Task Force*, August 15, 2006, page 83. As part of the *Energy Policy Act of 2005*, an Interagency Task Force for Radiation Source Protection and Security (Task Force) was created to report periodically to the President on these and other topics. The task force is chaired by the NRC and comprised of 14 federal agencies as well as State organizations. The Task Force released its initial report in August 2006 and will produce an updated report in August 2010.
4. *Report of the Radiation Source Security and Protection Task Force*, August 15, 2006, page 84.
5. *Report of the Radiation Source Security and Protection Task Force*, August 15, 2006, page 116.
6. Government Accountability Office, *DOE Needs Better Information to Guide Its Expanded Recovery of Sealed Radiological Sources*, (GAO-05-967), September 2005, pages 6-7.
7. According to section 3(a)(1) of the *LLRWPAA* (42 USC 2021c(a)(1)), States are responsible for Class A, B, and C LLRW generated by non-federal entities and most federal LLRW waste other than DOE owned/generated and U.S. Naval decommissioning LLRW.
8. Under the *Atomic Energy Act (AEA)*, the NRC is authorized to transfer some of its authority to the States on a state-by-state basis to regulate byproduct and source material and very small quantities of special nuclear material. These states are known as Agreement States. To date 37 States have become Agreement States.
9. *LLRWPAA* specifies that GTCC LLRW that results from NRC-licensed activities must be disposed of in an NRC-licensed facility.

Figure 1: LLRW Sealed Source Disposal



comprised of Connecticut, New Jersey and South Carolina, is served by the LLRW facility at Barnwell, South Carolina, which also accepted LLRW from states outside of the Atlantic Compact. In June 2000, South Carolina enacted legislation that restricted access to the Barnwell facility to Atlantic Compact states only, effective July 1, 2008. Appendix C to this document provides further background on the closure of Barnwell to waste generated outside the Atlantic Compact.

Barnwell's closure to non-Atlantic Compact States on July 1, 2008 has left LLRW generators in 36 states without a commercial disposal option for their disused sealed sources. As a result, LLRW generators in only 14 States have access to a disposal facility for Class A, B, and C disused sealed sources.[10] The remaining 36 states must store their LLRW disused sealed sources unless other disposition options are identified.[11] As depicted in the map in Figure 1, only two commercial disposal facilities (the facility operated by Energy*Solutions* in Barnwell, South Carolina and the facility operated by American Ecology in Richland, Washington) currently accept Class A, B, and C sealed sources from states within three of the regional compacts.[12] A third LLRW commercial disposal facility, operated by Energy*Solutions* in Clive, Utah, does not currently accept any sealed sources.

Furthermore, there is currently no disposal pathway for commercial sealed sources that are greater-

10. However, because of its relatively low activity limits, Barnwell does not accept most Class B and C LLRW sealed sources from Atlantic Compact states (see Table 2).

11. On September 10, 2009, the Executive Director of the Texas Commission on Environmental Quality (TCEQ) signed the final Radioactive Material License for the disposal of Class A, B and C low-level radioactive waste at Waste Control Specialists' (WCS) facility in Andrews County. The license allows WCS to operate two separate facilities for the disposal of Class A, B and C low-level radioactive waste—one for the Texas Low-Level Radioactive Waste Disposal Compact (which is comprised of Texas and Vermont), the other for waste designated as a federal responsibility under section 3(b)(1)(A) of the *LLRWPAA*.

12. Barnwell serves the Atlantic Compact states (Connecticut, New Jersey, and South Carolina) and American Ecology in Richland, Washington serves the Northwest Compact states (Alaska, Hawaii, Idaho, Montana, Oregon, Utah, Washington, and Wyoming) and the Rocky Mountain compact states (Colorado, Nevada, and New Mexico). The remaining 36 states are without a LLRW sealed source disposal option.

than-Class C (GTCC). DOE, which is responsible for GTCC disposal, is currently preparing an Environmental Impact Statement that analyzes alternatives for GTCC LLRW disposal. Table 2 demonstrates current commercial sealed source disposal landscape, including the Class A, B, C, and GTCC disposal limits for several commercially available sealed source radionuclides. DOE estimates that a GTCC LLW disposal facility could become available in approximately 10 years.

Table 2 – The Current Commercial Sealed Source Disposal Landscape

Radionuclide	Maximum Limit Allowed[a]			
	Non-GTCC Sources			GTCC Sources
	Barnwell Facility (3 States)	Richland Facility (11 States)	No Facility (36 States)	GTCC Facility[b]
Americium-241 Plutonium-238 Plutonium-239	10 nCi/gm	100 nCi/gm	No Disposal (ND)	>100 nCi/gm
Californium-252	10 Ci	13 Ci[c]	ND	Not applicable[d] (NA)
Curium-244	100 nCi/gm	100 nCi/gm	ND	>100 nCi/gm
Cobalt-60	10 Ci	145 Ci[c]	ND	NA[d]
Cesium-137	10 Ci	976 Ci	ND	>976 Ci
Iridium-192	10 Ci	13 Ci[c]	ND	NA[d]
Strontium-90	10 Ci	1,486 Ci	ND	>1,486 Ci
Radium-226	Disposal of radium-226 is available to all states at the Richland facility up to 1.2 Ci per source.[e]			NA[d]

Color Code	
Green	Disposal available commercially for Compact states up to maximum Class C limits for applicable radionuclides, considering concentration averaging.
Yellow	Disposal available commercially for Compact States but maximum limit is less than Class C limits for applicable radionuclides due to site-specific administrative limits, waste acceptance criteria, or license conditions.
Orange	Disposal capability being developed by DOE.[b]
Red	No disposal available.

a The maximum curie or activity limit allowed for an individual sealed source containing the specified radionuclide based on site-specific administrative limits, waste acceptance criteria, application of concentration averaging, or license conditions.

b A GTCC LLRW disposal facility does not currently exist; DOE is preparing an Environmental Impact Statement analyzing potential disposal alternatives for this waste. The maximum limit for the facility will be determined during the implementation and licensing phase for the selected alternative and will be greater than the Class C waste classification values shown in the Table (which assumes application of concentration averaging).

c The facility may accept sources in excess of this limit on a case-by-case basis based on worker exposure and other site-specific considerations.

d Sealed sources consisting of these radionuclides are not classified as GTCC LLRW when sent for disposal because there is no maximum Class C limit for the radionuclide or the radionuclide is not included in the list of radionuclides in 10 CFR § 61.55, Tables 1 and 2 that determine LLRW classification.

e Diffuse radium-226 is still considered naturally occurring radioactive material (NORM) for purposes of disposal, but discrete Ra-226 sources are now considered "byproduct material" per the NRC and compatible Agreement State regulations. However, the *2005 Energy Policy Act* has excluded radium-226 sources as LLRW, and some compact regulations still consider radium-226 containing waste as NORM. Disposal options are therefore still available to all states.

Removal and Disposition of Disused Sources – Problem Statement

The lack of disposal pathways for radioactive sealed sources, which make up less than 1% of all low-level radioactive waste by volume and activity, poses a national security concern. During their service lives, these sources have numerous essential and beneficial medical, industrial, and research applications. However, due to their high activity and portability, some of these sources could be used either individually or in aggregate in radiological dispersal devices commonly referred to as "dirty bombs," resulting in economic impacts in the billions of dollars and significant social disruption. Every year, thousands of sources become disused and unwanted in the United States. While secure storage is a temporary measure, the longer sources remain disused or unwanted the chances increase that they will become unsecured or abandoned. Thus, permanent disposal is essential. However, only 14 states currently have commercial LLRW sealed source disposal access, and there are significant political, statutory, and regulatory challenges associated with the creation of commercial disposal access for the remaining 36 states.

Current Trends in Sealed Source Disuse

Because sealed source licensees are not always required to report the reasons for keeping sealed sources in storage, it is difficult to know how many and what type of disused sealed sources are in storage as the result of the current lack of commercial LLRW disposition options. However, several initiatives to reduce the risk posed by storage of disused sources indicate the general magnitude of the problem.

The National Nuclear Security Administration (NNSA) Office of Global Threat Reduction (GTRI) Off-Site Source Recovery Project (OSRP) removes excess, unwanted, or orphaned radioactive sealed sources that pose a potential risk to public health, safety, and/or national security. The initial scope of the project included only GTCC sources. However, since the September 11 attacks, the mission has expanded to address broader public safety and national security requirements. In addition to disused GTCC sources, the expanded OSRP mission now includes recovery of a wide range of sources that, when designated as waste, would be classified as Class A, B, C, and GTCC low-level radioactive waste. GTRI prioritizes the recovery of registered disused radioactive sealed sources based on threat reduction criteria developed in coordination with the NRC.

The Conference of Radiation Control Program Directors (CRCPD) and GTRI have also collaborated to recover disused and orphaned sources through the Source Collection and Threat Reduction (SCATR) Program. SCATR's goal is to collect unwanted sealed sources that pose a potential threat to public health, safety, and national security. The CRCPD SCATR program is limited to non-actinide[13] sources less than 10 curies in activity. Examples of sources that would be eligible for the SCATR program include medical brachytherapy sources such as cesium-137 and radium-226, low-activity sources that exceed the NRC 120-day half-life limit for decay-in-storage, long half-life industrial sources, and calibration sources. Since its inception in 2007, the SCATR program has recovered 5,100 disused sources.[14]

In total, GTRI and its partners have been able to recover more than 22,000 sources representing over 700,000 curies from more than 700 sites in the United States. Many of these sources, if they had been lost or stolen and misused, could have caused the economic and health consequences described in the problem statement. Table 3 on the next page demonstrates the type, number, and radioactivity of the sealed sources recovered by GTRI since 1997.

13. Actinide sources include Americium, Plutonium, Curium, and Californium.

14. CRCPD also receives funding from the NRC for the CRCPD Orphan Source Program. Under the program, CRCPD recovers lower-activity unwanted beta/gamma sources. This program deals exclusively with "orphan" sources that no longer have a licensed owner.

Table 3 – GTRI/OSRP Sources Recovered 1997 to 2009

Radionuclide	Number of Sources	Percentage of Total Sources	Curies	Percentage of Total Curies
Americium-241	13,162	58.05%	14,722	2.06%
Plutonium-238	2,292	10.11%	11,479	1.60%
Plutonium-239	613	2.70%	768	0.11%
Curium-244	517	2.28%	54	0.01%
Californium-252	243	1.07%	<1	0.00%
Cesium-137	3,366	14.85%	18,658	2.61%
Cobalt-60	873	3.85%	77,350	10.81%
Radium-226	596	2.63%	5	0.00%
Strontium-90	55	0.24%	592,738	82.81%
Other radionuclides	955	4.21%	1	0.00%
Totals	**22,672**	**100%**	**715,775**	**100%**

In order to request that the GTRI recover a disused source through OSRP, the current owner must register the source with OSRP (http://osrp.lanl.gov). As of August 2009, there were over 9,000 sources registered, including americium-241, cesium-137, cobalt-60, radium-226 and other isotopes used in a wide variety of applications. On average, approximately 2,500-3,000 additional sealed sources are registered as unwanted each year. Since the closure of Barnwell, GTRI/OSRP has received numerous requests to accept sources that were formerly eligible for disposal at Barnwell, including thousands of additional smaller beta-gamma sources such as cesium-137 and cobalt-60.

In the course of its source recovery activities, GTRI/OSRP has identified three primary disposal-related challenges:

Disposal Challenge 1 – Lack of disposal for high-activity beta/gamma sources (primarily cobalt-60, cesium-137, and strontium-90) in wide use primarily in medical and industrial irradiation and power generation applications. Commercial disposal facilities have activity limits below those found in many of these types of devices, even when the sources are not GTCC.

There have been discussions in recent years about the future of cesium-chloride sources, including looking at the feasibility of phasing out highly dispersible forms of cesium-chloride. Appendix B to this document summarizes those discussions. If cesium-chloride is phased out or eliminated, the cesium-chloride disposal challenge could be exacerbated, depending on the rate at which cesium-chloride use is curtailed or eliminated.

Disposal Challenge 2 – Lower-activity beta/gamma sealed sources in the 36 states without disposal access. These sources are used in a wide variety of medical and industrial applications.

Disposal Challenge 3 – Sealed sources using foreign-origin americium-241. There is a significant increase in the amount of foreign-origin americium-241 material that is incorporated into U.S. manufactured sources used by U.S. licensees because the U.S. no longer produces americium-241. All new gauges and devices utilizing americium-241 must use foreign-origin material. However, US-manufactured sealed sources containing foreign-origin material —including americium-241, plutonium-238, and plutonium-239—that exceed the thresholds for Class C disposal, do not currently have a disposal path in the U.S.

Potential Solutions

The Focus Group has worked over the past eight months to collect information and perspectives on a wide range of potential solutions, which are summarized in Table 4 below. Group members recognize that the ultimate solution may be a combination of these or other options in order to resolve the specific challenges posed by sealed sources of different types, classes, and origins. Furthermore, developments in a number of ongoing activities, such as the DOE effort to develop a GTCC disposal facility, final legal determination regarding the authority of the Northwest Compact vis-à-vis the Clive, Utah, facility,[15] and the Waste Control Specialists (WCS) licensing process underway[16] in Texas, may impact the ultimate solution.

In addition, there are several programs underway to recycle used sealed sources. Source recycling can be cost effective and in the short-term reduce the number of disused sealed sources. However, due to damage, low activity, physical configuration, or short half-life, source recycling is not always an option. Even in the case of recycled sources, the useful life will eventually terminate and the source owner will need to dispose of the source if a disposal pathway is available, or store the source onsite if no disposition pathway exists.

To address the three disposal challenges specified above and pursue any one or a combination of the solutions described below, a broad range of stakeholders will need to be involved. Given the potential impact on the sealed source community and the Nation in the event that a source is lost or stolen, and misused, Focus Group members agree that solutions must be found.

Next Steps

This paper constitutes a significant part of the deliverable requested by the NSCC and NGCC in December 2008, but does not include specific recommendations or a messaging strategy. The Focus Group will continue its efforts to fully explore and evaluate the potential options above and seek to "down-select" from these, providing the NSCC and NGCC recommended options and the appropriate messaging strategy for working with stakeholders to implement a solution. The Focus Group also intends for this part of the deliverable to be used to communicate the scope and character of the challenge and possible solutions to LLRW stakeholders.

Table 4 – Potential Solutions[a]

	Disposal/ Management Alternative	Advantages	Implementation Challenges
1	Commercial, for-profit Class A, B, and C disposal facility w/DOE GTCC facility	• Shared site, construction, and operations aspects for efficiency • Limit public/political concerns to one site • Would address disposal challenge #1 and #2	• Possible separate regulatory authorities/ requirements for each facility (if located in an Agreement State) • Economic viability challenged by limited waste volumes • Could require Federal legislation and/or appropriations • Would require compact approval to accept out-of-compact waste
2	Co-disposal of foreign-origin Am-241, Pu-238 and Pu-239 sources with domestic sources	• Disposal of waste is based on the same physical, chemical, and radiological characteristics • Would address disposal challenge #3	• Could require case-by-case review and/or legislative changes • Could raise questions concerning the propriety of expending public resources for the benefit of the private sector

15. Appendix D to this document provides further information with regard to this litigation.
16. In September 2009, the State of Texas issued the final license for a LLRW disposal facility to be operated in Andrews County, Texas, by Waste Control Specialists (WCS) to serve the needs of the Texas Compact (Texas and Vermont) at the present time.

Table 4 – Potential Solutions[a] (cont.)

	Disposal/ Management Alternative	Advantages	Implementation Challenges
3	Physical destruction and down-blending for disposal as Class A LLRW	• Would comply with waste acceptance criteria (WAC) at the Clive facility, which is the only commercial disposal facility with no compact limitations • Would address disposal challenge #2 and possibly a subset of challenge #1	• Destruction of sealed sources may increase the risk of environmental or occupational contamination • Down-blending to meet waste acceptance criteria may be opposed by regional, state, or local stakeholders
4	Concentration averaging of LLRW to allow management as GTCC waste by DOE	• Technically viable for many sealed source waste classes • Would address subset of sources in disposal challenge #1 and #2	• Could be construed as inconsistent with the division of responsibilities between the Federal Government and the states as envisioned in the *LLRWPAA*
5	Increase decay-in-storage horizon to facilitate management of short half-life sealed sources	• Could decay sources to Class A level and perhaps exempt levels removing the need for Class B or C disposal access • Technically viable for shorter half-life material, including cobalt-60 • Would address subset of sources in disposal challenge #1 and #2	• Solution limited to relatively short half life sealed sources • Expensive life cycle cost • Requires fairly long-term (50 yr) security • Potentially significant institutional concerns with long-term LLRW storage • Does not solve the lack of disposal options for sealed sources of any class in 36 States
6	Targeted emergency disposal access per NRC authorization to address immediate security need via 10 CFR Part 62, "Emergency Access To Non-Federal And Regional Low-Level Waste Disposal Facilities"	• Possible stopgap solution for small, specific waste stream in extreme emergency with no other alternative • Would address subset of sources in disposal challenge #1 and #2	• NRC's implementation regulation, 10 CFR Part 62 establishes a formidable threshold for justifying that an emergency exists that cannot be mitigated by other means • The rule is intended to be very limited in time and waste streams • In over twenty years there have been no requests for implementation
7	Case by case exemption by existing compacts for disposal of discrete numbers of high-risk sealed sources	• Relatively immediate solution for part of the sealed source disposal problem • Would address subset of disposal challenge #1 and #2	• Regional, State, and local stakeholders may object • Case by case exemptions for the large number of sources without disposal access would be administratively burdensome
8	Range of DOE GTCC disposal alternatives addressed in draft GTCC Environmental Impact Study	• Would likely involve a relatively small physical "footprint" • Would address subset of sources in disposal challenge #1 and #2 and all sources in disposal challenge #3	• Scope of GTCC EIS limited to GTCC waste • Multiple year process before construction could begin • Timeline is highly dependent on Congressional action
9	Develop/expand Federal/State/ compact consolidated storage facility	• Provides short-term, temporary solution for spectrum of problematic radioactive sealed sources • Would temporarily address sources in disposal challenge #1, #2, and #3	• Only temporary solution • Responsibility of storage and disposition of Class A, B and C could transfer back and forth between Federal and state jurisdiction • Additional life-cycle cost could be significant (paid by whom?) • Would not address the reality that storage facilities do not want to store no-disposal-pathway waste • Shortage of space is not a major obstacle for existing Federal storage facilities

Table 4 – Potential Solutions[a] (cont.)

	Disposal/ Management Alternative	Advantages	Implementation Challenges
10	Develop/expand commercial consolidated storage facility	• Short-term solution potentially available now • Waste remains under NRC/Agreement State regulatory control pending disposal • Would temporarily address sources in disposal challenges #1, #2, and #3	• Only temporary solution • Questions about ultimate disposition of Class A, B, and C sealed sources remains • Significant added life-cycle cost • Would not address the reality that storage facilities do not want to store no-disposal-pathway waste
11	Encourage/expand sealed source recycling programs	• Fewer political or legal obstacles to implementation • Would temporarily address a subset of disposal challenges #1, #2, and #3	• Only certain sources can be effectively recycled • Only a short term solution for those sources that can be recycled
12	New Federal disposal facility exclusively for all radioactive sealed sources, including Class A, B, C, and GTCC	• Permanent disposal of all classes of sealed sources • Small footprint • Potentially fewer institutional challenges (especially if on pre-existing federal facility) • Would address subset of disposal challenge #1 and #2	• Would require statutory and regulatory changes • Could raise questions concerning the propriety of expending public resources for the benefit of the private sector • There may be State/local opposition with regard to the siting of the new facility
13	Open currently operating DOE LLRW disposal facilities for commercial LLRW	• Immediately available disposal capacity • Immediate, permanent security provided for Class A,B, and C sealed source waste streams • States relieved of statutory responsibility • Would address sources in disposal challenge #1, #2, and #3	• Would require statutory and regulatory changes • Could raise questions concerning the propriety of expending public resources for the benefit of the private sector • Could be opposed by host states and compacts
14	New, "full service" commercial disposal facility developed outside of the compact restrictions	• Permanent disposal for Classes A, B, and C LLRW • Traditional regulatory structure • Would address sources in disposal challenge #1, #2, and #3	• Economic incentive (e.g., business risk/ reward) for assuming the risk is likely decades away • Political challenges to development remain the same as during attempts to implement LLRWPA over the last two decades • Would likely entail legislative changes

Table 4 – Potential Solutions[a] (cont.)

	Disposal/ Management Alternative	Advantages	Implementation Challenges
15	Remove legal and regulatory restrictions that apply to currently operating commercial disposal sites	• Sufficient actual disposal capacity absent restrictions • Permanent disposal for Classes A, B, C LLRW • Traditional regulatory structure • Would address subset of disposal challenge #1 and #2	• No incentive for host states to change status quo • No foreseeable dynamic for change • Legislative changes would be necessary • Existing host States have indicated that they may close sites if compact authorities to restrict waste are eliminated
16	Utilize EPA Regulated Hazardous Waste Disposal Facilities under the Resource Conservation and Recovery Act (RCRA) to accept sealed sources, taking into consideration the half-life of the radionuclide and post-closure care period	• Currently in place at some RCRA disposal facilities for accelerator produced radioactive materials. • Would address disposal challenge #2	• Regional, State, and local stakeholders may object • Legislative changes necessary • Most sources require licensing per the Atomic Energy Act (AEA). It is unclear if RCRA facilities could meet AEA Part 61 licensing requirements. • Thus far, no RCRA facility operators have sought AEA Part 61 license • For some short half life waste, it may be possible to remove some AEA requirements through exemption process, but radiation protection rules are immutable.

a There could be technical, regulatory, legal, and/or political challenges to some of the sealed source waste management alternatives provided in Table 4 beyond those listed under “Implementation Challenges.”

Appendix A – Focus Group Participant List[17]

Name	Agency/Organization	Participant Type
Allard, David	Conference of Radiation Control Program Directors and Organization of Agreement States/ Pennsylvania	NGCC
Anderson, Curtis	National Nuclear Security Agency (NNSA)/MELE Associates, Inc.	SME
Buzzell, Jennifer	Centers for Disease Control	SME
Clarke, Devane	Texas Commission on Environmental Quality	SME
Coggins, Terry	Mississippi St. University	SME
Coleman, Norm	National Institutes of Health	SME
Cuthbertson, Abigail	Department of Energy/NNSA	NGCC
Cutler, Kirsten	Department of State	NGCC
Dallman, Lee	Ohmart/Vega Corp	SME
Devine, Terry	Conference of Radiation Control Program Directors	SME
Dornsife, Bill	Waste Control Specialists	SME
Elsen, Mike	Conference of Radiation Control Program Directors/Washington	SME
Fairobent, Lynne	The American Association of Physicists in Medicine	NSCC
Ferguson, Charles	Council on Foreign Relations/NNSA	SME
Gallaghar, Bob	Conference of Radiation Control Program Directors-Organization of Agreement States/ Massachusetts	NGCC
Gallego, Rich	Thomas Gray and Associates, Inc	SME
Hageman, John	Southwest Research Institute	SME
Hansen, Annette	Philotechnics	SME
Harness, Kyle	Ohmart/VEGA Corp	SME
Haynes, Richard	Conference of Radiation Control Program Directors/South Carolina	SME
House, William	Energy Solutions/Barnwell	SME
Joyce, Jamie	Department of Energy/Environmental Management	SME
Kroeger, Nathan	Rad Source Technologies, Inc.	SME
Martin, David	Department of Homeland Security, Nuclear Sector-Specific Agency/Energetics Incorporated	NGCC
McBurney, Ruth	Conference of Radiation Control Program Directors	NGCC
Miller, John	International Isotopes, Inc.	NSCC
Natarajan, Nitin	Department of Health and Human Services	NGCC
Passetti, Bill	Conference of Radiation Control Program Directors-Organization of Agreement States/Florida	NGCC
Plapp, Brendan	Department of State	NGCC
Renquist, Cary	Eckert-Ziegler	NSCC
Ribaudo, Catherine	National Institutes of Health/Radiation Safety	NGCC
Rogers, Alice	Conference of Radiation Control Program Directors/Texas Department of State Health Services	NGCC
Roughan, Kate	QSA Global	NSCC
Schultheisz, Daniel	Environmental Protection Agency	SME

17. In accordance with CIPAC guidelines, participants that are not members of the NSCC or NGCC were invited to participate at Subject Matter Experts.

Name	Agency/Organization	Participant Type
Selig, Edward	Advocates for Responsible Disposal in Texas	SME
Shaffner, James	Nuclear Regulatory Commission	SME
Sommerville, Jim	State of Georgia	SME
Storton, John (Jack)	Babcock & Wilcox	SME
Surovi, Scott	Covidien	NSCC
Swain, Patricia	Nuclear Regulatory Commission, Federal & State Materials & Environmental Management Programs	NGCC
Tonkay, Doug	Department of Energy/Environmental Management	SME
Vanags, Uldis	State of Vermont	SME
Williams, Jim	Department of Transportation	SME
Whitworth, Julia	Los Alamos National Laboratory/NNSA	SME
Wiza, Jerry	RAM Services, Inc.	SME
Zarling, John	Los Alamos National Laboratory/NNSA	SME

Appendix B – Disposition or Disposal of Cesium-Chloride Radioactive Sealed Sources

Cesium-137/chloride (cesium-chloride) radioactive sealed sources have a number of medical applications that provide needed benefits to society. Cesium-chloride is particularly useful in blood irradiation and several other critical medical procedures. However, concerns about the widespread use of highly dispersible forms in certain devices led the Interagency Task Force for Radiation Source Protection and Security to recommend in its 2006 report that a 2-year study should be made to evaluate the feasibility of phasing out cesium chloride in a highly dispersible form. The working group assigned with fulfilling this recommendation judged that an immediate phase-out would not be feasible but that a gradual, stepwise phase-out could be feasible. The working group also examined the domestic use of cesium-chloride, the potential alternatives to cesium-chloride, and the challenges associated with transportation and disposal of cesium-chloride. The working group proposed a set of recommendations for a path forward on phase-out of dispersible forms of cesium-chloride.

In addition, the Nuclear Regulatory Commission (NRC) staff reported to the NRC Commission on this topic in late 2008. The staff recommended and the Commission agreed that no action to eliminate the use of cesium-chloride was appropriate at this time but directed the staff to continue to work with Federal partners "to encourage further technological developments for alternative forms of cesium-137." One of the aspects that the Commission asked the staff to consider with its federal partners was the disposition of such sources at the end of life. Given the charter and composition of the Removal and Disposition of Disused Sources Focus Group, NRC staff thought it appropriate to engage the Removal and Disposition of Disused Sources Focus Group members in assisting the staff in addressing this charge.

Most category 1 and 2 cesium-chloride sources would be classified as Greater-Than-Class C waste in accordance with 10 CFR Part 61, depending on concentration averaging, and therefore disposal will ultimately be the responsibility of the U.S. Department of Energy. If a decision is made to curtail the use of cesium-chloride sources, there would likely be an impact on the cesium-chloride waste stream as these sources are retired at an accelerated rate (depending on how the phase-out is administered). Currently, there are over 1,000 Category 1 and 2 source devices in use domestically.

Even without a phase-out of cesium-chloride, the immediate challenge remains: there are limited disposal options for cesium-chloride sources that have exceeded their useful life and are currently unwanted. The Global Threat Reduction Initiative (GTRI) Off-Site Recovery Program (OSRP) may recover cesium-chloride sources that present public health and safety or national security concerns, but such recoveries would be subject to GTRI's recovery criteria and prioritization as well as budgetary and logistical constraints, such as the availability of the appropriate radioactive material transport packaging. There may also be an opportunity to permanently dispose of a small subset of these sources that are in states that comprise the Northwest or Rocky Mountain Low-Level Radioactive Waste Compacts. The host disposal facility for these compacts, located near Richland, WA, has waste acceptance criteria based on container size that allows a higher upper activity limit for Class C waste than that of the other commercial disposal facilities. Thus, some cesium-chloride sources in those compacts may be eligible for disposal at the Richland facility.

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Appendix C: Background Information on the Closure of Barnwell

The *Report of the South Carolina Nuclear Waste Task Force* provides a summary of the history and policy surrounding the closure of Barnwell.[18] Following the enactment of the *1980 Low-Level Radioactive Waste Policy Act* ("*1980 LLRW Policy Act*"), South Carolina advocated the formation of a Southeast compact region that corresponded to the size and configuration of the region that had been envisioned when the state first supported the proposed Barnwell facility 10 years earlier. The original Southeast Compact language enacted by South Carolina and the other Southeast Compact states in 1982 spelled out a process for selecting another compact state to eventually replace South Carolina as the host state for the region's disposal facility. This language was later revised to provide that, "in no event shall (the Barnwell facility) serve as a regional facility beyond December 31, 1992."[19]

The *1980 LLRW Policy Act* stated that compacts ratified by Congress could begin excluding waste from outside their respective borders beginning on January 1, 1986. However, because it had taken so long to negotiate compact provisions acceptable to all of the party states in the various compact regions, it became clear that there would not be time for compacts without disposal sites to establish new disposal facilities by 1986. In April 1985, following extensive discussions among state and compact officials, congressional staff, and nuclear utilities, a compromise was proposed under which the states already sited to host a facility would agree to extend access through 1992, and the non-sited states would have to meet site development milestones and pay disposal surcharges over and above the regular disposal fees.[20]

In 1986, North Carolina was designated by the Southeast Compact Commission to succeed South Carolina as host state for the Southeast Compact regional disposal facility. However, by 1991 it was clear that the new facility would not be ready by December 31, 1992, and South Carolina enacted legislation extending the role of the Barnwell facility as the regional disposal facility for the Southeast region through December 31, 1995. The law also granted conditional access to non-regional generators through June 1994.[21]

In June 1995, frustrated by the delays in the development of a disposal facility in North Carolina, and the Southeast Compact Commission's unwillingness to sanction North Carolina, South Carolina Governor David Beasley proposed legislation to withdraw from the Southeast Compact and to make the Barnwell facility available to waste generators in all states except North Carolina. In June 1995, the South Carolina General Assembly enacted the legislation. In promoting the new policy, Governor Beasley estimated that the new tax would raise $140 million a year for the state. However, for a variety of reasons, actual revenues from low-level radioactive waste disposal in South Carolina fell short of that estimate.[22] In an Executive Order dated June 10, 1999 South Carolina Governor Jim Hodges established the South Carolina Nuclear Waste Task Force in order "to provide to the people of South Carolina and the South Carolina General Assembly with a road map to discontinuance of South Carolina's role as the nation's nuclear dumping ground; and to recommend actions to ensure that future needs of South Carolina low-level waste generators are met."[23]

18. *Report of the South Carolina Nuclear Waste Task Force*, *Volume 1*, December 15, 1999 ("*South Carolina Task Force Report*"), available at http://www.energy.sc.gov/publications/finalnucreport.pdf.
19. *South Carolina Task Force Report*, page 7.
20. *South Carolina Task Force Report*, pages 7-8.
21. *South Carolina Task Force Report*, page 9.
22. *South Carolina Task Force Report* at page 10.
23. *South Carolina Task Force Report* at page 1.

In December 1999, the South Carolina Nuclear Waste Task Force adopted a resolution that recommended the Governor enter into negotiations with the Atlantic Compact (which at the time consisted of Connecticut and New Jersey) to define the terms and conditions for South Carolina's membership in the Compact. The Task Force Report recommended that "such an agreement should . . . give the state a legal means to accept waste from only three states, instead of continuing to open the disposal site to every state in the nation."[24] The resolution noted that "if waste volumes received at the Barnwell facility continue at current levels, South Carolina's nuclear power reactors will have no place to dispose of their waste when they decommission in thirty years."[25]

The South Carolina Task Force Report did not specifically address the subset of waste comprised of radioactive sealed sources and was not asked to consider the safety or security implications of the decision on the states that would lose access to commercial disposal with the closure of Barnwell to out-of-compact waste.

24. *South Carolina Task Force Report* at page 32.
25. *South Carolina Task Force Report* at page 31.

Appendix D: Background Information on the Energy*Solutions*/Clive Lawsuit

On May 5, 2008, Energy*Solutions* filed a lawsuit that, among other things, challenges the authority of the Northwest Compact to govern the company's Low-Level Radioactive Waste (LLRW) disposal facility in Clive, Utah. The lawsuit was initiated after the company filed an application with the U.S. Nuclear Regulatory Commission to import up to 20,000 tons of potentially contaminated material from Italy and to return for export to generators in Italy any of the imported waste that can not be recycled or does not meet the Clive facility's waste acceptance criteria for disposal. The State of Utah and the Northwest Compact oppose the application, with the compact maintaining that its current resolution and order authorizing the Clive facility to dispose of LLRW from other compacts and unaffiliated states does not apply to foreign-generated waste.

On May 15, 2009, the U.S. District Court for the District of Utah, Central Division, issued a ruling which held, among other things, that with regard to the importation of LLRW from outside of the compact region, the Northwest Compact does not have the authority to restrict access to the Clive disposal facility. The court based this ruling on its finding that Clive is a private facility operating in interstate commerce that is not covered by the compact system—i.e., it is not a "regional disposal facility" as defined under federal law. The court further ruled, however, that the Northwest Compact has authority to regulate the disposal of LLRW that is generated within the compact's regional boundaries—including restricting disposal access for such waste to the Clive facility. Finally, the court's ruling maintains the authority of the Northwest Compact to regulate the Richland facility operated by American Ecology—regardless of the origin of waste that is sent thereto. The court's decision is currently under appeal.

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