Borehole Disposal and the Cradle-To-Grave Management Program for Radioactive Sealed Sources in Egypt

J.R. Cochran, S.D. Carson
Sandia National Laboratories[1]
P.O. Box 5800, Albuquerque, NM 87185
USA

K. El-Adham, Y.T. Mohamed
Egyptian Atomic Energy Authority
3 Ahmed El-Zomor Street, Nasr City, Cairo
Egypt

ABSTRACT

The Integrated Management Program for Radioactive Sealed Sources (IMPRSS) is greatly improving the management of radioactive sealed sources (RSSs) in Egypt. When completed, IMPRSS will protect the people and the environment from another radioactive incident. The Government of Egypt and Sandia National Laboratories are collaboratively implementing IMPRSS. The integrated activities are divided into three broad areas: the safe management of RSSs in-use, the safe management of unwanted RSSs, and crosscutting infrastructure. Taken together, these work elements comprise a cradle-to-grave program.

To ensure sustainability, the IMPRSS emphasizes such activities as human capacity development through technology transfer and training, and development of a disposal facility. As a key step in the development of a disposal facility, IMPRSS is conducting a safety assessment for intermediate-depth borehole disposal in thick arid alluvium in Egypt based on experience with the U.S.'s Greater Confinement Disposal boreholes. This safety assessment of borehole disposal is being supported by the International Atomic Energy Agency (IAEA) through an IAEA Technical Cooperation Project.

INTRODUCTION

The Director General of the IAEA Mohamed El-Baradei often speaks about the need for a "cradle-to-grave" system for managing radioactive materials. This article highlights an example program in which the Government of Egypt (GOE) and Sandia National Laboratories (SNL) have undertaken cooperative efforts to greatly improve the cradle-to-grave management of RSSs in Egypt.

[1] Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000

Radioactive sealed sources have been used in Egypt for over 50 years in a wide range of peaceful applications and the GOE has licensed ~1,900 RSS. In addition to the 1,900 licensed RSSs, the GOE currently holds about 800 unwanted RSSs in long-term storage, and hundreds more will become unwanted over the next 25 years. The IAEA states that long-term storage of unwanted radioactive materials is not sustainable, and only proper disposal permanently removes unwanted radioactive materials from the biosphere. [1]

Beneficial and Hazardous

Radioactive sealed sources are being used daily and worldwide in medicine, manufacturing, consumer products, construction, oil and gas exploration, research, space exploration, teaching, and military applications. In many cases, RSSs are used as beneficial tools for tasks that would otherwise be difficult or impossible. In Egypt, the largest numbers of RSSs are used in the fields of medicine and oil and gas exploration.

In addition to their many beneficial uses, some of the more potent RSSs are a threat to public health and the environment if they are mismanaged. Accidents involving RSSs have resulted in very significant environmental contamination, social disruption, over-exposure, amputations and even death. The high specific activity of the material in many RSSs means that the release of microgram quantities of the radioactive material can cause significant human health and environmental harm. For example, in Goiânia, Brazil, a 50-TBq (1300 Ci) Cesium-137 RSS was stolen from a closed medical clinic and cut open; four people died, several hundred suffered health effects, panic ensued and 112,000 people sought medical attention. Several years were required to decontaminate or demolish buildings. This incident greatly affected human health and caused significant environmental contamination in Goiânia. In Egypt an Irridium-192 RSS was mismanaged and this incident resulted in the death of two persons and radiation over-exposure of many other villagers.

IMPRSS

To protect the people and environment in Egypt from additional accidents, the GOE and SNL have undertaken the IMPRSS. The IMPRSS is funded by the U.S. Agency for International Development and is being implemented by the U.S. Department of Energy's Office of Policy and International Affairs through SNL. The Egyptian Atomic Energy Authority (EAEA) is the lead authority within the GOE for the implementation of the IMPRSS and the EAEA is responsible for the recovery, storage and disposal of all unwanted RSSs in Egypt. The safe and secure management of RSSs that are in-use is the responsibility of the Ministry of Health and Population's Executive Office for Radiation Protection (EORP). As discussed later, the Egyptian Nuclear Materials Authority is supporting the IMPRSS disposal activities.

IMPRSS activities are divided into three broad areas: the safe management of RSSs in-use, the safe management of unwanted RSSs and cross-cutting infrastructure. The IMPRSS work activities for insuring the safe management of *in-use* RSSs include: (1) Tracking; (2) Awareness, and (3) Security against theft. The work activities for insuring the safe management of *unwanted* RSSs include: (4) Recovery; (5) Conditioning and Storage; (6) Recycling, and (7) Disposal. The

cross-cutting infrastructure includes (8) Emergency Response and (9) Regulatory Modernization. Taken together, these nine work elements shown in Fig. 1 comprise a cradle-to-grave program. Progress is being made on each of these nine work elements. This article summarizes progress in the three areas of tracking, awareness, and disposal.

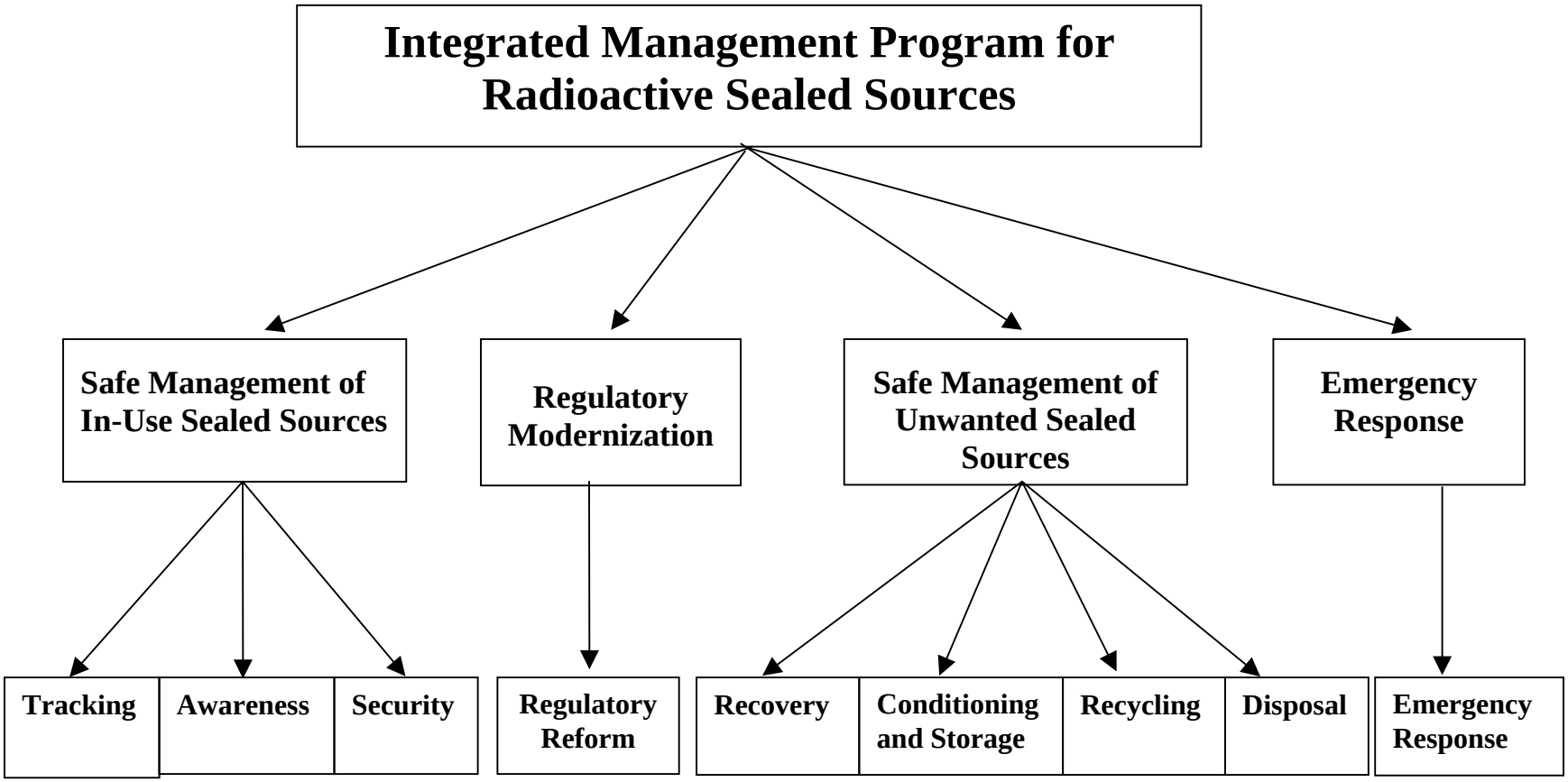

Fig. 1. IMPRSS work elements

TRACKING

The first of the nine elements of IMRSS is tracking. The goal of the tracking task is to have an up-to-date database that lists all the RSSs in Egypt with their radionuclides, activities, uses, locations, and custodians. Significant progress on tracking has been made, moving the GOE from a set of antiquated paper logbooks to a computerized system that implements the IAEA's Regulatory Authority Information System (RAIS) database. RAIS is a hierarchical inventory and tracking system for RSSs developed through the IAEA to provide member states with common software for tracking and controlling RSSs. IMPRSS has funded a barcode-based system that is compatible with the IAEA's RAIS database. IMPRSS has made the barcode software available to the IAEA for distribution to other IAEA member states. [2] Currently, Egypt's RAIS database includes ~1,900 RSSs that are licensed for use in Egypt. An accurate inventory of RSSs in a country is a critical resource for protecting the safety and security of citizens and the environment.

AWARENESS

Awareness is the second of the nine elements of IMPRSS. Political and technical support of IMPRSS requires that Egyptian officials and staff have an awareness of the potential consequences of the mismanagement of RSSs. IMPRSS has hosted four joint workshops to improve awareness. Approximately 60 people working for the GOE attended the "Radioactive Sealed Sources Awareness Seminar; Challenges and Solutions" that was presented by IMPRSS and co-hosted by the Ministry of Energy and Electricity and the Ministry of Health and Population on December 16 - 17, 2003 in Cairo (Fig. 2). The greatest collection of knowledge about RSSs in Egypt attended this seminar. At the end of the seminar, the attendees had an increased awareness of the benefits and hazards of using RSSs and the attendees understood the roles of each ministry and the goals of IMPRSS. An awareness seminar for people that regularly use RSSs in medicine and industry was held February 11-14, 2004 in Cairo. About 100 RSS users attended the second seminar.

The third and fourth of the four awareness seminars were held at SNL in Albuquerque, New Mexico in March and July of 2004. These seminars provided a first-hand demonstration of the characteristics of a robust cradle-to-grave RSSs management program for high-ranking GOE officials. Attendees included the Chairman of the EAEA, the Deputy Minister of Health and Population and representatives from the U.S. Embassy in Cairo and the U.S. State Department in Washington DC. Additional seminars are planned to teach doctors in Egypt to recognize radiation overexposure.

As a part of the awareness work, a hands-on "technology demonstration center" is being built in Cairo to provide information on the total infrastructure necessary to safely and securely provide cradle-to-grave management of RSSs. Finally, awareness / safety brochures have been designed and will be printed in Arabic for broad distribution in Egypt.

Fig. 2. Photographs from the first awareness seminar in Cairo

BOREHOLE DISPOSAL

The EAEA currently holds about 800 unwanted RSSs in long-term storage, and hundreds more will become unwanted over the next 25 years. Many of these unwanted RSSs will remain radioactive for hundreds to thousands of years. Such RSSs contain long-lived Americium-241 or Radium-226 or high activities of intermediate half-lived nuclides Cesium-137 and Strontium-90. These sources will not decay to background or dismissal levels in 100 to 300 years and typically these RSSs cannot be safely disposed in near surface facilities. Deep-mined geologic repositories have long been proposed for dangerous long-lived RSSs. Deep-mined geologic repositories utilize isolated and stable portions of the lithosphere at depths greater than 300 m to remove radioactive wastes from the biosphere for thousands to millions of years. Although conceptually simple, development costs for deep-mined geologic repositories can be prohibitively expensive.

Because near-surface disposal facilities are not safe for disposal of long-lived RSSs and because deep-mined geologic repositories are very expensive, the EAEA is assessing the safety of intermediate-depth borehole disposal. The IMPRSS and SNL are assisting the EAEA with this assessment. Sandia's expertise in intermediate-depth borehole disposal is based on Sandia's completion of the Safety Assessment that demonstrates that intermediate-depth Greater Confinement Disposal (GCD) boreholes in the U.S. provide "geologic isolation" of radioactive wastes as defined by the U.S. Environmental Protection Agency's 10,000-year standard codified in 40 Code of Federal Regulations (CFR) 191. [3] The GCD boreholes are about 36 m deep; the bottom 15 m was used for waste disposal and the upper 21 m was backfilled with native alluvium. These boreholes are located in a thick sequence of arid sand and gravel.

Site-Specific Safety Assessment

The goal of the disposal task is to conduct a site-specific safety assessment of intermediate-depth borehole disposal in thick arid alluvium in Egypt based on experience with the GCD boreholes. The GOE will use the results of the site-specific safety assessment, and other information, to decide if an intermediate-depth borehole disposal system will be constructed. Completion of a site-specific safety assessment requires the selection and characterization of a candidate site. Ongoing efforts to identify and characterize a site are detailed below.

Preliminary Site Search Criteria

Egyptian scientists are reviewing Egypt's geology for sites with characteristics similar to those of the GCD boreholes in the U.S. The U.S. GCD boreholes are situated in a thick sequence of arid alluvium, composed of weakly stratified, gravelly sand in the Frenchman Flat basin of the Nevada Test Site. Groundwater is approximately 236 m below the land surface. Frenchman Flat is in one of the most arid areas of the U.S. with an average annual precipitation of 130 mm per year.

Based on the GCD site setting, site selection criteria in Egypt are:

- Arid climate, < 130 mm per year precipitation,
- Thick deposits of sand and gravel (alluvium), > 150 m thick,
- Deep water table, > 150 m below land surface, and

- No potential for surface flooding.

The secondary site search criteria are:

- No dwelling within 1 km,
- Land owned by the government,
- No volcanic activity in the geologically-recent past, and
- No valuable subsurface resources such as oil, gas and gold.

Simple geological settings and homogeneous materials are preferable to complex geologic settings and materials, as simple settings and materials are easier and less expensive to characterize and model, thus providing greater confidence in the results of the safety assessment.

Scientists from the EAEA and the Egyptian Nuclear Materials Authority are working to identifying sites that best meet the site-search criteria. Large portions of Egypt are *hyper-arid*, with an average annual precipitation of zero to two mm per year (zero to 0.08 inches per year) (Fig. 3). Because of this great aridity, approximately 96% of the total area of Egypt is barren desert. Based on the site search criteria, six preliminary sites have been selected and the list of six sites is being reduced to three sites based on additional site selection criteria. Egyptian scientists, with assistance from SNL and the IAEA, will down-select to a single site for site characterization and safety assessment analysis.

IAEA Technical Cooperation

The IAEA is assisting the GOE and IMPRSS through an IAEA Technical Cooperation (TC) Project. The first coordinating meeting for IAEA TC Project EGY/3/016 was held in April 2005 in Cairo. The TC Project addresses three areas: safe management of spent high-activity radioactive sources (SHARS); quality assurance of waste management activities and intermediate-depth borehole disposal. The TC Project will provide independent consultation and review, as well as scientific visits, expert missions and fellowships for Egyptian scientists to work with their counterparts in other countries. One of the broad goals of the TC Project is to coordinate SHARS conditioning for storage with conditioning of unwanted RSSs for borehole disposal. The IEAE TC Project is being implemented in the 2005 – 2007 funding cycle.

Sustainability

To ensure sustainability, the IMPRSS emphasizes human capacity development through technology transfer and training, increased public and government awareness, regulatory modernization, the purchase of equipment, and the development of a disposal facility. The IMPRSS has provided significant one-on-one training of Egyptian professionals and the in-country implementation of effective cradle-to-grave RSSs management is being undertaken by Egyptians with IMPRSS support. A far-reaching goal of the project is to help create a mechanism by which a routine disposal option is available, such that future unwanted sealed sources would have a direct disposal path at a cost that encourages appropriate management by licensees.

Fig. 3. Photograph of the hyper-arid western desert of Egypt

SUMMARY

The GOE and SNL are collaboratively implementing IMPRSS to protect the people and the environment from a possible radioactive incident. There are nine work elements in IMPRSS's cradle-to-grave program and three of these work elements are tracking, awareness and disposal. Awareness is critical for technical and political support of IMPRSS, and four awareness seminars have been held, two in Cairo and two in the U.S. Significant progress on tracking has been made, moving the GOE from a set of antiquated paper logbooks to a computerized system that implements the IAEA's RAIS database. Approximately 1,900 RSSs are being tracked in Egypt.

The EAEA currently holds about 800 unwanted RSSs in long-term storage, and hundreds more will become unwanted over the next 25 years. The goal of the disposal task is to conduct a site-specific safety assessment of intermediate-depth borehole disposal in thick arid alluvium in Egypt based on experience with the GCD boreholes. Egyptian scientists have selected six potential sites based on the site selection criteria and will down-select to one site for detailed site characterization.

The IAEA is also assisting the GOE and IMPRSS through an IAEA TC Project for safe management of SHARS, quality assurance of waste management activities and intermediate-depth borehole disposal. The TC Project will provide independent consultation and review, as well as scientific visits, expert missions and fellowships for Egyptian scientists to work with their counterparts in other countries.

REFERENCES

1. *Disposal Options for Disused Radioactive Source*, 2005, Technical Reports Series no. 436, International Atomic Energy Agency, Vienna.
2. Carson, S.D., Schetnan, R., Hasan, A. and Mohamed, Y.T., 2006, "Implementation of the Regulatory Authority Information System in Egypt," to be published in *Proceedings from Waste Management '06*, Waste Management Symposia, Inc., Tucson, AZ.
3. Cochran, J.R. and Hasan, A., 2005, "Greater Confinement Disposal of Radioactive Waste in Borehole Facilities," in *Disposal of Low Activity Radioactive Waste, Proceedings of an International Symposium, Cordoba, Spain, 13-17 December 2004*, organized by the IAEA, in co-sponsorship with the Agence ationale pour la gestion des déchets radioactifs (ANDRA) France and in co-operation with the OECD Nuclear Energy Agency (NEA), International Atomic Energy Agency, Vienna.