Updated Decision Support Tool for the Management of Waste and Debris from Radiological Incidents

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ABSTRACT

Unique challenges exist for the handling, transport, and disposal of debris resulting from homeland security incidents, disasters or other national emergencies. Access to guidance for facilitating decision making in the safe and timely disposal of debris is critical to helping restore a community or region and prevent further contamination or spread of disease. For a radiological dispersal device (RDD) or other radiological incident, proper characterization of the quantity, properties, and level of contamination of debris and decontamination residue can have a significant impact on cleanup costs and timelines. A suite of decision support tools (DSTs) is being developed by the U.S. EPA's Office of Research and Development to assist individuals responsible for making decisions associated with handling, transport, treatment, and disposal of such debris. The DSTs are location-specific to help identify specific facilities and contacts for making final disposal decisions. The DSTs provide quick reference to technical information, regulations, and other information to provide decision makers with assistance in guiding disposal decisions that are important for the protection of public health, first responders, and the environment. This tool is being developed in partnership with other U.S. government agencies, EPA program offices, industry, and state and local emergency response programs.

INTRODUCTION

Incidents of national significance with a sizeable environmental component can be caused by industrial accidents; natural disasters such as hurricanes, floods, wildfires, and earthquakes; terrorist attacks using chemical, biological, radiological, or nuclear (CBRN) weapons; and disease outbreaks or intentional contamination impacting the safety of the U.S. food supply or agricultural sector. These incidents require an integrated response from federal, state, and local government. The Department of Homeland Security (DHS) has released the National Response Framework (NRF) [1] and the National Incident Management System (NIMS) [2] to provide a framework for responding to Homeland Security incidents of national significance. Additionally, the DHS has identified fifteen National Planning Scenarios for which every federal, state and local emergency response agency is to create emergency plans [3]. Most of these fifteen scenarios involve disposal of contaminated material. As a result, disposal decision making has become more complex. Emerging issues have surfaced that underscore the need for emergency response plans to include tools that will assist decision makers in effectively managing debris and waste from incidents of national significance to minimize threats to human health and the

environment. Effective debris and waste disposal can significantly reduce the overall restoration costs. The National Science and Technology Council estimates that natural disasters alone cost an average of $52 billion per year in the form of lives lost and property destroyed [4]. The Solid Waste Association of North America captured key lessons learned from the aftermath of the Hurricane Katrina response that are important to address in current emergency response plans [5].

There is a wide range of potential events that can lead to large volumes of debris or potentially difficult-to-manage waste. Traditional hazards include wildland and urban fires, floods, oil spills, transportation accidents, earthquakes, hurricanes, tornadoes, and pandemics. Additional challenges will be potentially faced from either deliberate or accidental contamination with industrial chemicals, biological/chemical warfare agents, radiological dispersal devices (RDDs), or improvised nuclear devices (INDs). Foreign animal disease (FAD) outbreaks also pose disposal challenges and occur worldwide. The foot- and- mouth disease outbreak in the United Kingdom in 2001, chronic wasting disease in North America, and the avian influenza outbreaks occurring in Asia, resulted in large volumes of animal carcasses to dispose of and highlighted some of the uncertainties regarding how this type of disposal could be managed.

In 2002, the National Homeland Security Research Center (NHSRC) of the U.S. Environmental Protection Agency was created. As part of the NHSRC research effort, technical information and tools are being developed to help decision makers respond to incidents of national significance. A part of this program specifically addresses waste disposal issues resulting from such incidents. One of the major outputs from this research is the development of a suite of Disaster Debris Management and Disposal Decision Support Tools (DDMD-DSTs) [6,7,8]. The objective for the development of these tools is to provide assistance to (1) emergency responders who have to determine the most appropriate options for handling, transport, and disposal of debris; (2) state and local agencies who have responsibility for facility permits and ensuring compliance with applicable regulations; and (3) waste management and water utility industries that provide safe disposal of these wastes without affecting the operation of their facilities, violating any applicable permits, or impacting worker safety.

It is important to note that these tools are not intended to override existing regulatory or legal requirements that apply to the disposal of materials. Rather they provide a starting point for cleanup activities and provide information to be used during response planning activities. Final disposal decisions can only be made after contacting the appropriate persons at state and regional regulatory offices and coordinating with the disposal site. The DDMD-DSTs also provide quick reference to technical information, and applicable regulations and guidance to assure safe and efficient removal, transport, treatment, and disposal of incident debris.

TECHNICAL APPROACH

The objective of the suite of DDMD-DSTs is to help reduce restoration time and expense by providing a stepwise approach in the decision making process for disaster debris management. Technical information is provided that is specific to the types of materials and contaminants involved. This information is also specific for the unique issues or challenges faced with ensuring public and worker safety throughout the packaging, transportation, treatment, and

disposal process. Rather than providing massive quantities of information to the user, the tool tries to distill information while maintaining links to more detailed information if desired. The web-based tools link the user to more detailed sources of data and information. Using a web-based platform also facilitates more-frequent updates based on available guidance, updated facility information, and changed points of contact. As of version 5.0 of the tool, released in June 2008, DSTs are currently available to address:

- Building decontamination residue (BDR) disposal;
- Decontamination wastewater disposal;
- Water system materials disposal;
- Natural disaster debris disposal;
- Agricultural biomass disposal; and
- Radiological Dispersal Device (RDD) debris disposal.

Waste streams that are covered include aqueous solutions and contaminated debris from decontamination of buildings, including furniture, ceiling tiles, wall hangings, and carpeting. With hurricane events, there can be significant quantities of waste that are contaminated from damaged chemical and industrial facilities, mold, and other pollutants. Cleanup of contaminated water treatment and distribution systems may involve the disposal of pumps, filters, piping, and other equipment. The waste also includes personal protective equipment from the cleanup crews, which may be contaminated with residual agents at varying and possibly unknown levels. For agricultural biomass and animal carcass disposal, other unique issues are addressed regarding the urgency in response time and need to minimize further impacts, and to reflect EPA's role as a support agency working with the U.S. Department of Agriculture (USDA) as the lead agency.

The suite of tools is password-protected and is designed so that the information can be accessed in several ways, ranging from direct queries of the various databases contained in the DSTs, to a decision scenario approach with saved files suitable for planning purposes. Fig. 1 provides a screenshot of the login page. Each user is assigned a unique username and password and is associated with one of four different user groups: (1) EPA and other federal agencies; (2) State and local agencies; and (3) industry, trade associations, or (4) the general public. Users can share scenarios that are created if they wish, either within their own user group or to everyone. If the user chooses the scenario based approach, the user must specify the incident location and the type and characteristics of the event. Users then follow a stepwise approach to determine the quantity and inventory of waste material, potential disposal facilities, and transport options. For example, back-of-the-envelope waste quantity estimators are available for determining potential residues from the decontamination of hospitals, hotels, offices, schools, shopping centers, theaters, and residences. Links to guidance and training modules for the disposal of agricultural biomass and animal carcasses are also available through USDA.

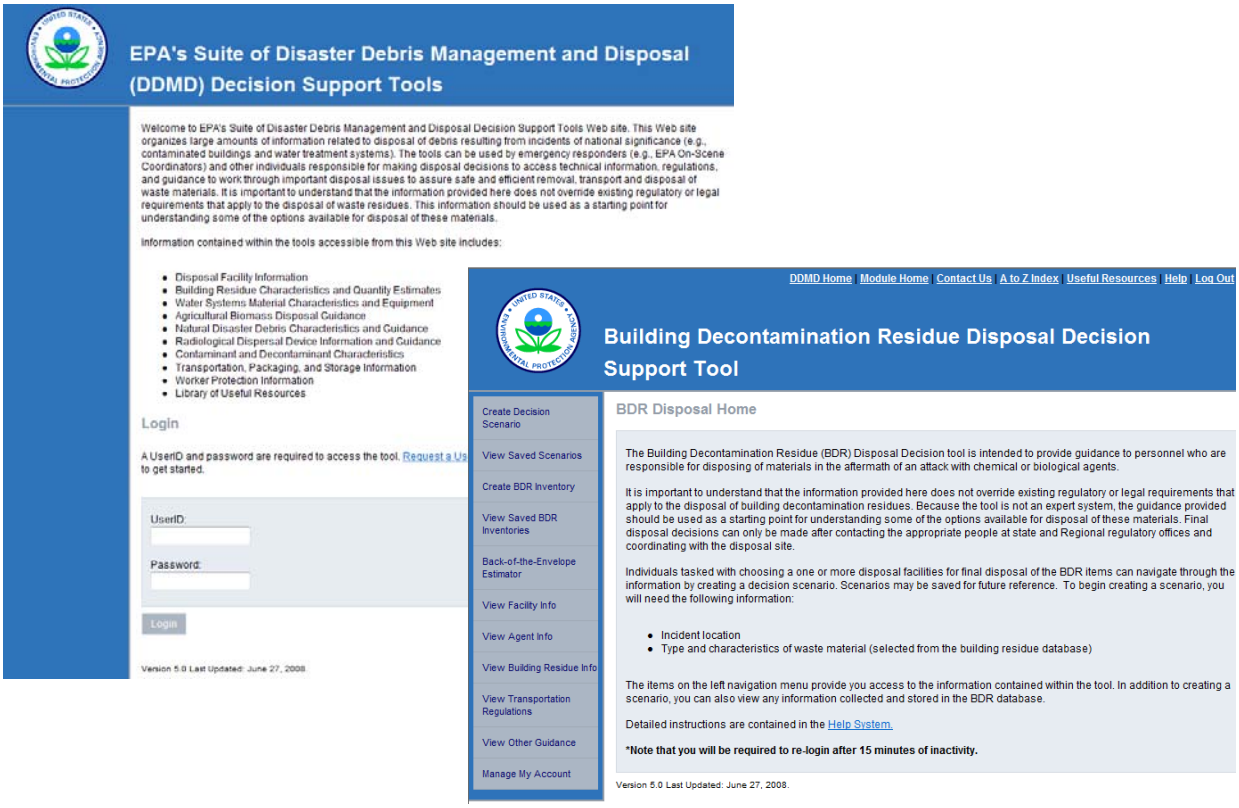

Fig. 1. Screenshots from the Disaster Debris Management and Disposal Tool.

Information contained within or accessible through the DSTs includes:

- Treatment/disposal facility information with a database of incinerators, landfills (hazardous waste, municipal solid waste, and construction/demolition debris), wastewater treatment facilities, electric arc furnaces, wood-fired boilers, aluminum and copper recyclers, medical waste autoclaves, commercial radioactive waste disposal facilities, and Federal radioactive waste disposal facilities;
- BDR characteristics and quantity estimates and guidance and/or regulations for worker protective equipment, building decontamination residue removal, packaging and shipment;
- Water systems materials characteristics and equipment, as well as guidance for disposal of water treatment facility residues;
- Agricultural biomass disposal (including animal carcass disposal) guidance;
- Natural disaster debris characteristics and guidance;
- Contaminant and decontaminant characteristics;
- Regulatory information for disposal of various classifications of radioactive waste;
- Worker protection information; and
- Library of resources to assist in the decision making process.

Building Decontamination Residue DST

The DST for disposal of BDR was the first tool developed with work beginning in 2003. This DST was developed in response to the cleanup of buildings from anthrax attacks on government

and news media buildings in 2001. The DST was developed by working closely with stakeholders who had first hand experience in dealing with the aftermath of the 2001 anthrax attacks. Industry and others who have expertise or concerns associated with developing appropriate guidance for disposal of incident debris were also involved in the DST development [9]. The DST provides assistance or guidance to the address the following:

- Estimating waste quantities and debris characteristics to generate waste profile information;
- Identifying available treatment/disposal options and capacity for the different categories of waste on a geographical basis, including contact information for the range of potential disposal facilities. [The range of treatment/disposal facility types include incinerators, landfills (hazardous waste, municipal, construction and demolition debris), autoclaves, and wood-fired boilers];
- On-site preprocessing and packaging of waste materials to make the material more amenable for management in a given facility;
- Access to guidance for transporting the waste materials; and
- Access to guidance to minimize risk to workers handling the waste materials, to the treatment/disposal facility workers, and to people along the transportation route to the treatment/disposal facility, and to minimize potential for contaminating the treatment/disposal facility.

The DST for BDR also contains external links to the various transportation regulations as well as transportation companies suitable to haul the materials to the selected treatment/disposal facility. The DST has an external link to "SafeStat", where potential haulers can be evaluated for their safety records. Finally, the DST provides a link to the U.S. Department of Energy's Transportation Routing Analysis Geographic Information System (TRAGIS) tool [10]. This Geographical Information Systems based tool allows appropriate transportation routes to be created.

Decontamination Wastewater Disposal DST

The Decontamination Wastewater Disposal DST provides guidance on the handling, transport, and disposal of wastewater generated during the decontamination of buildings or materials with chemical or biological contaminants. Information provided includes potential treatment/disposal facilities, contaminant/decontaminant information including decontaminant treatment options, and applicable hazardous materials transportation regulations for liquid waste. The tool does not provide methodology for estimating the quantity of wastewater because of the wide variability based on the nature of the event.

Water System Materials Disposal DST

Drinking water treatment plants, water supply networks, the water using community, and wastewater treatment plants are linked together as an integrated system. In the event that chemical or biological contamination is introduced at some point in this system, significant cleanup may be required. For developing a scenario, the incident location and system characteristics are specified. For the treatment/disposal of debris from the decontamination of a drinking water treatment plant, the user must specify the throughput for each unit operation and

provide characteristics of the primary and secondary treatment and type, solids management, filtration operations, disinfectant, and any other treatment in use. This enables the user to calculate and inventory debris to be managed. The DST also provides access to guidance on debris handling and transport, and available disposal facilities. When underground pipes need to be disposed of, their removal will disturb the surrounding soil and there may be subsequent ex-filtration causing contamination of the soil. The DST allows users to account for the quantity of disturbed soil that may require removal based on the pipe diameter and length for each type of pipe specified.

Agricultural Biomass Disposal DST

The Agricultural Biomass DST has been developed in collaboration with USDA. It is intended to provide information to personnel who are responsible for disposing of animal carcasses or plant materials in the aftermath of an event. The USDA has developed several training modules that can be accessed within the tool by clicking "Disposal Options" from the left navigation menu. Access to several other key resources for additional guidance is provided using hyperlinks to the National Center for Animal Health Emergency Management and the National Animal Health Emergency Management System Guidelines.

Natural Disaster Debris Disposal DST

The Natural Disaster Debris Disposal DST is intended to provide information to personnel who are responsible for disposing of debris in the aftermath of a natural disaster. It provides access to planning and guidance documents for the management of such debris. The tool provides access to a large number of natural disaster case studies, preparedness guidance documents, and applicable rules and regulations. This DST has less emphasis on estimating the quantity of debris/waste and more emphasis on finding an appropriate path to reuse, recycling, treatment, or disposal. The Natural Disaster Debris DST addresses the situation where a contaminated facility is demolished rather than restored. It also contains a database of treatment/disposal facilities and recyclers. Guidance for dealing with a variety of waste types that may be encountered in a large-scale cleanup and recycling/disposal operation is available. Twenty-five distinct types of wastes (e.g., green waste, auto batteries, white goods, putrescibles, etc.) are addressed by the tool. Other information available includes:

- Case studies organized by disaster type (e.g. hurricanes, tornados, earthquakes, floods);
- Considerations for handling mass debris including hazardous, non-hazardous, and special wastes;
- Disaster debris reduction/recycle/disposal methods and equipment;
- Applicable regulations and disposal guidance; and
- Identification of potential facilities and contact information for providing safe disposal of disaster debris and opportunities for materials recovery for recycling programs.

Radiological Dispersal Device Debris Disposal DST

Work on the Radiological Dispersal Device (RDD) Debris Disposal DST began in 2007. The first version of the DST was released in September 2007 with Version 4.2 of the Suite of DDMD

DSTs and Version 5.0 was released in June 2008. Development of the RDD Debris Disposal DST is ongoing and additional content is expected to be added in the future. The RDD Debris Disposal DST provides officials and decision makers with RDD and radioactive waste information related to:

- RDDs in general and potential radionuclides for use in an RDD;
- Waste types and regulatory classifications;
- Storage, disposal, and transportation regulations; and
- Treatment, storage, and disposal facilities.

Additionally, the RDD Debris Disposal DST contains links to useful documents, other useful tools and resources, case studies, and other Federal agencies and U.S. Department of Energy (DOE) national laboratories.

Due to the multitude of issues surrounding radioactive waste, particularly its highly regulated nature, decisions regarding debris disposal from an RDD incident would likely involve consideration of many factors, with input from multiple local, state and federal agencies, various experts, consultants, and the affected community. Therefore, the RDD Debris Disposal DST was designed to be a clearinghouse of radioactive waste-related information rather than a hierarchical tool that would guide decision-makers through a specified sequence of decisions that might have to be made in the aftermath of an incident.

Version 5.0 of the RDD Debris Disposal DST contains several enhancements and additions since the original release of Version 4.2. Among these are topics related to the National Response Framework (NRF), the National Contingency Plan, and Protective Action Guides (PAGs) [11,12] and other additions including a Back-of-the-Envelope Estimator (BoEE), detailed information on commercial and Federal radioactive waste disposal facilities, basic radionuclide properties, and searchable Federal radioactive waste regulations.

Fig. 2 presents the home page for the RDD Debris Disposal DST, which is the starting point for accessing the information contained in the tool.

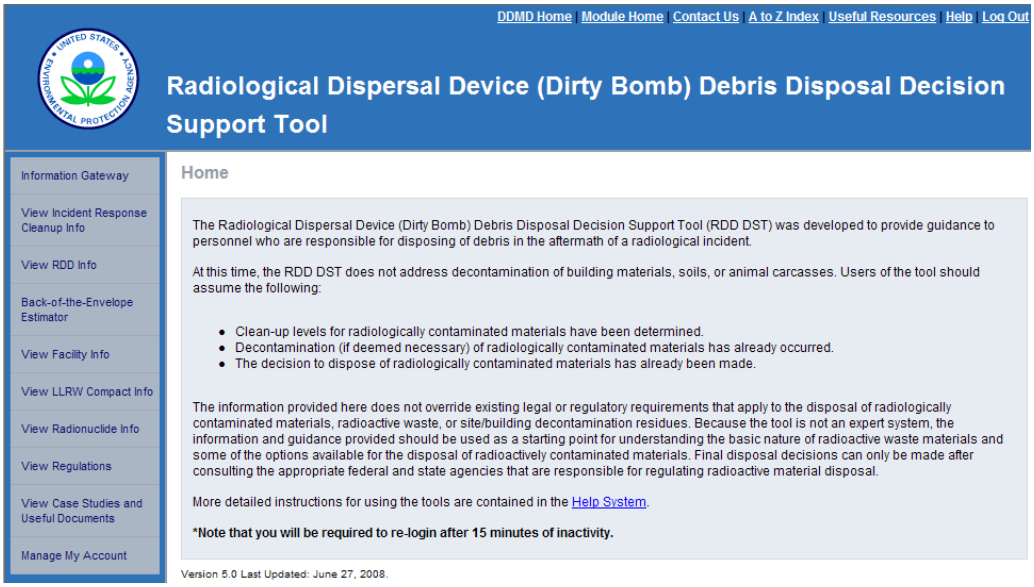

Fig. 2. Radiological Dispersal Device (RDD) Debris Disposal DST Home Page.

The DST is designed with a menu bar on the left side of the page that facilitates quick access to:

- The Information Gateway
- Incident response and cleanup information;
- Information on RDDs;
- The Back-of-the-Envelope Estimator;
- Facility database that includes radioactive waste disposal facilities;
- Information on the low-level radioactive waste compacts;
- A database of basic radionuclide properties;
- Information on Federal radiological-related regulations; and
- Useful documents related to RDDs and RDD incidents.

Global links are provided in a menu bar at the top of the tool that facilitate navigation within the DDMD DSTs, provide a mechanism to provide feedback on the tool, provide access to an A-Z Index, links to additional useful resources, and access to an online help system for the tool.

Significantly enhanced from Version 4.2, the Information Gateway (shown in Fig. 3) presents information in a graphical, tree-structure and users can view details about a particular topic by selecting the associated box of interest. Topics available include information on radioactive materials (source material, special nuclear material, and byproduct material), basic information on various types of radiological incidents, and detailed information on the classifications of radioactive waste, treatment technologies, and disposal facilities. For the radioactive waste classifications, users are presented with detailed information on the waste type itself, transportation considerations, treatment and disposal technologies, relevant regulations, and available disposal facilities. The tool includes detailed information on all radioactive waste types, including low-level radioactive waste (LLRW) and mixed waste (MW). Information on other waste types (i.e., orphan sources, naturally occurring radioactive materials (NORM), mill tailings, transuranic waste (TRU), and high-level radioactive waste (HLW)) are included in the

DST, however, these wastes would likely be encountered in conjunction with radiological incidents other than the detonation of an RDD. Examples of these types of events include transportation accidents, nuclear power plant accidents, re-entry of satellites, and abandoned or improperly disposed sealed radioactive sources. For LLRW, several disposal and treatment options currently exist. Disposal decisions must take into account the nature of the contaminated material, the location of the RDD incident relative to disposal facilities, and any applicable local, state, and Federal regulations. Additionally, coordination with the Low-Level Radioactive Waste Compacts and U.S. Nuclear Regulatory Commission (NRC) Agreement States should be expected when determining the final disposition of contaminated debris classified as LLRW.

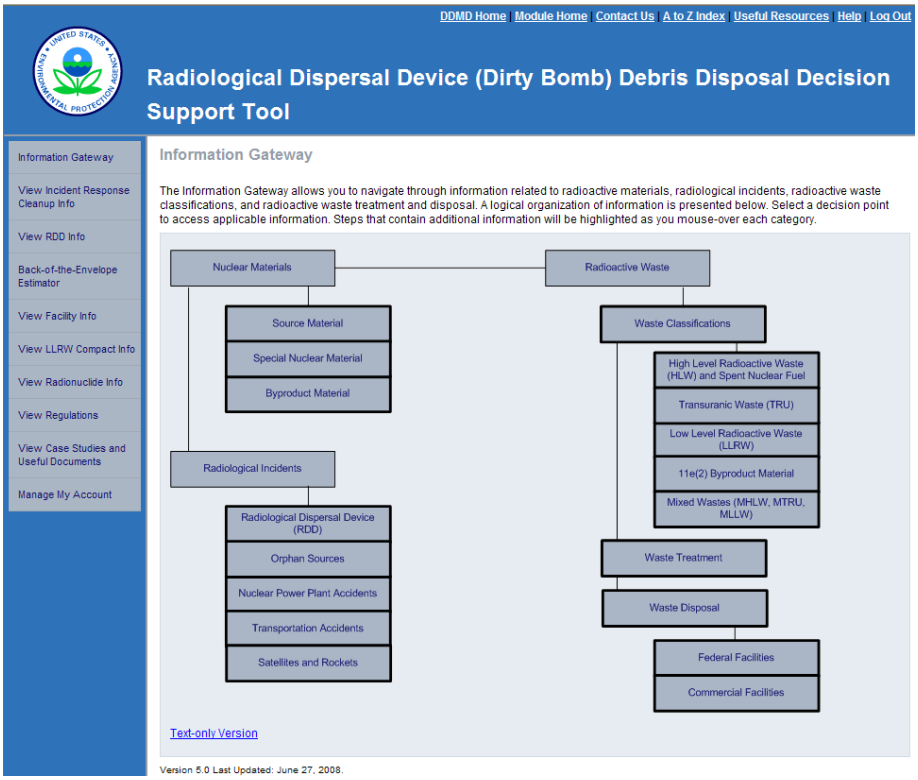

Fig. 3. RDD Debris Disposal DST Information Gateway Page.

New to Version 5.0 of the RDD Debris Disposal DST, the BoEE (shown in Fig. 4) builds on the functionality of the Back-of-the-Envelope Estimator contained in the Building Debris Disposal DST. Users can estimate waste quantities for various types of facilities including residences, hotels, office buildings, schools, shopping malls, hospitals, and theatres. Based on user input, the BoEE will generate estimates for the amount of debris that can be expected for disposal of any one facility or a combination of multiple facilities. Unique to the RDD Debris Disposal DST BoEE is the additional ability for users to generate an estimate of how the radiologically contaminated building debris might be classified according to 10 CFR 61.55 based on the concentration of the contaminating radionuclide. Users of the BoEE also have the ability to segregate up to three different waste streams and specify differing levels of contamination for each stream.

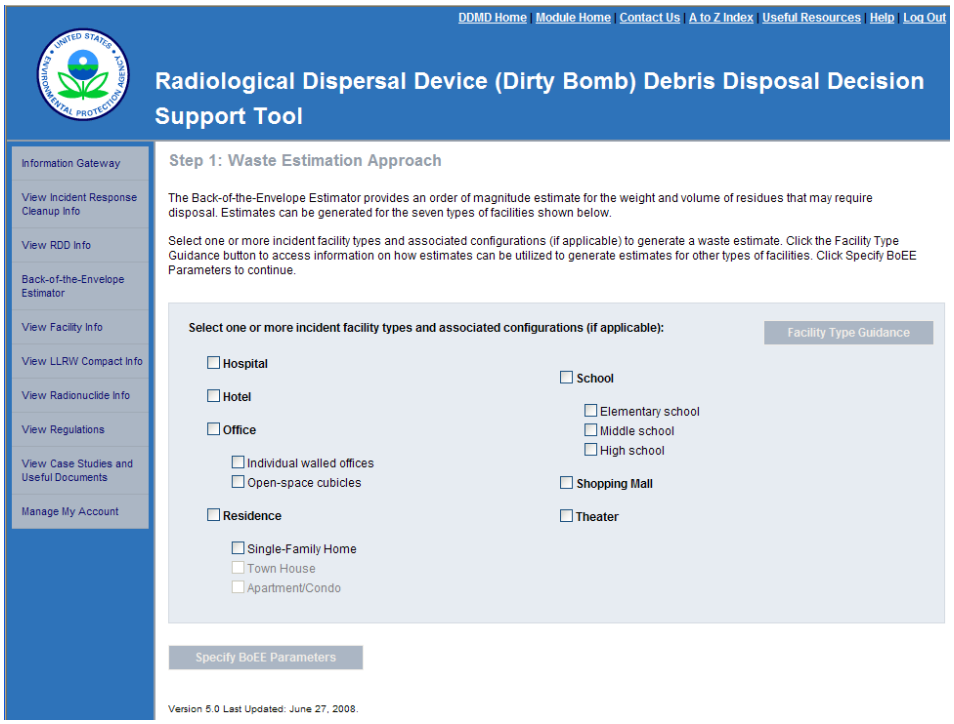

Fig. 4. RDD Debris Disposal DST Back-of-the-Envelope Estimator Page.

Future versions of the tool will contain functionality to assist users in determining LLRW classification based on multiple contaminating radionuclides, such as decay products from the initial contaminating radionuclide.

The latest version of the RDD Debris Disposal DST also contains detailed information on commercial and Federal radioactive waste disposal facilities. Facility location, contact information, available disposal capacity (if available), and radioactive waste types accepted are available. Users of the DDMD DST can access radioactive waste disposal facility information either through the main menu on the left side of the RDD Debris Disposal DST or through the Information Gateway.

Basic radionuclide properties, such as half-life, decay mode, and radiation energies, are also available through the RDD Debris Disposal DST. The property information is searchable according to the radionuclide of interest and was compiled based on radionuclide data available through Argonne National Laboratory [13]. Future versions of the DST will contain enhanced radionuclide property information and data, to possibly include radionuclide decay chains and daughter products.

Case studies and useful documents can be accessed from the left menu bar in the RDD DST. This feature of the tool is presented in Fig. 5 and includes links to radiological incident case studies from the International Atomic Energy Agency (IAEA), as well as links to useful documents covering topics such as:

- Incident response;
- Site investigation;

- Radioactive waste characterization;
- Radioactive material treatment technologies;
- Radioactive waste storage and disposal;
- RDDs/dirty bombs; and
- Radioactive waste transportation.

The Case Studies and Useful Documents page can also be accessed by selecting the Useful Resources link found in the global links at the top of the tool and then by selecting the Useful Documents and Reports link on the Useful Resources page. The Useful Resources page contains additional resources for users, many of which are also available on the Useful Resources pages found in the other DSTs. Specific to the RDD DST, however, are links to analytical and DOE national laboratories, and links to useful data resources, tools, and software.

Additional content will be developed and added to future versions of the RDD DST based on user feedback and stakeholder input. As with other DSTs in the tool, the RDD DST is being developed by EPA's National Homeland Security Research Center, but includes valuable input from stakeholders representing EPA, DOE, US Army Corps of Engineers, and others.

Fig. 5. RDD Debris Disposal DST Useful Documents and Reports page.

NEXT STEPS

Stakeholder feedback is used to set priorities and determine additional modules and revisions. As each version of the DSTs is completed, a workshop is held with stakeholders to obtain feedback and expert review. Typically this is done by assigning "homework" as part of each workshop to determine the ease of use in working with the DST and if it succeeds in providing needed information for the decision making process. For those having responded to previous events, it is particularly helpful to get their insight and guidance.

The different DSTs are in various stages of development. The BDR DST was the first to be created and the only remaining changes are to add additional calculators for other facility types (i.e., airports and indoor and outdoor arenas). A major focus over this next year will be to customize the user interface to be optimal for either the type of user or the user's planned use of the tool for a given session. Another major focus over this next year will be to prepare for migration of the tool to EPA servers.

CONCLUSIONS

EPA's Office of Research and Development has developed a suite of web-based decision support tools that will assist in the decision making process for the disposal of debris resulting from incidents of national significance. The use of the DSTs will provide decision makers information that is location-specific including contact information for disposal facility options. Guidance for handling and transportation is provided that is specific to the different types of disasters and contaminants. Outputs from the tool such as waste profiles and characterization information can be shared with facilities and transportation companies. DST outputs are also helpful in planning activities and understanding the costs for different disposal options, although the cost estimation portion of the tool is very much in its infancy. It is planned that future versions of the tool will enable estimation of total costs based on transportation, decontamination, and staging/storage decisions. The tool is not intended to override existing regulatory or legal requirements that apply to disaster debris handling, transport, or disposal.

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