EM Task 12 - Laser Cleaning of Contaminated Painted Surfaces

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LASER CLEANING OF CONTAMINATED PAINTED SURFACES

INTRODUCTION

Surface decontamination of concrete and steel surfaces in nuclear facilities provides cost savings during decommissioning operations by allowing recycling or reuse of concrete and steel structures. Separation of radionuclides and other contamination from the concrete or steel substrates also allows reduction in volume of hazardous materials during the D&D (decontamination and decommissioning) process, resulting in further cost savings.

Several techniques are available or under development for surface decontamination in nuclear facilities. Each technique has its merits; however, none of them is universally the best choice for all surface decontamination applications. Some issues which confront an organization selecting a surface decontamination technique for a particular application are as follows:

- Project scale
- Concrete or metal surfaces
- Contamination by radiological and other hazardous materials
- Stage of surface decontamination technology development (e.g., commercial, R&D)
- Equipment operating costs
- Collection of waste generated by surface decontamination
- Occupational health and safety requirements
- Utilities required for operations
- Real-time control of surface decontamination
- Recycling or reuse of decontaminated substrates
- Waste
  - Characterization
  - Classification
  - Transport
  - Storage
  - Treatment
  - Disposal
- D&D equipment decontamination

Because of the multitude of factors which influence the environmental and economic aspects of selecting a surface decontamination technique, it is difficult to select the best method in a given situation; an objective basis for comparing techniques is needed.

OBJECTIVES

The objective of this project is to develop a software tool for use by personnel selecting a surface decontamination technique. The software will incorporate performance data for available
surface decontamination techniques. The major activities in the project are broken down as follows:

Task 1 – Complete decision tree development
Task 2 – Literature search for surface decontamination reports
Task 3 – Compilation of database from literature data
Task 4 – Sensitivity analysis and model design
Task 5 – Design of model data structures
Task 6 – PC software design and coding

ACCOMPLISHMENTS

Work during this reporting period completed Tasks 1, 2, 3, 5, and 6. Task 4 activities resulted in a prototype of the model design; sensitivity analysis and model modifications are in progress at the time of this report. Task 4 will be complete prior to the end of December 1997. A working prototype of the software implementation of the surface decontamination model and technology database has been completed. The program developed at the Energy & Environmental Research Center (EERC) called Surface Decontamination Assistant allows comparison of surface decontamination techniques for a user-defined application scenario.

Task 1 – Decision Tree Development

The decision tree developed over the course of this project was completed during this reporting period. Appendix A contains Figures A1 through A3, which depict the surface decontamination decision tree. The decision tree functions as a framework for design and implementation of the computer model, allowing comparison of surface decontamination technologies.

Task 2 – Literature Search for Surface Decontamination Reports

Literature pertaining to surface decontamination applied in D&D operations has been identified and acquired using a number of information resources, including the Remedial Action Program Information Center (RAPIC), the U.S. Department of Energy (DOE) Information Bridge, DIALOG database, Current Contents, and other traditional literature search tools. A complete list of the documents in the literature database for this work is given in Appendix B.

Task 3 – Compilation of Database from Literature Data

Available data on surface decontamination operations have been gleaned from available reports. Several articles [1, 2, 4–9] contain evaluations of surface decontamination techniques for specific cases. Data have been compiled from a number of articles and an attempt made to put the data into a form allowing technology comparisons to be made.
In addition to technology performance data gleaned from the literature, a survey of surface removal equipment vendors was completed to obtain additional information for the technology database. A listing of the database as incorporated into the computer model is given in Appendix C.

Some of the performance data in the database are vendor-supplied, and portions of the technology entries were extracted from data collected under less-than-optimal experimental conditions. Therefore, the program is designed to allow additional technologies to be added as well as modifications to the performance data for technologies already resident in the database. Modifications and additions to the database will maximize the utility of the Surface Decontamination Assistant model.

**Task 4 – Sensitivity Analysis and Model Design**

*Sensitivity Analysis*

Sensitivity analysis is being applied to evaluate the software implementation of the logic depicted in the flow charts of Figures A1 through A3 (see Appendix A). At the time of this report, the model is under evaluation. It is envisioned that adjustments to the software will be made in order to produce a model that ranks surface decontamination technologies for a user-supplied application scenario.

*Model Design*

The model is designed to provide an overall figure of merit for each applicable surface decontamination technique under a user-defined application scenario. The overall figure of merit is an aggregate value derived from intermediate figures of merit for the major aspects of the surface decontamination process. As defined in the Surface Decontamination Assistant model, intermediate figures of merit are computed for the following:

- Surface removal
- Waste transportation
- Waste disposal
- Amount of recyclable waste
- Environment, health, and safety (EH&S)
- Technology implementation, operation, and maintenance

A number of assumptions are built into the current form of the Surface Decontamination Assistant model. Assumptions intrinsic to the execution of the model at this time are as follows:

1. Types of surface contamination are known.
2. Surface coating composition and thickness are known.
3. Depth of surface contamination is known.
4. Technologies are capable of achieving 100% surface decontamination.
5. Operation costs are based on a vendor service cost, including technology deployment and transportation to the site of application.

6. Practitioners are willing to employ more than one technique to achieve 100% surface decontamination.

7. No transuranic waste (TRU) or spent nuclear fuel (SNF) are part of the surface decontamination waste stream.

8. Solid and liquid waste streams are separated.

9. Removed substrate waste remains in solid form.

10. On-site waste disposal will employ existing vehicles and personnel.

11. Radioactive waste for on-site disposal will be of the contact-handled (CH) type.

12. All waste shipments are full loads for the style of transport.

As described above, the model will provide a comparison of techniques based on a user-defined application scenario. The user inputs to the model are as follows:

1. Site name, location, substrate, and contamination descriptions
2. Surface type (e.g., floor, ceiling) and material (steel or concrete)
3. Surface area to be decontaminated, amount of surface that is hard to reach, coating thickness, and removal thickness
4. General categories of contamination (e.g., radionuclides)
5. Surface area that is contaminated in each category
6. Distance to off-site storage and disposal facilities
7. Surface decontamination technologies to be included in the analysis
8. Transportation and disposal costs
9. Priority ranking for EH&S; operational, maintenance, and reliability issues; surface removal costs; transportation costs; and disposal costs.
10. On-site disposal transportation distance
11. Distance from nonhazardous material deposit facility
12. Type of transportation for wastes (truck or rail)

Details of the Surface Decontamination Assistant model implementation are given in Appendix D.

**Task 5 – Design of Model Data Structures**

The Surface Decontamination Assistant software has as one of its key components an extensible database of surface decontamination technology performance data. The technology database is designed to incorporate all the information that is unique to each surface decontamination technique and necessary to application of the Surface Decontamination Assistant model. Each technology database record contains the following fields:
- Technology name
- Description, including type of process (e.g., physical, chemical, effects on the substrate)
- Applicable substrates (concrete, steel, or both)
- Aggressive surface removal capabilities
- Production rate
- Operating cost
- Volume, weight, phase (solid or liquid), and density of secondary waste
- Thickness of surface removal
- Number of passes needed to achieve 100% surface coating removal
- Vertical surface-cleaning ability
- Ability to clean hard-to-reach areas
- On-line analysis capabilities
- Utility costs
- EH&S factor
- Implementation state, operation, and maintenance factor
- Equipment design for decontamination factor
- Technology development stage
- Number of workers necessary for operation

Appendix C contains a listing of the technology database.

**Task 6 – PC Software Design and Coding**

The architecture of the Surface Decontamination Assistant software is based on the major subsections illustrated in Figure 1.

The user interacts with the Surface Decontamination Assistant software through a set of dialog boxes. The user is lead through a series of input dialogs where the following aspects of the user-defined application scenario are entered:

1. **Scenario summary description** – site name, location of site, general substrate description, general contamination description, site activation date, modification date.
2. **Detailed site description** – surface type, substrate material, total area of the surface, area of hard-to-reach portions of the surface, thickness of surface coating, total thickness of the surface to be removed.
3. **General contamination information** – generic types of contamination.
4. **Quantified contamination information** – area of recyclable surface, area of surface not contaminated by hazardous waste, area contaminated by CH waste for on-site disposal, area contaminated by CH waste for off-site disposal, area contaminated by RH waste.
Figure 1. Surface Decontamination Assistant software architecture.

5. **Transportation information** – off-site transportation distance, on-site transportation distance, nonhazardous waste transportation distance, style of transport.

6. **Technology selection** – pick technologies to evaluate using the model.

7. **Setup inputs** – transportation fees, waste disposal fees, priority rankings.

A detailed description of the program structure and illustrations for each of the dialog boxes presented by the program are in Appendix E.

**FUTURE WORK**

Sensitivity analysis will be continued to evaluate the Surface Decontamination Assistant model, allowing optimization of the generated outputs to complete Task 4 of this project by December 31, 1997.

Work during the next year will involve distribution of the software to selected practitioners of surface decontamination within DOE and the U.S. Department of Defense. The software will be distributed with a questionnaire to allow user feedback on the software. At least one cycle of software distribution and modifications will be completed.
REFERENCES


APPENDIX A

SURFACE DECONTAMINATION DECISION TREE
Figure A1. Surface decontamination decision tree, Sheet 1.
Figure A2. Surface decontamination decision tree, Sheet 2.
Figure A3. Surface decontamination decision tree, Sheet 3.
APPENDIX B

LITERATURE DATABASE
LITERATURE DATABASE


10. S.A. SAIC. Market Assessment Decontamination of Radioactivity – Contaminated Concrete; 1996.


APPENDIX C

TECHNOLOGY DATABASE
<table>
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<th>Technology Name</th>
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APPENDIX D

SURFACE DECONTAMINATION ASSISTANT
MODEL DESIGN
SURFACE DECONTAMINATION ASSISTANT
MODEL DESIGN

SURFACE CHARACTERISTICS AND WASTE DEFINITION

The model determines a performance index (PI) for decontamination of a metal or concrete surface using a user-defined scenario as input. The user-defined scenario can include various types of substrate material, amount of area to be removed/decontaminated, depth of removal, surface orientation (e.g., floor), type of contamination, type of transportation used for disposal, distance to disposal site, and fees charged for disposal. Outputs include the performance indices listed below, which together provide an overall PI for a decontamination technology:

- Surface removal
- Transportation
- Disposal
- Recyclability
- Environment, health, and safety
- Implementability, operation, and maintenance

Assumptions

- User knows types of contamination that occurred on site.
- User has knowledge of surfaces to be decontaminated.
- Depth of contamination is defined.

TECHNOLOGY SELECTION

Included within the model is a database of technologies that contains information on the operational aspects of each technology listed. The user can view this information while using the model to help determine which process is most applicable for the user’s situation. Listed below are the fields within the database records that are based on the variables used in determining the overall PI for a technology:

- Destructive or nondestructive process
- Substrate cleaning ability – metal or concrete or both
- Surface-cleaning ability only
- Production rate
- Operating cost
- Volume, weight, phase, and density of secondary waste
- Depth of cleaning
- Number of passes needed to achieve 100% decontamination
- Ability to clean vertical surfaces
• Ability to clean hard-to-reach areas (corners, cracks, etc.)
• On-line analysis capabilities
• Usual utility costs
• Environment, health, and safety factors
• Implementability, operation, and maintenance
• Equipment decontamination necessary
• Stage of technology development
• Number of workers necessary to operate technology

Decontamination technologies are classified as either destructive or nondestructive processes. Destructive processes are considered to have 100% effectiveness of decontamination due to the actual removal of the surface containing the contamination. For nondestructive processes, the model assumes that each technology has the ability to achieve complete removal of the contaminants even if the surface must be cleaned several times. Technologies that are not applicable to cleaning a particular substrate (concrete, metal) will not be selectable by the user for that particular application. For example, if the contaminant has seeped into a concrete floor, a surface-cleaning technology (nondestructive) will no longer be a viable selection. The model also asks the user the orientation of the contaminated surface, then excludes any technology from selection that is not able to clean surfaces of that orientation.

Assumptions

• All technologies are capable of 100% decontamination of the surface.
• Operation cost is a service cost, which includes deployment and transportation to site.

CALCULATION OF SURFACE REMOVAL FACTOR

This section describes how a PI of surface decontamination is determined. Variables used in the surface removal PI include operating cost, production rate, depth of removal, number of passes necessary for 100% cleaning, and area to be decontaminated/removed.

The model can determine several different contamination scenarios: 1) contamination that has seeped into the concrete below the surface coating, 2) decontamination of a room or building, and 3) easy- versus hard-to-reach areas to be decontaminated.

In Scenario 1, the contamination has seeped down into the concrete. There are two possible ways to achieve the objective of decontamination: 1) Removal of both the surface coating and the contaminated concrete with one technology. This technology would have to be a destructive process or a process that is capable of penetrating the contaminated concrete. 2) Performing two separate runs of the model using a nondestructive process to remove the surface coating and another to decontaminate the concrete. One reason for using two different technologies is to reduce secondary waste by using a nondestructive low-waste-producing technology to remove the surface coating.
Scenario 2 involves decontamination of rooms or buildings, which would include horizontal and vertical surfaces. Some technologies are not capable of cleaning vertical surfaces or ceilings. There are two possible ways to approach this scenario: 1) Enter the total surface area for the building/room and use one technology that is capable of cleaning all of the surfaces. 2) Use several technologies to decontaminate the building/room, and run the model a separate time for each technology and different surface orientation.

Scenario 3 involves areas that are hard to reach, defined as a deep crack or crease or an area within 6 inches of the corners of a room, versus areas that are easily cleaned. Several technologies are not capable of cleaning within 6 inches of a corner. 1) Select a technology that is capable of cleaning all of the contaminated surface. 2) Run the model twice, once using a technology to clean the easily accessible areas, but unable to reach into the corners, and a second time using a technology that is capable of cleaning in the corners.

Assumption

- User is willing to use one or more different technologies to decontaminate a site.

Algorithm Description

For the first step, the model determines the total number of passes needed to completely remove the contaminants using an equation based upon the depth of removal, the depth at which the technology can clean per pass, and the cleaning effectiveness of the technology (Ref. 22, Appendix B, pp 1–26).

A second equation determines the surface removal factor for a technology by multiplying the contaminated surface area by the technology operating cost and the number of passes needed by the process to complete the task. Floor surface is treated apart from vertical and ceiling surface areas because some technologies are able to decontaminate only floors (Ref. 22, Appendix B, pp 1–26).

The time needed to complete the user-defined decontamination task is provided in a third calculation. The parameters taken into consideration are the surface area to be cleaned, the production rate of a technology, the number of passes necessary, and the percent of the area that is hard to reach (as defined above). A compensation factor is included that determines the rate at which the total hours to decontaminate will increase because of areas that are more time-consuming to clean (hard-to-reach areas). The total hours will be used later to determine the amount of secondary waste produced by a technology.

CALCULATION OF WASTE VOLUMES AND WEIGHT

Two primary waste streams are produced during the decontamination process. One is surface debris, resulting from the actual removal of the contaminated surface, and the other is the secondary waste produced from the technology during the cleaning process. The secondary waste
can be in liquid or solid phase, which is indicated in the technology database. For future
definition of the types of waste to be disposed of at a storage or disposal site, the model tracks
both weight and volume of the primary solid waste and secondary liquid and solid waste. Each
phase of waste will be treated differently during transportation and disposal.

Assumptions

- No transuranic waste or spent nuclear fuel is being transported or disposed of.
- Technologies and site personnel are capable of removing one specific area, then another,
  without mixing the removed waste.
- Solid and liquid waste streams are kept separate.
- Primary substrate waste is always solid.
- On-site disposal will use existing trucks and personnel.
- No rail shipment of remote-handled waste.

Algorithm Description

The volume and weight of debris resulting from the removal of the contaminated surface
are calculated by multiplying the surface area by the depth of removal and the solid surface
volume by surface density, respectively.

Each technology produces a different amount and phase of secondary waste from the
decontamination process (Ref. 1, Appendix B, pp 1–26). The total volume and weight of the
secondary waste for both solid and liquid phase are determined by multiplying the volume and
weight of waste produced by each technology per hour by the total number of hours.

The total volume amount of solid waste produced during the decontamination process is
determined by adding the volume of surface debris and the volume of secondary waste. The
amount of solid secondary waste is determined using the percentage of secondary waste that is
solid from the technology database.

Waste Classification

Most U.S. Department of Energy (DOE) waste streams from decontamination processes fit
one of the following categories: low-level waste (LLW), greater-than-Class C (GTCC) LLW and
DOE equivalent waste, transuranic waste (TRU), spent nuclear fuel (SNF), and hazardous waste.
(Ref. 26, Appendix B, p 1). These wastes streams are grouped together into three transportation
categories:

- Contact-handled (<200 mrem/hr contact dose)
Remote-handed (>200 mrem/hr contact dose)
Hazardous waste

Most storage/disposal facilities accept LLW, MLLW, and TRU wastes (Refs. 26, 102, 137, Appendix B). For ease of use, the model classifies waste as contact-handled (CH) (<200 mrem/hr contact dose) or remote-handled (RH) (>200 mrem/hr contact dose) for transportation and disposal. Solid CH waste can be disposed of on-site, thus lowering disposal costs. All liquid CH waste is assumed to be disposed of at a DOE or commercial disposal facility.

For on-site CH disposal, the travel distances are assumed to be under 30 miles and existing trucks and personnel are assumed to be used for transportation, resulting in a cost of $1/ft³ based on Idaho National Engineering Laboratory (INEL) experience (Ref. 102, Appendix B, p 5). Other types of waste produced during the decontamination process are recyclable aggregate, recyclable scrap metal, and general construction and disposal (C&D) waste. Uncontaminated concrete can be disposed of in a C&D landfill at a default charge of $7/yd³ (Ref. 3, Appendix B). Recycled aggregate is assumed to fetch 80% of the value of virgin aggregate, $6.67/ton (=$8.45 * 0.80) (Engineering News Report 1996).

Only concrete is considered recyclable, since it is in the waste stream during the decontamination process. Being able to recycle concrete will lower disposal costs. Concrete in the waste is removable from the structure during the process when steel is never in the actual waste stream and is still attached after decontamination. The value of recyclability would be the same for all metal decontamination processes. One technology will not produce more or less metal that is suitable for resale or recyclable after the cleaning process than another.

**CALCULATION OF TRANSPORTATION COSTS**

Waste is classified for shipping as either contact- or remote-handled. Waste also can be transported by either truck or rail with specific weight restrictions and container device restrictions. As noted in a DOE technology assessment, "The volume of remote-handled waste is very small and does not warrant an estimate of rail costs in addition to truck costs" (Ref. 2, Appendix B, p 9). Also, the standard remote-handled containers are not designed for rail shipment. For this reason the model does not consider rail shipment of remote-handled waste.

Transportation costs are determined in the form of cost-per-loaded-mile (CPLM) format. Most transportation is by truck, but rail can be used where practical. The CPLM unit rate is a variable cost dependent on the distance traveled. It has two subcomponents:

- **Carrier cost** – covers the variable costs associated with the cargo carrier. The carrier is the entity that takes title to the waste from the shipper during transportation, i.e., the trucking or railroad company.

- **Hardware costs** – the variable costs associated with procuring and maintaining the special hardware used during the transportation of waste. Special hardware consists
mainly of trailers and railroad cars equipped with special tight-sealing enclosures or shielded casks.

Fixed costs generally consist of demurrage cost of the carrier and the hardware used in the shipment, which are independent of the distance traveled. Fixed costs are incurred during loading and unloading operations.

Guidelines for liquid waste shipments by truck or rail differ from those for solid shipments because of the need to provide secondary containment of spills that might occur in transit. Liquid components will only be 50% of the shipment volume. A common method used for packaging liquids is to place the liquid waste in a 30-gal closed-top drum, which is then placed in a 55-gal open-head drum. Absorbent is placed between the two containers, allowing the absorbent to remain noncontaminated, not adding to the disposal costs (Ref. 26, Appendix B).

Assumptions

- On-site disposal will be solid CH waste only.
- All loads are full shipments.

Algorithm Description

**Truck – Contact-Handled Waste**

- 48-ft-long unshielded truck trailers
- Solid type of waste: LLW, MLLW, alpha LLW, alpha MLLW
- Solid load: 44,000 lb per shipment – 88 drums @ 500 lb
- Liquid type of waste: LLW, MLLW
- Liquid load: Type A container, 44,000 lb per shipment – 88 drums @ 500 lb

A calculation is done to determine the number of truckloads necessary to transport the waste to a DOE storage/disposal facility. The number of trucks needed are rounded up to the nearest full load. 2600 gallons is the estimated amount of liquid per shipment. Multiplying 2600 gallons by the density of water equals 21,688 lb/shipment (Ref. 26, Appendix B). Another computation determines the cost of transportation by multiplying the number of loads by the one-way distance traveled to a disposal facility and charge per mile. For the cost per mile, all distances traveled to DOE storage/facility sites are considered to be over 300 miles.

The fixed costs are multiplied by the number of loads and added to the total cost. The format is the same: 1) determine the number of loads necessary to remove waste, and 2) calculate the transportation cost for rail CH, truck RH, CH on-site disposal, and C&D disposal costs.

**Rail – Contact-Handled Waste**

- 40-ft-long intermodel (sea-land) containers
Solid type of waste: LLW, MLLW

Liquid load: Type B container, 38,000 lb per container – 76 drums @ 500 lb

Load: 44,000 lb per container – 11 boxes @ 3945 lb
or 38,000 lb per container – 76 drums @ 500 lb

Liquids – number of shipments = total quantity of liquid gal/18240 lb

_Truck – Remote-Handled Waste_

Type of Waste: LLW, MLLW, alpha LLW, alpha MLLW, GTCC/DOE equivalent waste

Load: 13,400 lb per shipment – 14–55 gallon drums per shipment

Liquids – number of shipments = total quantity of liquid gal/6422 lb

_Truck – On-Site Disposal_

Mass of solid waste

Number of truckloads at 44,000 lb per truckload

Fixed costs for loading/unloading and other costs associated with the use of trucks (fuel, etc.)

**CALCULATION OF DISPOSAL FEES AND RECYCLE CREDITS**

The fees charged by DOE and commercial storage/disposal facilities vary greatly from location to location (Refs. 3, 102, 137, Appendix B). The model uses an average for the different types of waste, which is considered fair, because the fee is the same for each technology. If the user wishes to change or knows the fee charged by a particular facility, that number can be entered instead.

- Contact-handled waste, off-site – High $300/ft³ (Ref. 137, Appendix B), medium $150/ft³ (Ref. 102, Appendix B, ), low $100/ft³ (Ref. 57, Appendix B)

- Contact-handled waste, on-site – $60/ft³ (Ref. 26, Appendix B)

- Remote-handled waste – High $740/ft³, medium $300/ft³, low $150/ft³ (Ref. 102, Appendix B)

- Construction and disposal waste – $0.26/ft³ (Ref. 3, Appendix B)

Assumptions

- User can use default values or will enter local disposal and recycle values.

Algorithm Description

The disposal and recycle values are determined by dividing the amount of material to be disposed or recycled by the material density and multiplying by the appropriate fee.

CALCULATION OF TECHNOLOGY PERFORMANCE INDICES

A PI is computed for each technology when it is selected. PIs can be compared against those for another technology if the decontamination scenario input values are identical. The higher the PI for a technology, the better the technology did decontaminating that scenario. The overall PI is composed of six different factors: surface removal, transport, disposal, recyclability, safety, and maintenance. To determine the safety and maintenance factors, performance scores were given each of the cleanup technologies in the areas of operation, maintenance, implementability, and environment, health, and safety (Ref. 57, Appendix B). The technologies were assigned nominal performance scores on a scale of 1 to 10, with 10 being the best. The criteria used were as follows:

- Implementability
  - Availability of the technology
  - Previous use of the technology
  - State of development of environmental management (EM) applications
  - Flexibility and adaptability

- Operation and maintenance
  - Setup
  - Cleaning operations
  - Equipment cleanup after shutdown
  - Equipment maintenance

- Environment, health, and safety
  - Regulatory compliance
  - Emissions of toxic gases, vapors, and dust
  - Worker exposure

The performance scores were independently assigned to the criteria by three raters: a senior chemical engineer with process experience, a research engineer, and a senior research chemist with recent background in developing a computer model for evaluating alternative surface-cleaning methods (Ref. 57, Appendix B).
Algorithm Description

Surface removal, transport, disposal, and recyclability were determined by summing all of the costs for each individual factor together and dividing by the total surface area removed. For example, all of the different types of waste disposal costs are added together (CH on-site, CH off-site, RH off-site, and C&D) then divided by the total surface area input by the user.

Disposal, surface removal, and transportation are all costs, with a lower cost meaning savings. To obtain an index number that gets larger to indicate a greater value, these variables are divided into a factor. The user has the ability to give one factor of merit more weight, or importance, than another factor by giving each factor a priority ranking. Each factor is assigned a priority rank with a value of 1-10, with 10 being the best. The program takes each PI and multiplies each value by the priority ranking given by the user, then sums together the six PIs and divides by the sum of the priority rankings.
APPENDIX E

SURFACE DECONTAMINATION ASSISTANT
SOFTWARE DESIGN
SURFACE DECONTAMINATION ASSISTANT SOFTWARE DESIGN

As described in the body of the report, the program applies the Surface Decontamination Assistant algorithm, taking its inputs from a user-defined application scenario and the database of technology performance data, resulting in technology comparisons.

User-Defined Application Scenario

Upon program execution, the user is presented with the main screen dialog, shown in Figure E1.

Interaction between the user and the software model is done via a series of input dialogs. Once the Run Complete Scenario button shown in Figure E1 is pressed, the user is led through a series of inputs defining the application scenario. The inputs requested of the user by each dialog are listed below.

First, a summary description of the site is entered as listed below and illustrated in Figure E2:

1. Site name
2. Location of site
3. General substrate description
4. General contamination description
5. Scenario (site) activation date
6. Scenario modification date

![Figure E1. Surface Decontamination Assistant main dialog.](image-url)
Upon pressing the Continue button shown in Figure E2, the user is prompted for more detailed site information as listed below and shown in Figure E3.

i. Surface type
ii. Substrate material
iii. Total area of the surface
iv. Area of hard to reach portions to be decontaminated
v. Thickness of surface coating
vi. Total thickness of surface to be removed

Next, when the Continue button depicted in Figure E3 is pressed, the user can select general categories, as shown in Figure E4.

As before, pressing the Continue button illustrated in Figure E4 brings the user to the input dialog shown in Figure E5, Quantified Contamination Definitions. The inputs needed are estimated surface areas of the following waste categories:

i. Recyclable
ii. Construction and disposal (can be sent to a landfill)
iii. Contact-handled (<200 mrem/hr) for off-site storage
iv. Contact-handled (<200 mrem/hr) for on-site storage
v. Remote-handled (>200 mrem/hr)

Figure E2. Input scenario summary description dialog.
Figure E3. Site Information dialog.

Figure E4. General Contamination Definition dialog.
Once the contamination input dialog is completed by pressing the Continue button, the user is prompted for information on the details of transportation to remove waste from the decontamination site. Listed below are the inputs, and the dialog is illustrated in Figure E6.

i. Distance to off-site waste storage  
ii. Distance to on-site waste storage  
iii. Distance to landfill disposal site  
iv. Style of waste transport

Pressing the Continue button shown in Figure E6 brings the user to the surface decontamination Technology Selection dialog depicted in Figure E7.

Pressing the Continue button shown in Figure E7 will initiate a dialog box prompting the user to name and save the application scenario. After the application scenario data are saved, program control is returned to the output viewer shown in Figure E8.

Pressing the Cancel button illustrated in Figure E8 will return program control to the main input screen shown in Figure E1.
Figure E6. Waste transportation input dialog.

Figure E7. Surface decontamination Technology Selection dialog.
Technology Comparisons

Technology comparison outputs are obtained by pressing the Generate Results button shown in Figure E1. The Surface Decontamination Assistant program outputs take three forms. Upon completion of a program run, the user is presented with a tabular output containing a summary of the technology comparisons, as shown in Figure E8.

Another type of output produced by the program is a series of bar graphs showing the indices (surface removal, figure of merit, etc.) computed by the program. An example of the figure-of-merit bar graph is shown in Figure E9.

Finally, the program generates a table containing all user-defined inputs and model results in a comma-delimited ASCII file formatted to allow reading the data into other programs such as spreadsheets, graphics programs, and other data analysis packages.

Setup Inputs for Fixed Site-Specific Information

Some user inputs not contained in the normal input sequence are accessed via the Setup menu. Selections available under this menu are described below.

A dialog is provided to allow the user to specify transportation and disposal costs (Figure E10). The inputs available are included on the following page:
1. Transportation fees
   i. Off-site truck contact-handled (CH) waste fee
   ii. Off-site rail CH waste fee
   iii. Off-site truck remote-handled (RH) waste fee
   iv. On-site CH waste fee
   v. Construction (nonhazardous) waste fee

2. Waste disposal fees
   i. CH waste on-site fee
   ii. CH waste off-site fee
   iii. RH waste off-site fee
   iv. Construction (nonhazardous) waste fee
   v. Aggregate income (recycle concrete)
   vi. Scrap metal income (recycle metals)

The user is also allowed to give priority to specific aspects of the surface decontamination process by adjusting the ranking of the categories listed on the dialog box shown in Figure E11. This allows the user to calibrate the model to individual preferences.
Figure E10. Transportation and Disposal Fees.

Figure E11. Priority Ranking user input.