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P2Pro(RSM): A Computerized Management Tool for Implementing DOE's Authorized Release Process for Radioactive Scrap Metals

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Contents

Contents (Cont.)

Tables

Figures

Figures (Cont.)

Notation

The following is a list of the acronyms and abbreviations (including units of measure) used in this report. Notation used only in equations is defined with those equations.

Acronyms, Initialisms, and Abbreviations

ALARA	as low as reasonably achievable
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
GUI	graphical user interface
LLW	low-level waste
MEI	maximally exposed individual
NRC	U.S. Nuclear Regulatory Commission
P2Pro(RSM)	Pollution Prevention Authorized Release Protocols (Radioative Scrap Metals)
QA	quality assurance

Units of Measure

Bq	becquerel(s)
cm^2	square centimeters(s)
dpm	disintegration(s) per minute
ft^2	square foot (feet)
ft^3	cubic foot (feet)
g	gram(s)
h	hour(s)
in.	inch(es)
lb	pound(s)
MB	megabyte(s)
mrem	millirem(s)
MT	metric ton(s)
pCi	picocurie(s)
yr	year(s)

Abstract

Within the next few decades, several hundred thousand tons of metal and several million cubic meters of concrete are expected to be removed from nuclear facilities across the U.S. Department of Energy (DOE) complex as a result of decontamination and decommissioning (D&D) activities. These materials, together with large quantities of tools, equipment, and other items that are commonly recovered from site cleanup or D&D activities, constitute non-real properties that warrant consideration for release from regulatory control for reuse or recycle, as permitted and practiced under current DOE policy. The provisions for implementing this policy are contained in the *Draft Handbook for Controlling Release for Reuse or Recycle of Non-Real Property Containing Residual Radioactive Material* published by DOE in 1997 and distributed to DOE Field Offices for interim use and implementation. This manual describes a computer management tool, P2Pro(RSM), that implements the first 5 steps of the 10-step process stipulated by the Handbook. P2Pro(RSM) combines an easy-to-use Windows interface with a comprehensive database to facilitate the development of authorized release limits for non-real property.

Section 1
Introduction

Provisions for release of U.S. Department of Energy (DOE) property containing residual radioactivity have been specified in DOE Order 5400.5, "Radiation Protection of the Public and Environment," as amended, which was first issued on February 8, 1990. On March 25, 1993, DOE began the process to codify (proposed rule, Title 10, Part 834, *Code of Federal Regulations* [10 CFR 834]) such standards and requirements that have been further interpreted in DOE guidance. Current releases are generally limited to materials with surface contamination for which explicit release levels have been prescribed in DOE Order 5400.5. Although these release levels were not specifically related to dose or risks, a screening analysis indicates that the implied doses to a hypothetical individual are generally at a level of a few millirem per year (Chen 1993). No equivalent release levels for volumetric contamination are currently sanctioned by DOE or any regulatory agencies.

Because of the lack of explicit release standards, a process of "authorized" release, which is based on a case-by-case (but systematic) approach, is permitted under the existing DOE Order 5400 or the proposed rule of 10 CFR 834. This approach provides for the development of authorized release limits through a series of prescribed steps before approval for release is granted. Specific requirements include the following: (1) pertinent radiological characteristics must be identified and specified for the materials, (2) release limits must have been derived to meet the as-low-as-reasonably-achievable (ALARA) objectives, (3) requisite documentation must be completed and approved by DOE authorities, and (4) concurrence by appropriate stakeholders must be sought and obtained.

Although authorized release has been practiced within DOE for several years, the materials have been limited primarily to scrap metals with only surface contamination. Furthermore, the practice lacks systematic and detailed guidance. In support of the authorized release process, DOE has published interim guidance that has been incorporated into the proposed rule of 10 CFR 834. To further clarify the provisions and to implement the policy, the *Draft Handbook for Controlling Release for Reuse or Recycle of Non-Real Property Containing Residual Radioactive Material* (herein referred to as the Handbook) was published by DOE in 1997. The document has been distributed throughout DOE Field Offices for interim use and implementation.

The release process prescribed by the Handbook applies only to non-real DOE property for which the preferred future use involves reuse or recycle. Release occurs when the property is transferred out of DOE control by sale, lease, gift, or other disposition, provided that the property does not remain under the radiological control of DOE, the U.S. Nuclear Regulatory Commission (NRC), or a responsible Agreement

State.[1] The release does not apply to real property, radioactive wastes, soils, liquid discharges, or gaseous or radon emissions. Examples of categories of property that are covered include:

- Consumable items such as wood, containers, labwares, and paper;
- Personal items such as clothing, brief cases, bags, respirators, and gloves;
- Office items such as computers, telecommunication equipment, unused office supplies, and furniture;
- Tools or equipment such as hand tools, construction machinery, vehicles, tool boxes, ladders, and scales; and
- Scrap materials such as wood, tanks, scrap metals, concrete, wiring, doors, and windows.

The authorized release approach described in the DOE Handbook consists of 10 steps for non-real property. These steps (Figure 1.1) address the general areas of property characterization, evaluation and development of authorized limits, approval of release, verification, and implementation of release. It is important to note that authorized or supplemental limits (i.e., the secondary limits applied only to special conditions) may be derived for individual releases of non-real property (e.g., one-time sale of reusable copper wire) or for categories of non-real property (e.g., scrap metal or office machines) that are routinely released over time. In the latter case, once authorized limits (or supplemental limits) have been approved for a category, individual releases of non-real property within that category are assumed to meet ALARA requirements if compliance with the limits has been demonstrated. Therefore, the entire 10-step process is not necessarily required for each proposed release. Determining the possible existence of previously established authorized or supplemental limits applicable to the proposed release is addressed early in the 10-step process (Figure 1.1).

The Pollution Prevention Authorized Release Protocols (Radioactive Scrap Metals) [P2Pro(RSM)] computer management tool described in this document is a Windows®-based application intended to facilitate the implementation of the methodologies outlined in the Handbook. While guiding the user through the first 5 steps of the 10-step process, P2Pro(RSM) compiles the data gathered and prepares a report comparing the costs and health risks associated with the various alternatives analyzed. The report can be submitted as part of the application to the DOE Operations Office.

Chapter 2 of this manual provides the basic design of P2Pro(RSM) and instructions for installation and use. Chapter 3 provides the framework of the database [a core

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[1] Agreement States are states with which the NRC or the U.S. Atomic Energy Commission has entered into an effective agreement under Subsection 274b of the Atomic Energy Act of 1954, as amended (73 Stat. 689).

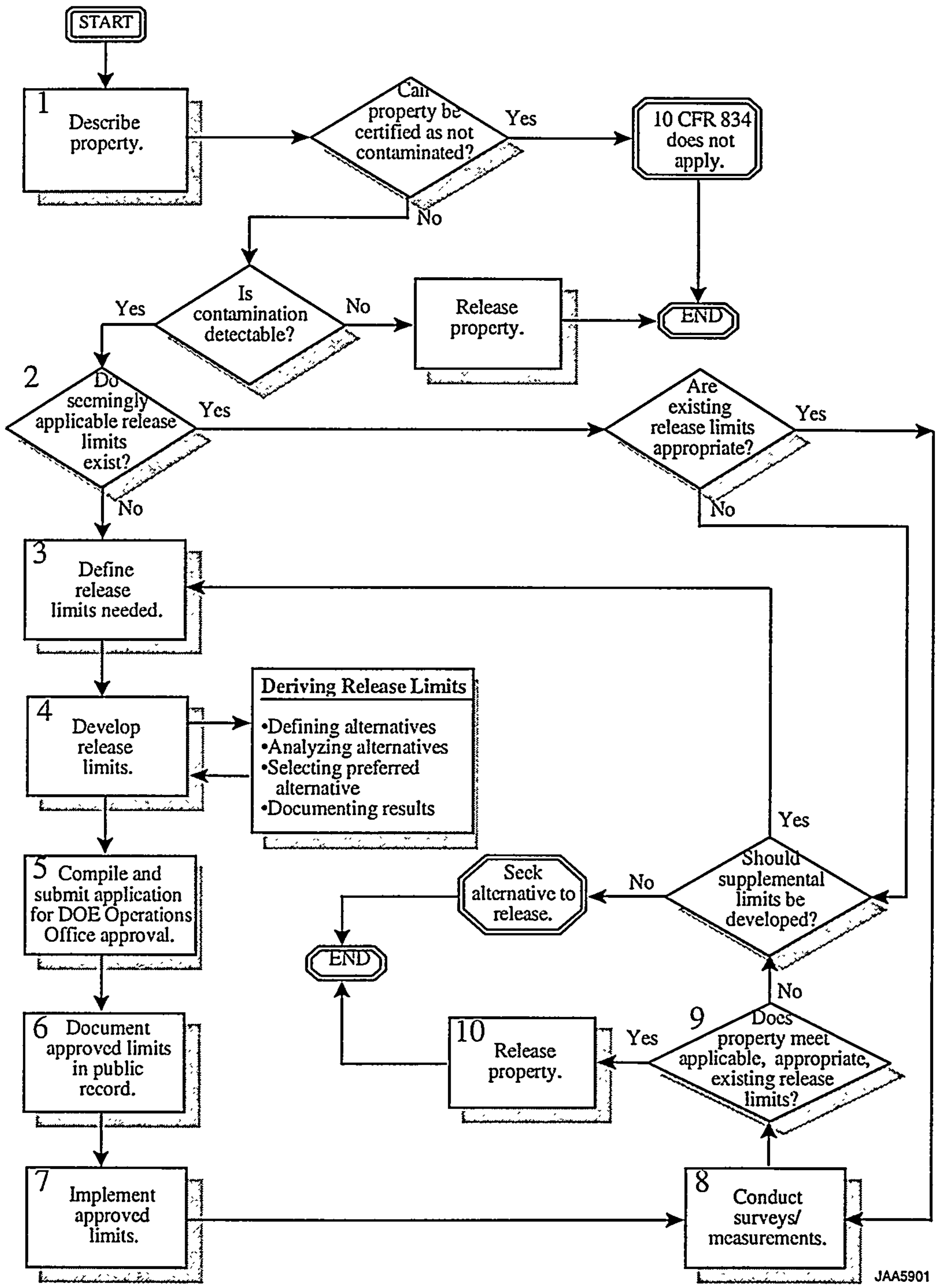

Figure 1.1 Authorized Release Process

component of P2Pro(RSM)] and the methodology used to estimate the costs associated with each alternative analyzed in the ALARA analysis. The Appendix provides a sample case study of a hypothetical release of scrap metal from a DOE facility and the output results from P2Pro(RSM).

Section 2
P2Pro(RSM) Overview

P2Pro(RSM) is a Windows-based computer management tool that guides the user through the first 5 steps of the 10-step authorized release process as listed below (Flemming et al. 1997).

1. Characterize property and prepare a description.
2. Determine whether applicable authorized or supplemental limits exist.
3. Define authorized or supplemental limits needed.
4. Develop authorized or supplemental limits using ALARA.
5. Compile and submit application to the DOE Operations office for approval.
6. Document approved limits in the public record.
7. Implement approved limits.
8. Conduct surveys/measurements.
9. Verify that applicable authorized or supplemental limits have been met.
10. Release property.

The development of authorized release limits (Step 4) requires a dose assessment and cost analysis to compare the costs and risks associated with multiple disposition alternatives in accordance with the ALARA principle. With P2Pro(RSM), the user creates the alternatives for consideration by using a combination of six distinct modules: Surveying & Volume Reduction, Decontamination, Recycle (Metal Melt), Transportation, Reuse, and Burial. Each alternative may involve one or more of the six modules. As an example, a user could compare the risks and costs of direct disposal with those of decontamination and recycle.

When the pertinent information for the non-real property has been entered into the database and the alternatives under consideration have been assembled, P2Pro(RSM) estimates the costs and risks for each alternative and provides the user with the results. The physical and radiological characteristics, combined with the results of the dose and cost assessment for each alternative analyzed, can be printed and attached to the application submitted to the DOE Operations Office for approval.

This chapter will provide the information for installing and running P2Pro(RSM). Each of the first 5 steps of the 10-step authorized release process are described, and an example of the interface for each step of the process is provided. Specific equations used for the dose and cost assessments are provided in Chapter 3, and a sample problem is provided in the Appendix.

2.1 Program Installation

The P2Pro(RSM) management tool is available on 1.44-MB, 3.5-in. diskettes. The protocol is a self-installing program that runs under Microsoft Windows 3.1 or later. The software requires a 80486 processor or higher (a Pentium series processor is recommended). To install P2Pro(RSM) in Windows 95 or 98, the user inserts disk 1 and presses the "Start" button, chooses "Run," and types *a:\setup*. For Windows 3.x, the file menu must be chosen and the "Run" option selected from the Windows Program Manager. When the installation is complete, a P2Pro(RSM) icon will appear inside the P2Pro(RSM) program group.

2.2 Running P2Pro(RSM)

The P2Pro(RSM) management tool is fully Windows compatible and allows data entry, scenario selection, text results display, and file opening and saving in a user-friendly environment. The program was designed to run in a fashion similar to a "setup wizard" program to guide the user through the authorized release process. Double-clicking on the P2Pro(RSM) icon (option) will start the program. The first screen provides information about the version of the software.

After the "About" screen has been closed, the program begins, and the user is prompted with a screen asking whether a new authorized release limit is going to be derived or whether an older file is going to be opened. If a new limit is to be derived, the user clicks on the "Derive a new authorized release limit" button and designates a file name for the new case. A new file name can contain a maximum of 25 characters, including spaces.

If the user clicks on the "Open an existing authorized release limit" button and proceeds to click on the "Continue" button, a list of existing files will be displayed from which the user can select. Figure 2.1 shows the initial user input screens.

P2Pro(RSM) takes the user through the first 5 steps (i.e., through "Compile and Submit Application to DOE") of the 10-step authorized release process. As the user goes through each process, a status bar is displayed at the top of the screen showing how far the user has progressed.

2.2.1 Step 1: Describe the Property — Physical Description

After the user chooses either to edit an existing file or create a new authorized release limit, the first step of the authorized release process is initiated. The user selects the non-real property category that best fits the material. Under the main category, subcategories are provided to further characterize and describe the property. Descriptions with examples are provided for each subcategory. A default surface-to-mass ratio (see Chapter 3) is also shown; the user should modify this value if material-specific information is available. After the material subcategory has been selected, the total amount (mass) of non-real property proposed for authorized release must be entered. The amount can either be in metric tons or kilograms. When the user has finished entering the data, the "Next" button should be pressed to proceed to the following screen. Figure 2.2 is an example of the physical characterization screen.

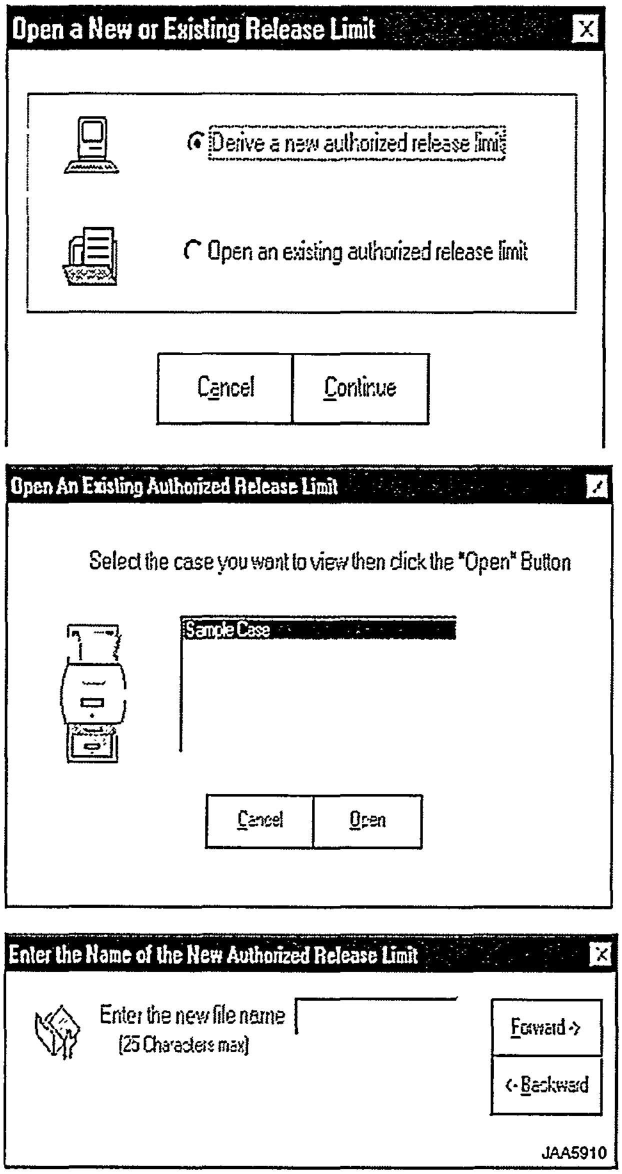

Figure 2.1 Project Name/Project Retrieval Screens

2.2.2 Step 1: Describe the Property — Radiological Properties

After the physical description of the non-real property has been entered into P2Pro(RSM), radiological properties of the material are entered. The initial radionuclide property window (Figure 2.3) is a summary window that shows the radionuclide contamination levels for the non-real property. If this is a new file, this window will not contain any data. The user may add or modify the radionuclide contaminants by clicking on the "Add Radionuclide" button. This action will open a window that allows the user to add or modify radionuclide contaminants, as shown in Figure 2.4.

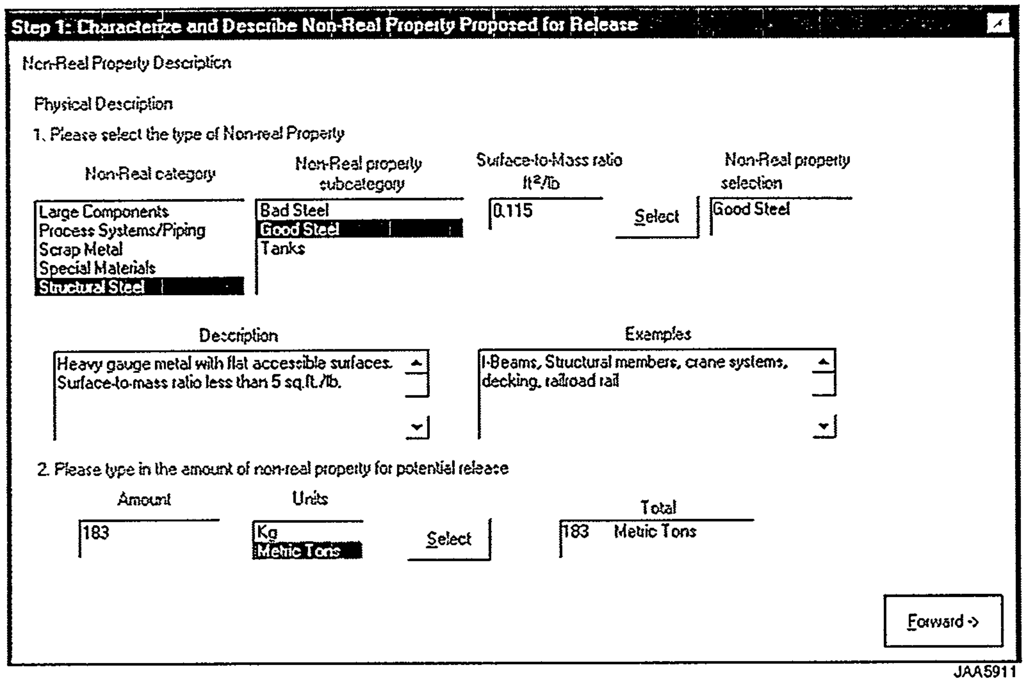

Figure 2.2 Physical Characterization and Description Window

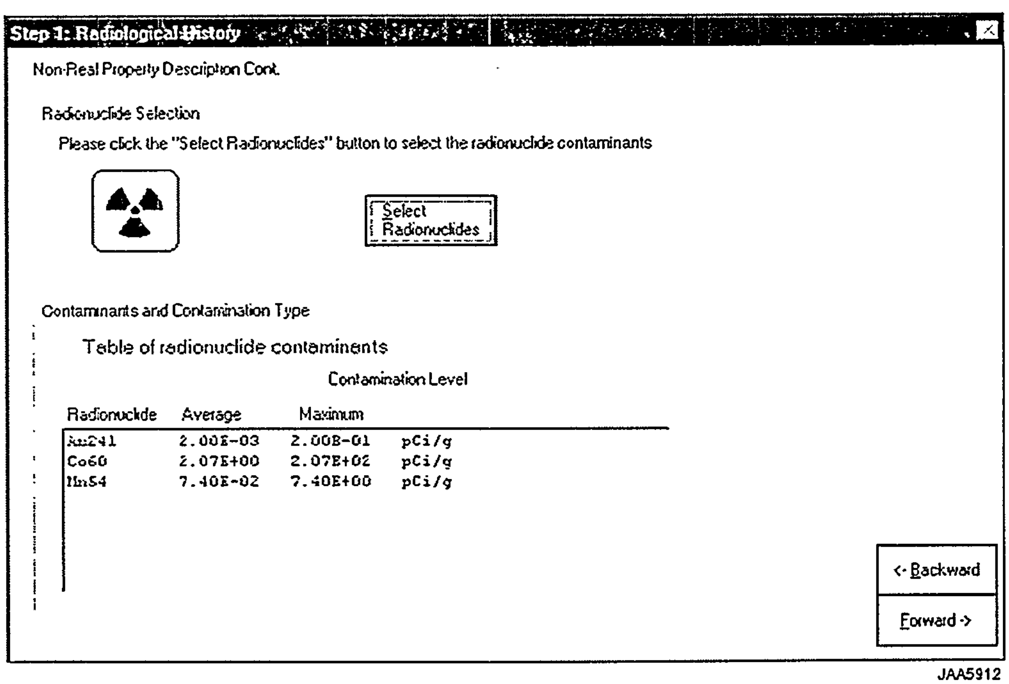

Figure 2.3 Main Radionuclide Contamination Window

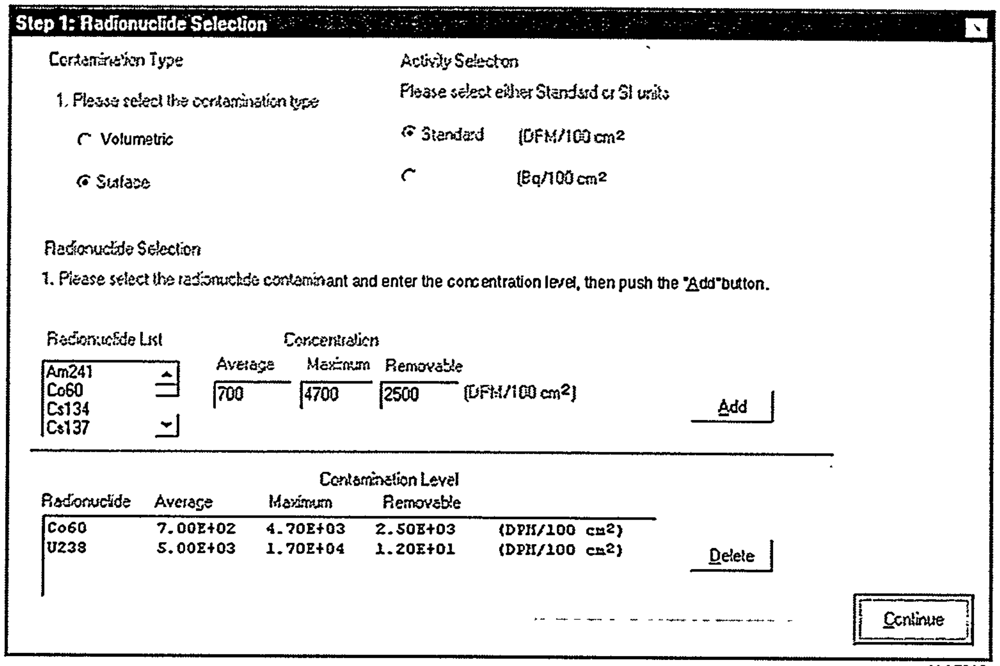

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Figure 2.4 Radionuclide Contaminant Data Entry Window

Initially, the user specifies whether the non-real property is surface or volumetrically contaminated by clicking on the appropriate radio button. This selection, combined with the material description, will determine which decontamination methods (if any) are available later in the program. After selecting the contamination type, the user specifies whether the contaminant concentration values are in standard or SI units. The user then can select the applicable radionuclides from the scroll list. Clicking on the radionuclide will highlight it in the list, and the user can then enter the concentration for each radionuclide.

For volumetrically contaminated non-real property, average and maximum concentrations are entered for each radionuclide. This procedure enables the program to estimate a range of doses from the disposition of the non-real property. For surface-contaminated non-real property, the user must enter the average, maximum, and removable concentrations that correspond to surface release limits provided in DOE Order 5400.5.

After the concentrations have been entered, the user clicks the "Add" button to add the radionuclide to the selection list. After completing radionuclide data entry, the user must click the "Continue" button to return to the main radiological history screen. The user should then click the "Forward" button to continue through the authorized release process.

2.2.3 Step 2: Do Release Limits Exist? / Step 3: Define Release Limits

When the radionuclide contaminants have been entered into P2Pro(RSM), the program checks the contamination levels against existing release limits, provided that release limits already exist. Currently, no guidelines are available for volumetrically contaminated non-real property. If this situation is confronted, the user automatically proceeds to Step 4, "Develop authorized or supplemental limits using ALARA."

For surface-contaminated non-real property, the entered radionuclide concentrations are checked against the surface activity guidelines in DOE Order 5400.5. A computerized version of the table is provided in P2Pro(RSM) and is shown in Figure 2.5. The figure shows four radionuclide groups and three guidelines for each group, which correspond to the average, maximum, and removable concentration limits. The surface activities for each radionuclide are summed by group and concentration level. If the group guideline is exceeded for a specific concentration level, then the corresponding concentration level is colored red. In a similar manner, if the guideline is not exceeded, the concentration level is colored green. Finally, if the concentration level is equal to the guideline, the corresponding concentration level is colored yellow. The user must click the "Forward" button to continue through the authorized release process.

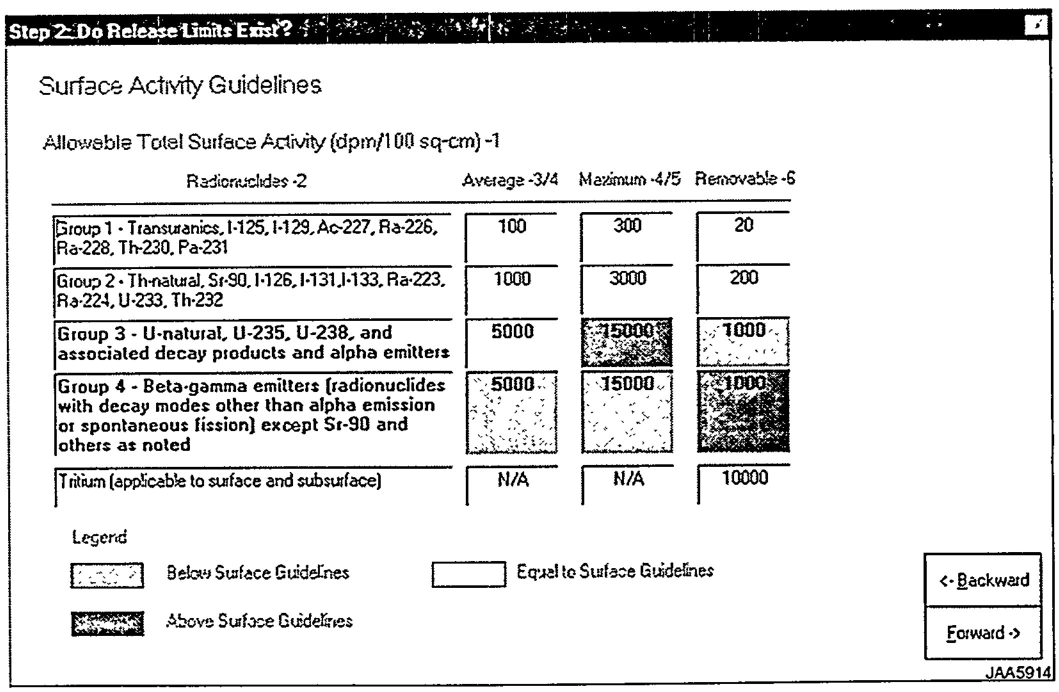


Figure 2.5 Surface Activity Free-Release Guidelines

Even if the contamination levels of the non-real property are below the guidelines in DOE Order 5400.5, the property cannot be free released without an ALARA analysis. Therefore, the activity levels in the Surface Activity Guideline table should not be treated as existing authorized limits until ALARA process requirements have been fulfilled. To fulfill the requirements of DOE Order 5400.5, the user must proceed to the ALARA analysis section by clicking the "Perform ALARA Analysis" button.

2.2.4 Step 4: Develop Authorized or Supplemental Limits Using ALARA

The authorized release limits are developed on the basis of the results of a dose assessment to ensure that radiological doses to members of the general public are kept "as low as reasonably achievable" or ALARA. With P2Pro(RSM), the ALARA analysis is conducted by constructing a set of disposition alternatives and evaluating the associated doses and costs for each alternative. The user assembles an alternative by selecting distinct modules for analysis. Each alternative may involve the use of one or more of the six modules: Surveying & Volume Reduction, Decontamination, Recycle (Metal Melt), Transportation, Reuse, and Burial. Figure 2.6 shows the three alternatives for the disposition of scrap metal in the main ALARA analysis window.

When the ALARA analysis is first started, the user must enter the name of the alternative to be analyzed. The user may enter more detailed information in the description section. After the name and description have been entered, the user must click the "Add" button to add that alternative to the list of alternatives and to proceed to the next set of windows to select the modules for use.

To edit or revise a previously constructed alternative, the user may select any alternative from the alternative list, shown in the bottom of Figure 2.6, and click the "Edit" button. The user must then provide a revised name and description for the alternative, after which the "Revise" button must be pressed to continue revising the alternative. The user may choose to remove an alternative from consideration by pressing the "Remove" button. All information pertaining to that alternative will then be removed from the program. After all alternatives have been constructed, the user can click on the "Results" button to view the results of the ALARA analysis.

After the "Add" (or "Revise") button has been pressed, the user moves to a window that displays the array of six modules used to build the alternative. The user may select the scenario or scenarios that best match the alternative that is under consideration by clicking on the check box next to the module. For example, if the user wants to estimate the costs and risks associated with a free release alternative, the Survey & Volume Reduction and Recycle alternatives would be selected. After all appropriate modules have been selected, the user continues construction of the alternative by clicking on the "Forward" button. Figure 2.7 is an example of the module selection screen.

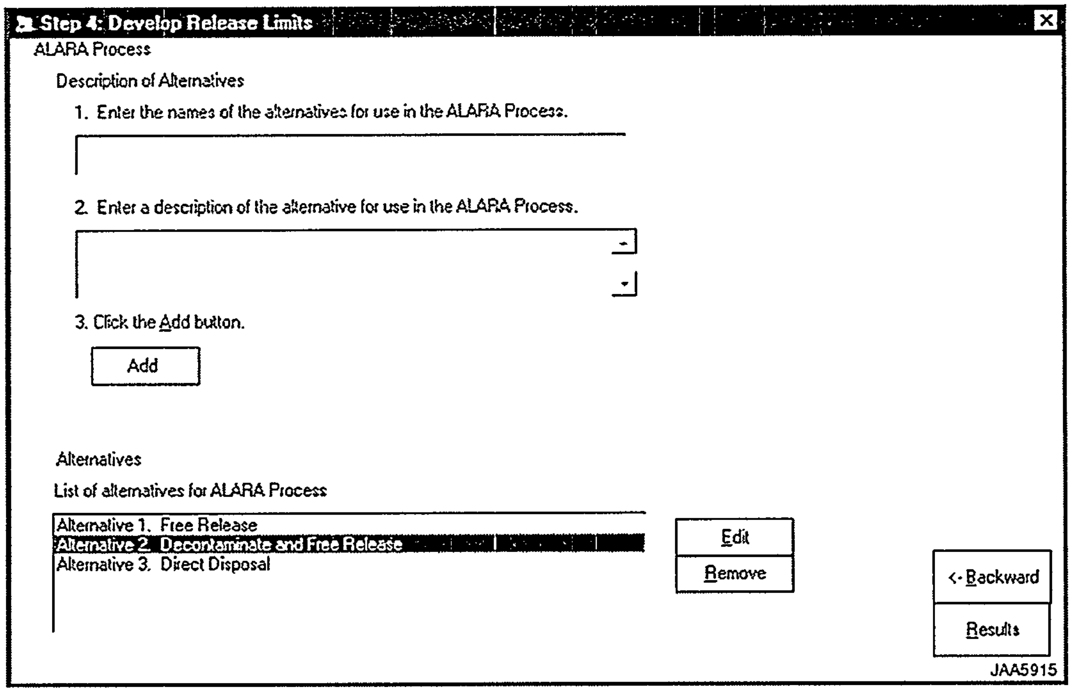


Figure 2.6 ALARA Analysis Setup Window

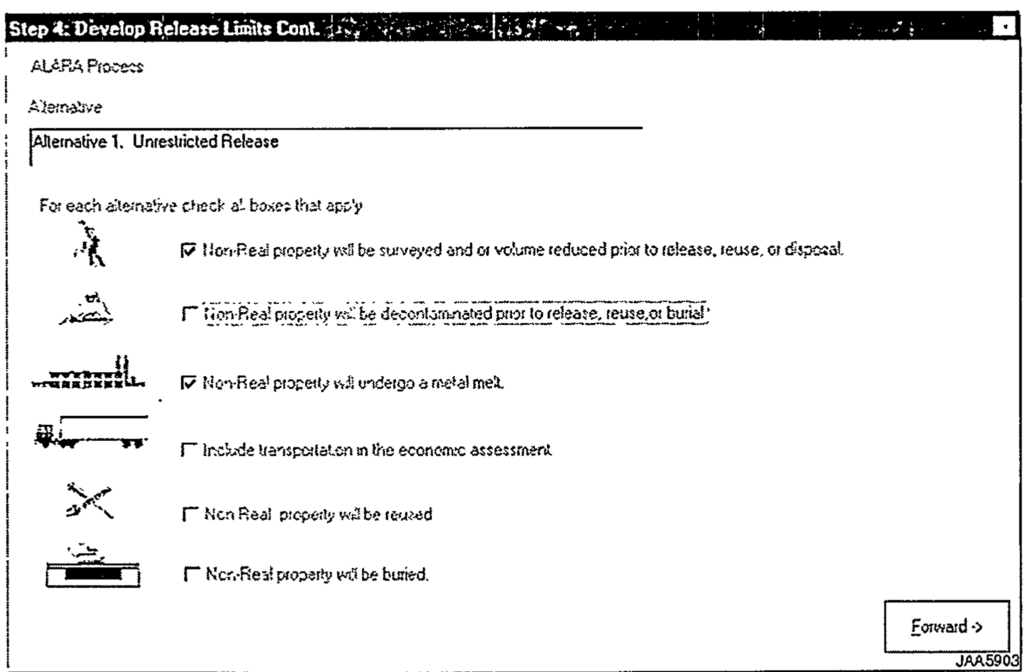


Figure 2.7 Module Selection Window

2.2.4.1 Step 4: Module 1 — Surveying & Volume Reduction

The Surveying & Volume Reduction Module estimates the cost associated with surveying the non-real property prior to release, reuse, or burial. A description of the methodology for estimating the associated costs is shown in Section 3.4.4.1. An example of the Surveying & Volume Reduction Module is shown in Figure 2.8. To select the scenarios, the user clicks on the check boxes or radio buttons appropriate for the alternative under consideration. When the user selects particular scenarios, key parameters can be edited. For example, if the user selects the radio button indicating that the non-real property will be volume reduced (default case), a text box appears so that the user can enter data pertaining to the volume reduction waste generation rate. Other parameters that the user can enter in the Surveying & Volume Reduction Module include the packaging density and the packaging waste generation rate. To include the price of the shipping containers in the cost estimate, the user must click on the check box "Include the price of the SeaLand/B25 boxes in cost estimate." When all data for the Surveying & Volume Reduction Module have been entered, the user clicks the "Forward" button to proceed to the next module or to return to the ALARA analysis window.

2.2.4.2 Step 4: Module 2 — Decontamination

The Decontamination Module is used when the non-real property undergoes decontamination prior to free release, reuse, or disposal. An example of the Decontamination Module data entry window is shown in Figure 2.9. The decontamination categories available for use are based in part on the material and contamination type. The methodology used for estimating the costs associated with decontamination are presented in Section 3.4.4.2. The user selects a decontamination category by clicking on the list box under "Decontamination Category." A listing of decontamination subcategories is presented in a list box under "Decontamination Sub-Category." For example, if the user wants to analyze the decontamination of a piece of surface-contaminated non-real property by abrasive blasting, multiple abrasive blasting types are available as subcategories. When the user selects a decontamination subcategory, default parameters appropriate for that decontamination method are presented in the text boxes. The parameters include the decontamination factor, material throughput, process cost, secondary waste generation, and secondary waste burial cost. If process-specific parameter values are available, the user may change the parameters by selecting the check box above the parameters. More than one decontamination method can be entered; for example, the user may want to consider abrasive blasting after water washing. When all the data have been entered for the Decontamination Module, the user must click the "Forward" button to proceed to the next module or to return to the ALARA analysis window.

2.2.4.3 Step 4: Module 3 — Recycle (Metal Melt)

The Recycle (Metal Melt) Module is used when the non-real property is to undergo a metal melt before free release. Examples of the Recycle (Metal Melt) windows are

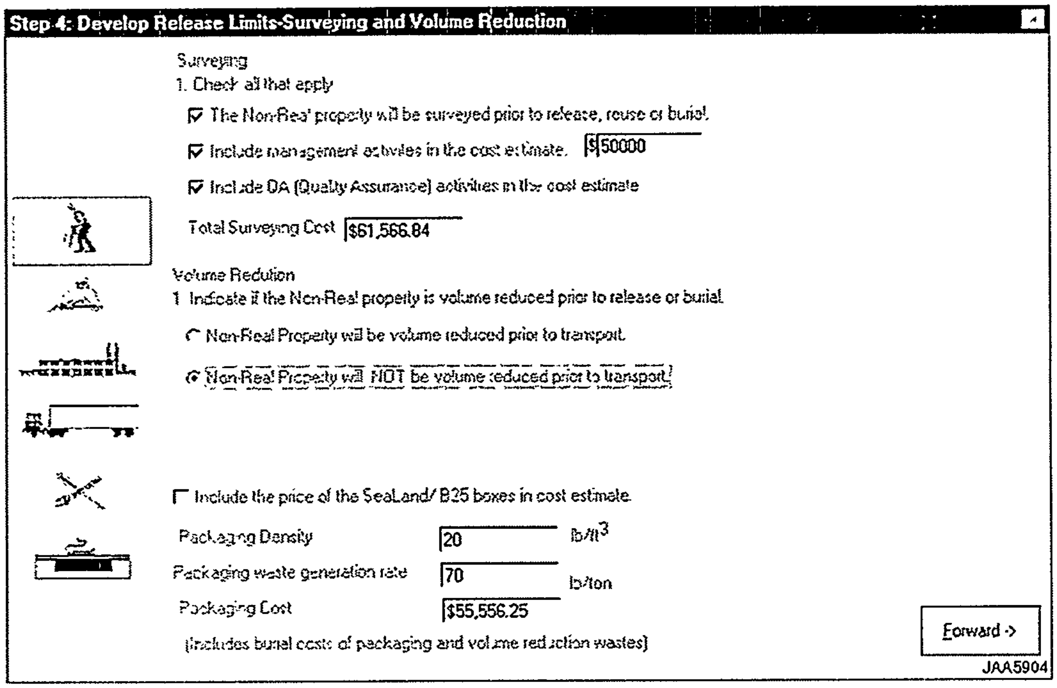


Figure 2.8 Surveying & Volume Reduction Data Entry Window

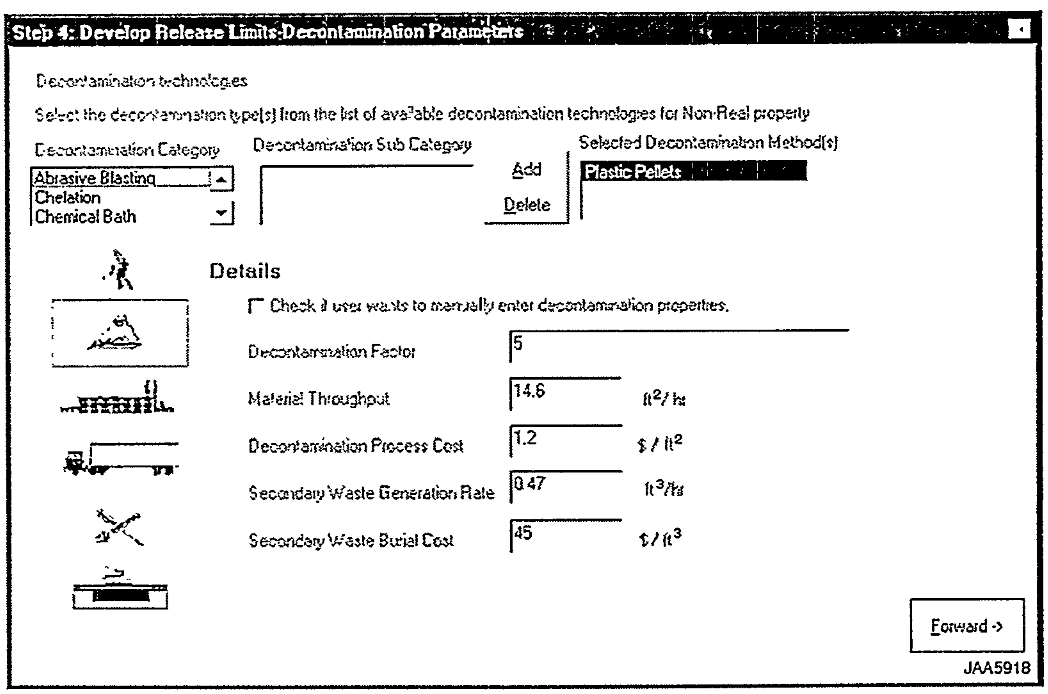


Figure 2.9 Decontamination Data Entry Window

shown in Figure 2.10. The first metal melt window consists of an array of check boxes that describe the scenarios and end-use products for consideration. The methodology for estimating the dose associated with each scenario or product is provided in Section 3.4.4.3. By default, all scenarios and products are considered. The user can deselect or reselect a specific process scenario or end-use product by clicking on the check box next to its name. If a check appears, then the dose associated with that particular scenario or product will be estimated. After the appropriate scenarios and products have been selected, the user must press the "More" button. The second metal melt window contains the key parameters for estimating the doses and costs for the Recycle (Metal Melt) Module. Default partitioning factors are provided for each radionuclide. If site-specific radionuclide partitioning factors are available, the user may replace the default values by clicking on the radionuclide in the list box and then clicking the "Edit" button. The user replaces the partitioning factors by typing the new values into the text box and clicking on the "Accept" button. If the user wants to return to the default values, the "Default" button should be pressed to load the default radionuclide partitioning factors into the database.

Similarly, the user may edit the selling price for the non-real property by checking the box "Check to edit the value of the non-real property." At this point, the user may either proceed to the next module (or return to the main ALARA analysis widow) by clicking on the "Forward" button, or return to the first Recycle (Metal Melt) Module screen by selecting the "Backward" button.

2.2.4.4 Step 4: Module 4 — Transportation

The Transportation Module data entry window is used to estimate the material transport costs for an alternative. An example of the Transportation Module data entry window is shown in Figure 2.11. The module estimates costs for transporting the non-real property, packaging and volume reduction wastes (if applicable), and secondary waste from decontamination (if applicable). The methodology for estimating these costs is provided in Section 3.4.4.4. The user selects one of the three items by clicking on that item in the list box. The user may alter the transportation mode, the distance traveled, and the number of shipments. The transportation mode can be altered by clicking on the button next to the desired mode. The distance traveled can be altered by clicking on the text box and modifying the distance. The number of shipments can be altered by selecting the radio button "Enter number of shipments." By default, the number of shipments is estimated on the basis of the total amount of non-real property. The estimated transportation cost for the selected item is displayed in the text box located at the bottom of the window. When all data for the Transportation Module have been entered, the user must click the "Forward" button to proceed to the next module or to return to the ALARA analysis window.

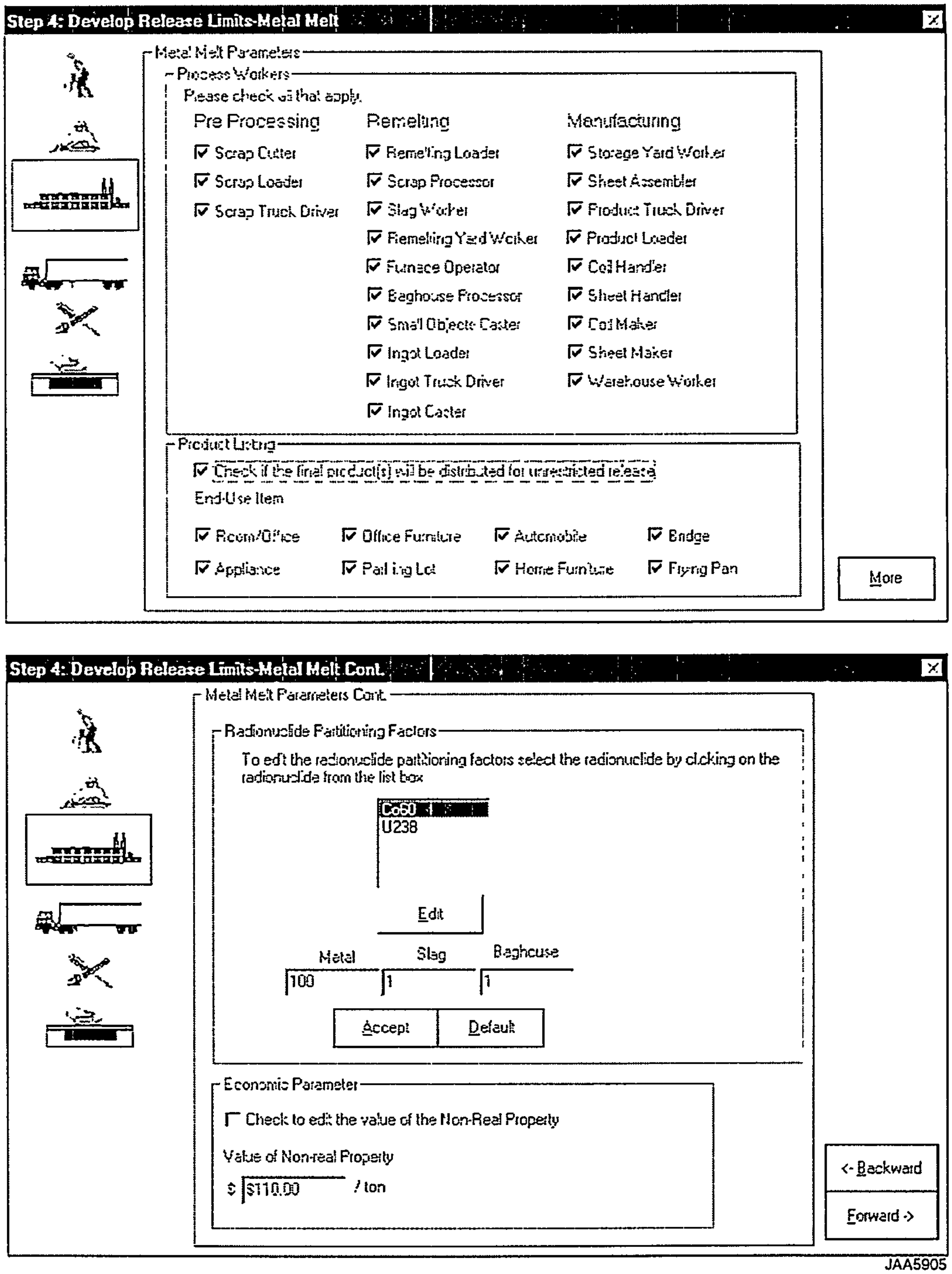


Figure 2.10 Recycle (Metal Melt) Data Entry Windows

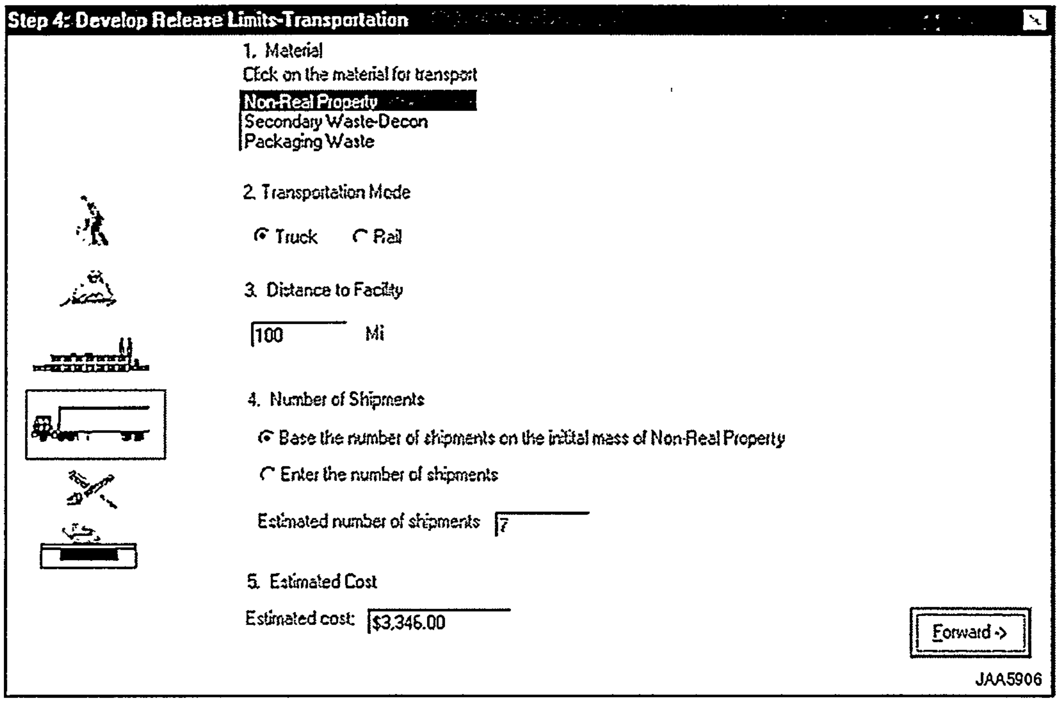


Figure 2.11 Transportation Data Entry Window

2.2.4.5 Step 4: Module 5 — Reuse

The Reuse Module is used to perform a dose assessment for the reuse of non-real property. The only user input required is selecting the item for reuse. Once the item has been selected from the list box, the user must press the "Forward" button to proceed to the next module or to return to the ALARA analysis window. An example of the Reuse Module data entry window is shown in Figure 2.12, and the methodology for estimating the dose to members of the public from reuse is provided in Section 3.4.4.5.

2.2.4.6 Step 4: Module 6 — Burial

The Burial Module is only used when the alternative under consideration is disposal or burial of the non-real property. The only parameter that can be entered is the unit cost for disposal. A default value of \$45 /ft^3 is provided by P2Pro(RSM) (Warren et al. 1995). This value may by overwritten by selecting the checkbox "Check to enter unit burial cost (\$/ft^3)." An example of the Burial Module data entry window is shown in Figure 2.13. The methodology for estimating the dose to an individual and the associated costs for burial are provided in Section 3.4.4.6.

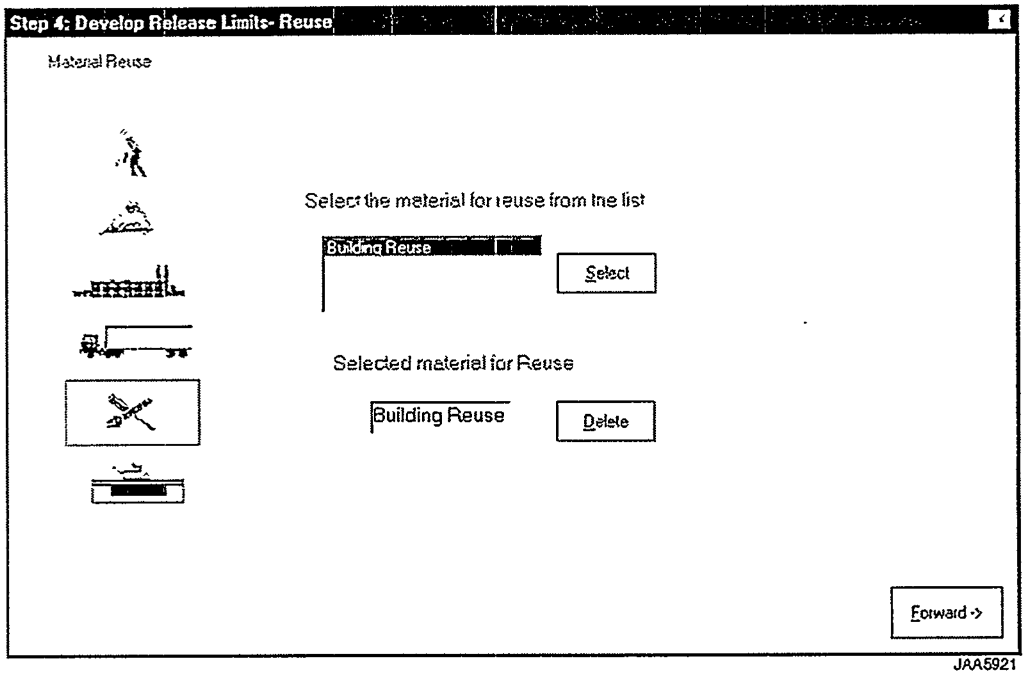


Figure 2.12 Reuse Data Entry Window

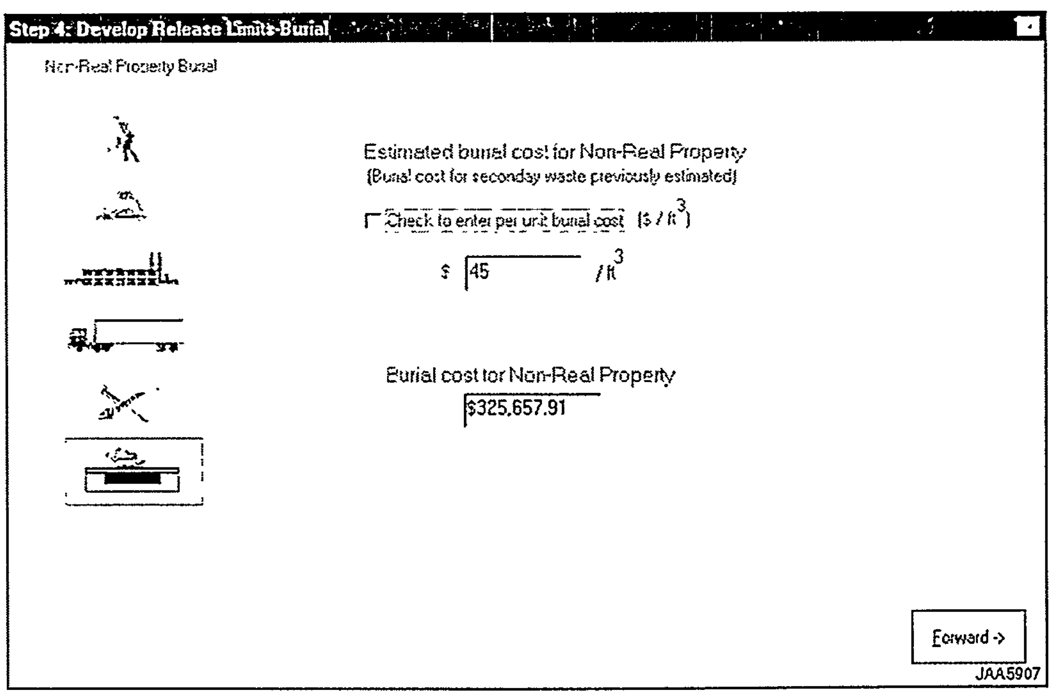


Figure 2.13 Burial Data Entry Window

2.2.5 Step 5: Compile and Submit Application for DOE Operations Office Approval

After all of the data have been entered into each module selected, the user is returned to the main ALARA analysis window. At this point, the user may enter additional alternatives or view the results of the ALARA analysis just conducted. To view the results of the ALARA analysis, the user must click the "Results" button shown in Figure 2.6.

After the user presses the "Results" button in the main ALARA analysis window, P2Pro(RSM) sorts and displays the results for each alternative. Figure 2.14 is an example of the dose assessment summary window. The dose assessment results shown are for the average contamination values. The user can query the database to display and sort the results in several methods. The display and sort options are performed by clicking the appropriate radio buttons. For example, to view the public doses associated with each alternative, the user would select the radio button under "Display Options" labeled "View Public Dose Only." To sort the displayed records by dose (in decreasing order), the user would then click the radio button labeled "Sort By Dose" under "Sort Options."

The user can view a more detailed table of results from the dose assessment by clicking the "View Details" button. The detailed results window is shown in Figure 2.15. The user may view the results of the dose assessment for each contamination category by clicking the appropriate radio button. Likewise, the dose assessment results for each module can be selected, and the user may specify whether the results should be process level or radionuclide level. The results are always sorted in descending order. After the results have been reviewed, the user can return to the summary window ("View Summary"). To edit or delete alternatives generated in Step 4, the user must click the "Edit Alternatives" button. To view the results of the economic analysis, the user must click the "Economic Assessment" button; likewise, to print a hardcopy of the analysis, the user must click the "Print" button.

Clicking on the "Economic Assessment" button brings up summary results of the economic assessment. Figure 2.16 is an example of the economic assessment window. By default, the cost results are displayed for each process and are sorted by alternative in ascending order; the results also could be displayed by cost in descending order. Costs associated with the alternatives (decontamination, transportation, etc.) are reported as negative values (displayed within parentheses); income received through the sale of non-real property is reported as a positive value (displayed without the parentheses.) A summary of the total cost for each alternative can be displayed by clicking the "View Total Cost" button. Detailed results of the cost assessment can be displayed by clicking the "View Details" button.

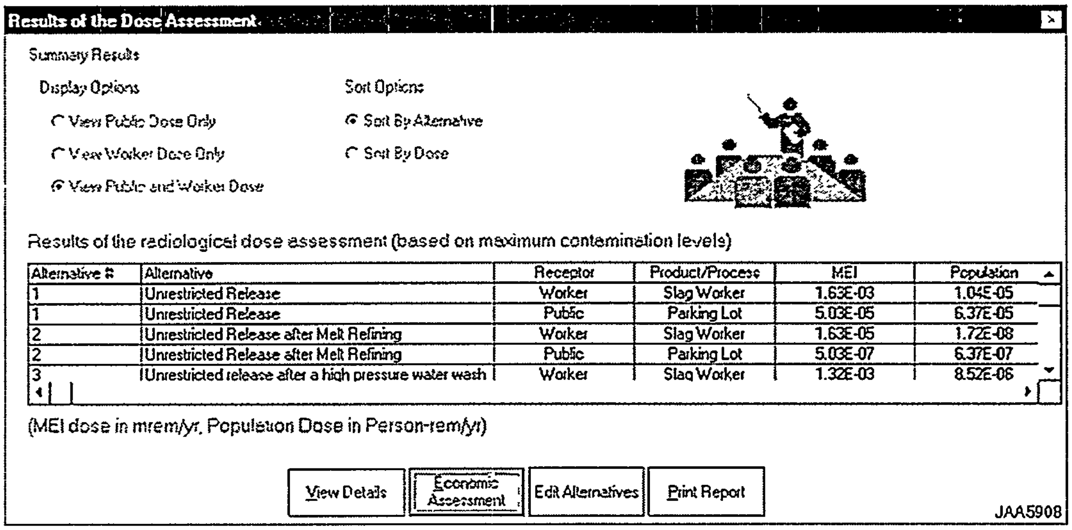


Figure 2.14 Summary Results for Dose Assessment

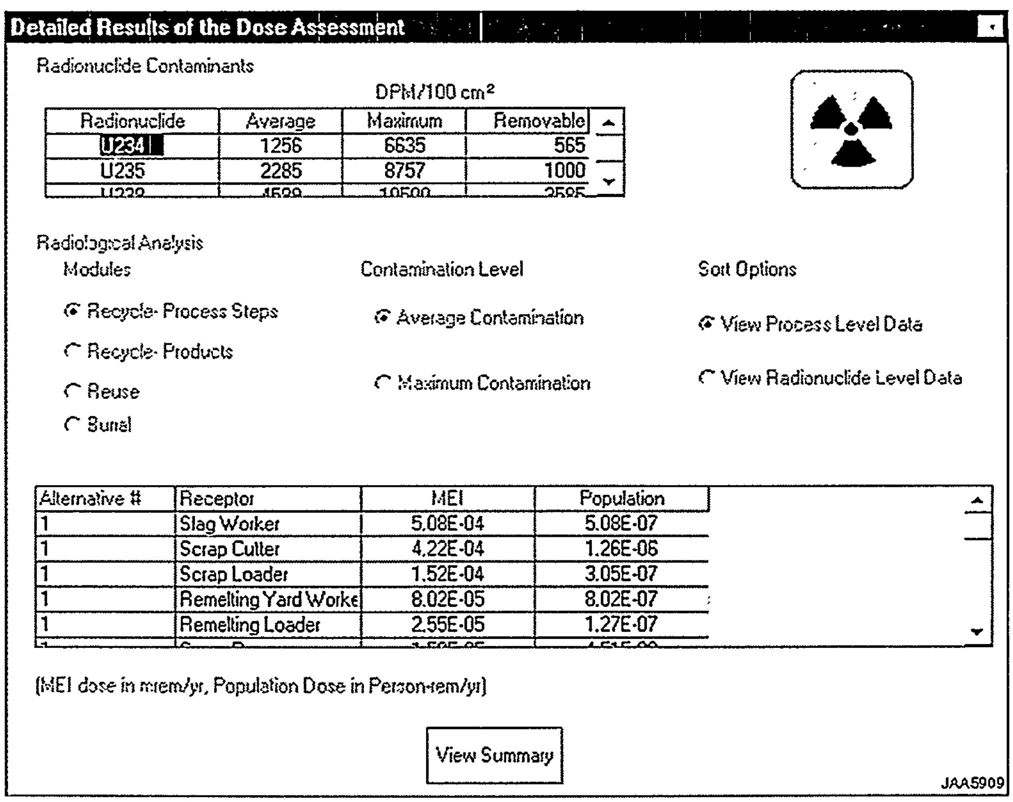


Figure 2.15 Detailed Results for Dose Assessment

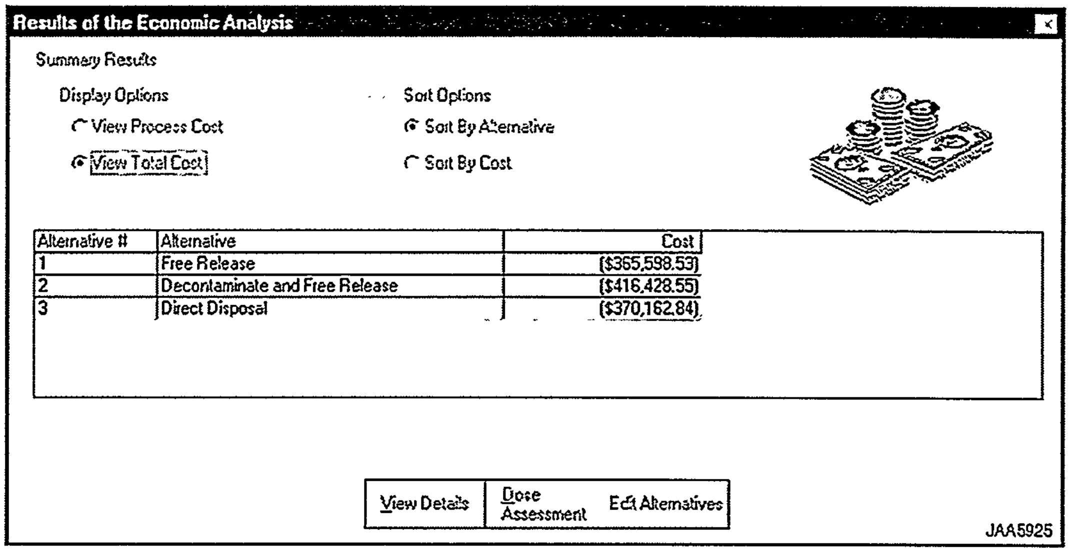
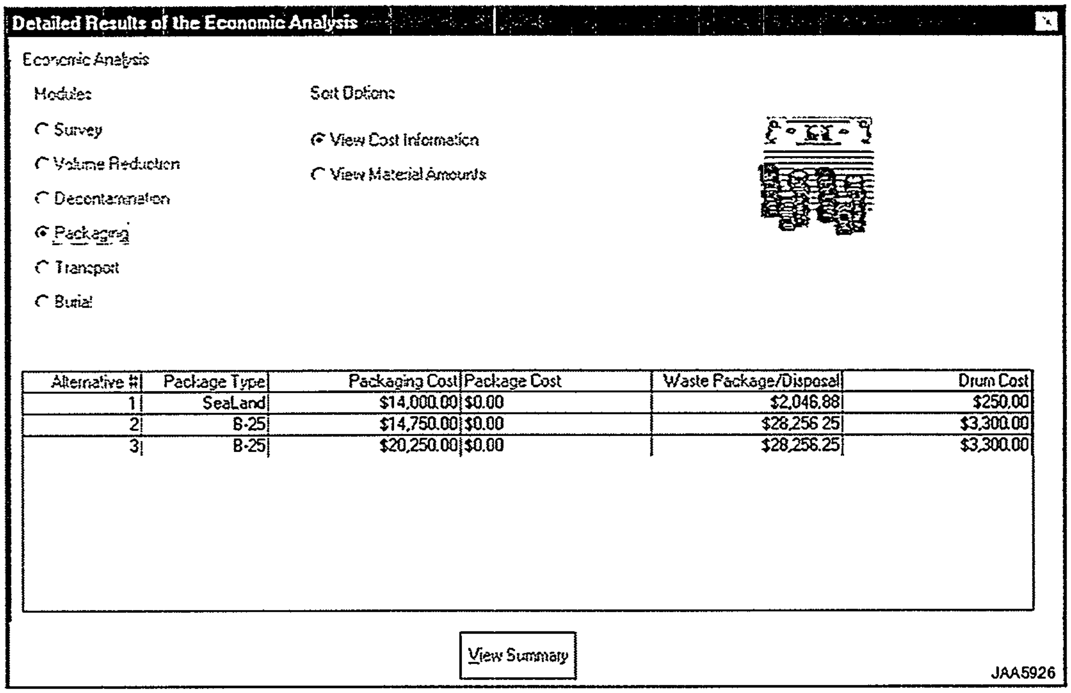


Figure 2.16 Summary Results for Cost Assessment

The window for displaying a detailed listing of the cost assessment (Figure 2.17) is similar to the window that displays the detailed results of the dose assessment. Either costs or material volumes can be displayed for each applicable module by clicking the appropriate radio button. The results are sorted by alternative in ascending order. To return to the main results menu, the user must click the button labeled "View Summary."

Clicking on the "Print" button will print the data and results compiled in Steps 1 through 4 of the authorized release process. The hardcopy printout will contain the physical description of the non-real property, radiological characteristics, a description of the alternatives analyzed, and the results of the radiological and cost analyses for selected modules (see the Appendix for an example). The results are grouped by alternative to allow for quick comparisons. The date and time are recorded on the hard copy for quality assurance (QA) purposes. The printed hard copy should accompany the application submitted to the DOE Field Office.



Alternative #	Package Type	Packaging Cost	Package Cost	Waste Package/Disposal	Drum Cost
1	SeaLand	$14,000.00	$0.00	$2,046.88	$250.00
2	B-25	$14,750.00	$0.00	$28,256.25	$3,300.00
3	B-25	$20,250.00	$0.00	$28,256.25	$3,300.00

Figure 2.17 Detailed Results for Cost Assessment

Section 3
Methodology

This chapter provides an overview of the database design in P2Pro(RSM) and the methodology used to estimate the costs and radiological risks associated with the authorized release limit for a non-real property. The database, a core component of P2Pro(RSM), contains data (unit cost factors and unit dose factors) to perform the ALARA analysis required for the development of authorized release limits. The graphical user interface (GUI) provides a connection to the database while performing the dose and risk calculations required for the authorized release process. The other function of the GUI is to output the results back to the database for viewing or printing.

3.1 Database Design

A main feature of P2Pro(RSM) is the interactive and expandable database that contains information pertaining to radiation risks and process costs. The database was designed with Microsoft Access Version 2.0 and is structured into three distinct sections: (1) Baseline Data section (2) User-Input section and (3) Results section. Figure 3.1 shows the structure of the database and the three sections.

The Baseline Data section provides baseline cost information, radionuclide dose conversion factors, decontamination factors, secondary waste generation rates, and other information for developing authorized release limits for non-real property. The default parameter values are stored in linked tables for quick access. The user is not able to alter or add data to this section with P2Pro(RSM). This section should be modified by skilled database designers using Microsoft Access Version 2.0. Figure 3.2 is an example of the data contained in the Baseline Data section.

The User-Input section is a subset of the Baseline Data section. The data stored in these tables are generated from sets of queries that are executed by the user of P2Pro(RSM). In general, the data stored in these tables can be modified with the protocol software. The information stored in the User-Input section will be used to perform the radiological and cost assessments to support the ALARA analysis. Tables identifying the User-Input section are prefixed with "Entry" such as "Entry_Decon." The User-Input section stores the data used to develop authorized release limits for each case. In this manner, a user can access information from a previous case and use the information as a template to generate a new set of authorized release limits. Figure 3.3 is an example of a table stored in the User Input section of the database.

The third section of the database is the Results section. The data stored in this section of the database include the results of intermediate calculations required for the cost and risk analysis that is required for the ALARA analysis. The data in the Results section are stored in tables for quick access so as to quickly generate reports that can be

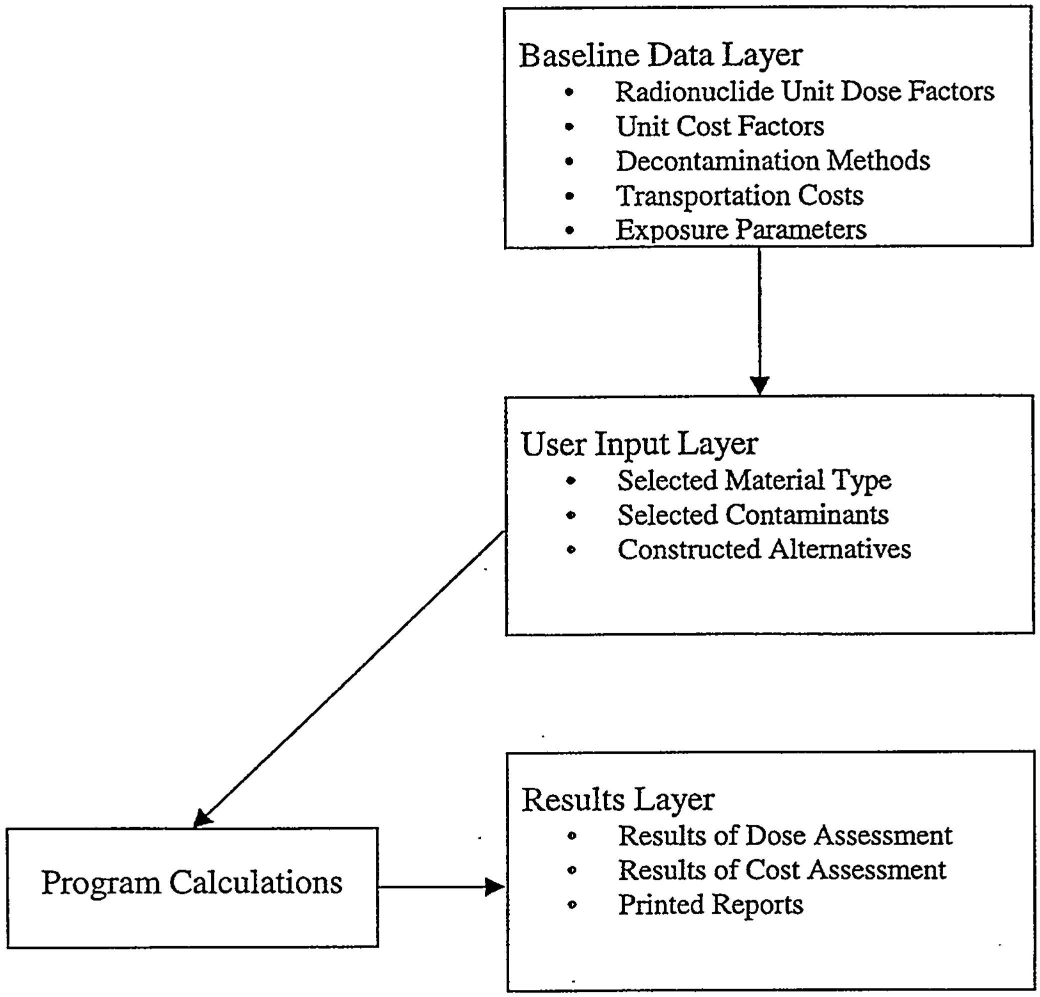


Figure 3.1 Database Structure of P2Pro(RSM)

submitted as part of the approval process. The tables in the Results sections are prefixed with "ALT," such as "ALT_Decon." Figure 3.4 is an example of a table stored in the Results section of the database.

3.2 Unit Dose Factors

The unit dose factors, stored in the Baseline Data layer, are used for the Recycle and Reuse modules. These values were generated using the RESRAD-RECYCLE computer code (Cheng et al. 1999). The unit dose factors were developed by estimating the dose a worker or member of the public would receive after processing 1 ton of scrap metal contaminated with 1 pCi/g for each radionuclide in P2Pro(RSM). For conservatism, radionuclides whose progeny have half-lives less than 180 days are included with the

Microsoft Access - [Table: Decon_cost]

File Edit View Format Records Window Help

Decon type	Decon Sub type	Decon factor	Material input	Decon cost	Secondary Waste	Burial	Decon factor desc
Abrasive Blasting	Dry Ice	5.00E+00	77.5	$1.30	0.005	$45.00	Avg. Max
Abrasive Blasting	Ice	5.00E+00	38.6	$1.00	3.2	$45.00	Avg. Max
Abrasive Blasting	Plastic Pellets	5.00E+00	14.6	$1.20	0.47	$45.00	Avg. Max
Abrasive Blasting	Sodum Bicarbonate & Water	2.00E+01	35.5	$2.75	5.3	$45.00	Avg. Max
Abrasive Blasting	Sponge	1.00E+01	24	$2.00	520	$45.00	Avg. Max
Abrasive Blasting	Steel Grit	1.00E+01	15.55	$2.90	0.02	$45.00	Avg. Max
Dry Vacuuming	Dry Vacuuming	5.00E+10	230	$0.37	0.07	$45.00	Rem
Melt Refining	Melt Refining	1.00E+10	0	$1,100.00	125	$225.00	Avg. Max
Water Washing	Hydrolasing	5.00E+10	25	$1.00	112	$45.00	Rem
Water Washing	Ultra High Pressure	5.00E+10	85	$2.00	32	$45.00	Rem
Wiping	Wiping	1.00E+00	160	$0.50	1	$4,500.00	Rem
*		0.00E+00	0	$0.00	0	$0.00	

Record: 1 of 11

Datasheet View NUM

JAA5927

Figure 3.2 Example Table from the Baseline Database Section

Microsoft Access - [Table: Entry_Transport]

File Edit View Format Records Window Help

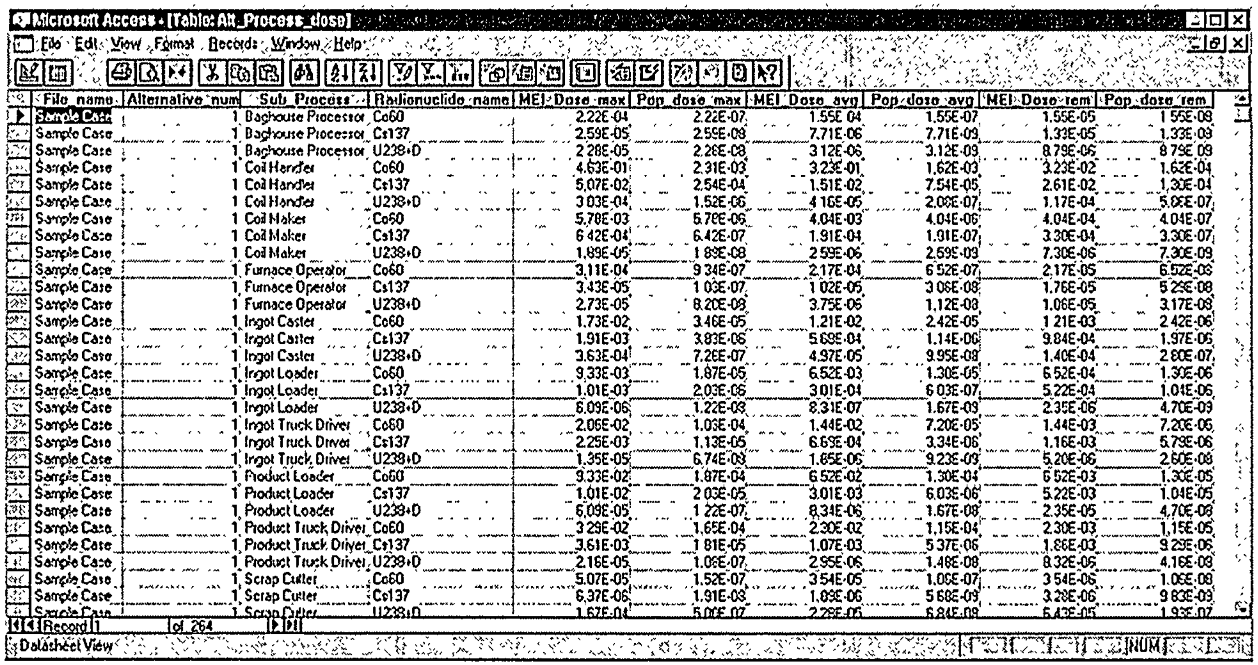
File name	Alternative num	Category	Distance	Mode	Shipments	UserInp
Sample Case	2	Non-Real Property	0	Truck	0	Yes
Sample Case	2	Packaging Waste	500	Rail	1	No
Sample Case	2	Secondary Waste-Decon	500	Rail	15	No
Sample Case	3	Non-Real Property	600	Rail	7	No
Sample Case	3	Packaging Waste	600	Truck	1	No
Sample Case	3	Secondary Waste-Decon	100	Truck	0	No
Surface with U	2	Non-Real Property	0	Truck	12	Yes
Surface with U	2	Packaging Waste	1000	Truck	1	No
Surface with U	2	Secondary Waste-Decon	1000	Rail	14	No
Surface with U	3	Non-Real Property	1000	Truck	7	No
Surface with U	3	Packaging Waste	1000	Rail	1	No
Surface with U	3	Secondary Waste-Decon	100	Truck	0	No
*	0		0		0	No

Record: 1 of 12

Datasheet View NUM

JAA5928

Figure 3.3 Example Table from the User Input Database Section



File_name	Alternative_num	Sub_Process	Radionuclide_name	MEI_Dose_max	Pop_dose_max	MEI_Dose_avg	Pop_dose_avg	MEI_Dose_rem	Pop_dose_rem
Sample Case	1	Baghouse Processor	Co60	2.22E-04	2.22E-07	1.55E-04	1.55E-07	1.55E-05	1.55E-08
Sample Case	1	Baghouse Processor	Cs137	2.59E-05	2.59E-08	7.71E-06	7.71E-09	1.33E-05	1.33E-08
Sample Case	1	Baghouse Processor	U238+D	2.28E-05	2.28E-08	3.12E-06	3.12E-09	8.79E-06	8.79E-09
Sample Case	1	Coil Handler	Co60	4.63E-01	2.31E-03	3.23E-01	1.62E-03	3.23E-02	1.62E-04
Sample Case	1	Coil Handler	Cs137	5.07E-02	2.54E-04	1.51E-02	7.54E-05	2.61E-02	1.30E-04
Sample Case	1	Coil Handler	U238+D	3.03E-04	1.52E-06	4.16E-05	2.08E-07	1.17E-04	5.86E-07
Sample Case	1	Coil Maker	Co60	5.78E-03	5.78E-06	4.04E-03	4.04E-06	4.04E-04	4.04E-07
Sample Case	1	Coil Maker	Cs137	6.42E-04	6.42E-07	1.91E-04	1.91E-07	3.30E-04	3.30E-07
Sample Case	1	Coil Maker	U238+D	1.89E-05	1.89E-08	2.59E-06	2.59E-09	7.30E-06	7.30E-09
Sample Case	1	Furnace Operator	Co60	3.11E-04	9.34E-07	2.17E-04	6.52E-07	2.17E-05	6.52E-08
Sample Case	1	Furnace Operator	Cs137	3.43E-05	1.03E-07	1.02E-05	3.06E-08	1.76E-05	5.29E-08
Sample Case	1	Furnace Operator	U238+D	2.73E-05	8.20E-08	3.75E-06	1.12E-08	1.06E-05	3.17E-08
Sample Case	1	Ingot Caster	Co60	1.73E-02	3.46E-05	1.21E-02	2.42E-05	1.21E-03	2.42E-06
Sample Case	1	Ingot Caster	Cs137	1.91E-03	3.83E-06	5.69E-04	1.14E-06	9.84E-04	1.97E-06
Sample Case	1	Ingot Caster	U238+D	3.63E-04	7.26E-07	4.97E-05	9.95E-08	1.40E-04	2.80E-07
Sample Case	1	Ingot Loader	Co60	9.33E-03	1.87E-05	6.52E-03	1.30E-05	6.52E-04	1.30E-06
Sample Case	1	Ingot Loader	Cs137	1.01E-03	2.03E-06	3.01E-04	6.03E-07	5.22E-04	1.04E-06
Sample Case	1	Ingot Loader	U238+D	6.09E-06	1.22E-08	8.31E-07	1.67E-09	2.35E-06	4.70E-09
Sample Case	1	Ingot Truck Driver	Co60	2.06E-02	1.03E-04	1.44E-02	7.20E-05	1.44E-03	7.20E-06
Sample Case	1	Ingot Truck Driver	Cs137	2.25E-03	1.13E-05	6.69E-04	3.34E-06	1.16E-03	5.79E-06
Sample Case	1	Ingot Truck Driver	U238+D	1.35E-05	6.74E-08	1.65E-06	9.23E-09	5.20E-06	2.60E-08
Sample Case	1	Product Loader	Co60	9.33E-02	1.87E-04	6.52E-02	1.30E-04	6.52E-03	1.30E-05
Sample Case	1	Product Loader	Cs137	1.01E-02	2.03E-05	3.01E-03	6.03E-06	5.22E-03	1.04E-05
Sample Case	1	Product Loader	U238+D	6.09E-05	1.22E-07	8.34E-06	1.67E-08	2.35E-05	4.70E-08
Sample Case	1	Product Truck Driver	Co60	3.29E-02	1.65E-04	2.30E-02	1.15E-04	2.30E-03	1.15E-05
Sample Case	1	Product Truck Driver	Cs137	3.61E-03	1.81E-05	1.07E-03	5.37E-06	1.86E-03	9.29E-06
Sample Case	1	Product Truck Driver	U238+D	2.16E-05	1.08E-07	2.95E-06	1.48E-08	8.32E-06	4.16E-08
Sample Case	1	Scrap Cutter	Co60	5.07E-05	1.52E-07	3.54E-05	1.06E-07	3.54E-06	1.06E-08
Sample Case	1	Scrap Cutter	Cs137	6.37E-06	1.91E-08	1.89E-06	5.68E-09	3.28E-06	9.83E-09
Sample Case	1	Scrap Cutter	U238+D	1.67E-04	5.00E-07	2.28E-06	6.84E-09	6.43E-05	1.93E-07

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Figure 3.4 Example Table from the Results Database Section

parents. The population dose is estimated by multiplying a unit dose factor by the radionuclide concentration and the total amount of radioactive scrap metal selected for release. The maximally exposed individual (MEI) dose is estimated in a similar fashion; however, the dose to an MEI reaches a maximum for a given radionuclide concentration when the amount of time required to process the material exceeds 2,000 hours per year (Cheng et al. 1999).

The unit dose factors for the Burial Module were obtained with the RESRAD computer code (Yu et al. 1993), which was developed by Argonne National Laboratory (Argonne) to estimate radiological doses to members of the public from soil contaminated with residual radioactive material. The dose conversion factors for burial were based upon the results from executing RESRAD for 32,000 tons of material contaminated with 1 pCi/g for a given radionuclide. The results were then scaled to a per-ton basis.

3.3 Unit Cost Factors

Cost estimates are developed for each management alternative specified on the basis of the quantities of material involved and the steps required to implement the alternative. To facilitate cost estimation, a database of default values is provided for each major component in a wide range of implementation steps. These default values were derived from both published cost-related studies and from contract price lists representing the 1995–1997 time period. As a result, they generally represent charges for contract services. In the majority of the modules, the user has the option of accepting the default values or of inputting unit-cost factors from other sources.

Process steps for which costs are estimated are as follows: management, regulatory interface, survey, QA, characterization, volume reduction, decontamination, packaging, transportation, burial, waste management, and, on the income side, proceeds of material sale. Within the category of decontamination, costs for water washing, abrasive blasting, and melt refining are covered in the default database.

In estimating costs, the initial surface-to-mass ratio and the mass density of the material at various stages of processing are crucial factors in the cost estimation. Default values are provided for several material categories; however, the user should replace these with situation-specific values whenever possible.

3.4 P2Pro(RSM) Design

This section will outline the design of P2Pro(RSM) and present the methodology used to estimate the costs and doses, which is part of the ALARA process. The parameters that are key to the cost and dose estimates are provided with estimated ranges to aid the user in developing authorized release limits.

3.4.1 Step 1: Describe the Property — Physical Description

The first step of the authorized release process involves describing and characterizing the non-real property. The user selects a material category that best describes the item proposed for authorized release. After selecting this category, P2Pro(RSM) displays a material subcategory by which the user can further characterize the non-real property.

A key parameter for developing authorized release limits for surface-contaminated non-real property is the surface-to-mass ratio. The surface-to-mass ratio is used to convert surface activity levels to volume activity levels after melting and recycling the material into end-use products (in the Recycle Module). In addition, the surface-to-mass ratio is used to estimate the decontamination costs and the amount of secondary waste generated from decontamination activities. Table 3.1 presents the material categories, subcategories, and surface-to-mass ratios available in P2Pro(RSM).

3.4.2 Step 1: Describe the Property — Radiological Properties

The key component in deriving authorized release limits for non-real property involves investigating the radiological history and estimating the amount of contamination present in the material to be released. The user inputs the radionuclide contamination levels in either SI units (Bq/g, Bq/cm^2) or traditional units (pCi/g, dpm/100 cm^2). To provide a range of results, as well as to compare decontamination

Table 3.1 Non-Real Property Physical Description Categories

Material Category	Subcategory	Surface-to-Mass Ratio (ft^2/lb)
Structural steel	Good steel	0.115
	Bad steel	10
	Tanks	5
Large components	Steam generators	5
	Turbine rotors	5
	Heat exchangers	5
	Fuel racks	5
	Diffusion cells	5
Process systems/piping	Large piping	5
	Small piping	0.115
Scrap metal	Scrap metal pile	5
	Scrap equipment	5
Special materials	Shield cask	5

methods, the user can input the maximum and average radionuclide concentrations for volumetrically contaminated materials. For surface-contaminated materials, the user can enter maximum, average, and removable concentration levels. The radionuclides currently available in P2Pro(RSM) are as follows: americium-241; cesium-134, -137; cobalt-60; europium-152; iron-55; manganese-54; neptunium-237; nickel-63; plutonium-238, -239, -240, and -241; strontium-90; technetium-99; thallium-230; and uranium-234, -235, and -238.

3.4.3 Step 2: Do Release Limits Exist? / Step 3: Define Release Limits

After the radiological history has been entered, the GUI checks the Baseline Data section of the database to determine whether release limits already exist. Currently, the only release limits that exist are for surface-contaminated non-real property as specified in DOE Order 5400.5.

3.4.4 Step 4: Develop Authorized or Supplemental Limits Using ALARA

P2Pro(RSM) checks to determine the availability of current release limits; if such limits do not exist, supplemental or authorized release limits must be derived. P2Pro(RSM) then guides the user through the ALARA optimization process. This process takes dose, economic, environmental, technological, and public policy factors into consideration. Currently, up to 10 alternatives can be considered in the ALARA analysis.

As stated in Section 2, P2Pro(RSM) contains six modules that can be accessed to develop a variety of release alternatives for performing the ALARA analysis required for the authorized release of non-real property: Surveying & Volume Reduction, Decontamination, Recycle (Metal Melt), Transportation, Reuse, and Burial.

A module may be used by itself, or several modules can be combined to form more complex alternatives. For example, a user could construct an alternative that combines the Decontamination Module with the Burial Module to estimate the doses and costs associated with burying decontaminated non-real property.

3.4.4.1 Step 4: Module 1 — Surveying & Volume Reduction

The Surveying & Volume Reduction Module estimates the costs associated with radiation surveys and volume reduction. The three components for the radiation surveys include surveying cost, management cost, and QA costs. The total cost for a radiation survey of the non-real property is the sum of the individual costs. Radiation doses are not modeled for the Surveying & Volume Reduction Module because the workers are assumed to be radiation workers who are monitored under a dosimetry/ALARA program. The surveying costs are estimated by using Equation 3.1:

$$SurveyCost(\$) = UC \times SR \times M \times SMR \times K, \qquad (3.1)$$

where

UC	=	unit cost (\$/h),
SR	=	reciprocal of the survey rate (h/ft^2),
M	=	mass of non-real property (metric tons[MT]),
SRM	=	surface-to-mass ratio of non-real property (ft^2/lb), and
K	=	factor to convert metric tons to pounds (2,204).

The cost associated with QA is currently estimated as 10% of the survey cost. The management cost is estimated at $50,000 per authorized release.

The cost associated with volume reduction is estimated by multiplying the unit cost for volume reduction ($/MT) by the mass of non-real property (MT), as shown in Equation 3.2:

$$VolRdCost(\$) = UR \times M, \qquad (3.2)$$

where

UR	=	unit cost for volume reduction (\$/MT) and
M	=	mass (MT).

Similarly, the amount of volume reduction waste is estimated by multiplying the volume reduction waste generation rate (lb/MT) by the mass of the non-real property (MT). The total cost for packaging non-real property consists of the cost for packaging the non-real property itself, the costs associated with volume reduction wastes (if applicable), the burial costs associated with volume reduction wastes, and the costs for the B–25/SeaLand type transportation containers (if applicable). In addition, P2Pro(RSM) estimates the cost associated with containerizing and burying the packaging wastes (pallets and other miscellaneous items). The packaging wastes are assumed to be placed in standard 55-gallon drums. P2Pro(RSM) estimates the number of drums associated with the packaging wastes on the basis of a loading density of 20 lb/ft^3 (Chen et al. 1996). If the non-real property undergoes a volume reduction, it is assumed that the property and the wastes associated with volume reduction are placed in B-25 type boxes with a packing density of 45 lb/ft^3(Chen et al. 1996). If the property does not undergo volume reduction, the packaging density is decreased to 20 lb/ft^3, and the material is assumed to be placed in SeaLand type containers. To increase the flexibility of P2Pro(RSM), the user is able to modify the packing density to incorporate situation-specific values.

The amount of packaging waste is estimated with Equation 3.3:

$$PackagingWaste(lb) = PWGR \times M, \tag{3.3}$$

where

$PWGR$ = packaging waste generation rate (lb/MT) and
M = mass (MT).

The number of containers required to package the non-real property and its associated wastes is estimated with Equation 3.4:

$$Containers = \frac{M}{\rho} \times K \times \frac{1}{Vol_{Package}}, \tag{3.4}$$

where

M = mass (MT),
ρ = packaging density (lb/ft^3),
$Vol_{Package}$ = volume of the package (ft^3) (either SeaLand, B-25, or 55-gallon type container), and
K = factor to convert metric tons to pounds (2,204).

The burial costs are estimated in a straightforward manner by multiplying the volume of the non-real property (reciprocal of the packaging density multiplied by the mass of the non-real property) by a unit cost factor for burial. P2Pro(RSM) currently assumes a unit burial cost of \$45/ft^3 (Warren et al. 1995).

The total cost for packaging of the non-real property (and burial of the volume reduction and packaging waste) is provided by Equation 3.5:

$$TotalCost(\$) = \sum_{WasteStream} \left[(ULC + CC) \times Containers + BC \right], \tag{3.5}$$

where

ULC = unit loading cost (\$/container),
CC = unit container cost (\$/container) (when applicable),
BC = burial cost (\$) (for volume reduction and packaging waste only), and
$WasteStream$ = individual waste stream (non-real property, volume reduction waste, and packaging waste).

3.4.4.2 Step 4: Module 2 — Decontamination

The Decontamination Module estimates decontamination levels, waste generation, and costs associated with decontaminating the non-real property before reuse, recycle, or burial. The decontamination methods available to the user are determined by the non-real property type as well as the contamination type. Currently, the only available decontamination process for volumetrically contaminated non-real property is melt refining. For surface contamination, multiple decontamination methods may be employed such as water washing followed by abrasive blasting. The Decontamination Module estimates the decontamination factor, decontamination waste generation, and disposal cost for each decontamination method selected. Default values are provided for each parameter, although the user may incorporate process-specific values if they are available. The decontamination methods available in P2Pro(RSM) are provided in Table 3.2.

The decontamination cost is the sum of the cost for physically decontaminating the non-real property and the burial cost for the decontamination wastes (secondary wastes). Radiation doses associated with the decontamination process are not calculated because the workers are assumed to be radiation workers. The cost for physically decontaminating the non-real property is estimated with Equation 3.6:

$$DeconCost(\$) = UDC \times SMR \times M \times K, \tag{3.6}$$

where

UDC = unit decontamination cost ($\$/ft^2$),
SMR = surface-to-mass ratio (ft^2/lb),
M = mass (MT), and
K = factor to convert metric tons to pounds (2,204).

The cost associated with disposal of the secondary wastes is estimated by multiplying the amount of secondary waste generated by the decontamination method by the unit disposal cost. Equation 3.7 provides the methodology used to estimate the costs associated with the disposal of secondary waste from decontamination methods (SWC):

$$SWC(\$) = SWGR \times \frac{1}{MI} \times SMR \times M \times K \times UDC, \tag{3.7}$$

where

$SWGR$ = secondary waste generation rate (ft^3/h),
MI = material input (ft^2/h),
UDC = unit disposal cost ($\$/ft^3$),
M = mass (MT), and
K = factor to convert metric tons to pounds (2,204).

Table 3.2 Decontamination Categories

Decontamination Method	Decontamination Factor	Applicable Contamination Category
Melt refining	Based on partitioning factors	Surface Volumetric
Abrasive blasting		Surface
Dry ice	5[a]	
Ice	5[a]	
Plastic pellets	5[a]	
Sodium	20[a]	
bicarbonate	10[a]	
Sponge	10[a]	
Steel grit		
Water washing		Surface
Hydrolasing	Removable contamination only[b]	
High-pressure wash	Removable contamination only[b]	
Dry vacuuming	Removable contamination only[b]	Surface
Wiping	Removable contamination only[b]	Surface

[a] Source: Ebadian et al. (1995).
[b] Source: DOE (1997).

The decontamination factors were developed on the basis of literature searches and accepted industry practices. For surface contamination, the decontamination level is estimated by two methods. When the user inputs the radionuclide contaminants, P2Pro(RSM) prompts the user for three contamination levels (average, maximum, and removable) in order to maintain consistency with DOE Order 5400.5. For the majority of decontamination processes, a single decontamination factor is utilized. This factor is applied uniformly to all three surface contamination categories. For example, if a decontamination factor of 10 is given for a particular decontamination method, the average, removable, and surface contamination levels would be reduced by a factor of 10. If multiple decontamination methods are used, then the decontamination factors would be multiplied together. However, some decontamination methods only remove the "removable" portion of the contamination. For these decontamination methods, the "removable" contamination level is set to 0, and the "average" and "maximum" contamination levels are reduced by the original "removable" amount. Equations 3.8 and 3.9 provide the methodology for estimating surface contamination levels after the non-real property has been decontaminated:

$$\left(A_{Rem,Avg,Max}\right)_{New} = \frac{A_{Rem,Avg,Max}}{\prod_i DF_i}, \qquad (3.8)$$

where

DF = decontamination factor for process i, and

$_{Rem, Avg, Max}$ = removable, average, and maximum surface contamination levels.

$$(A_{Avg, Max})_{New} = A_{Avg, Max} - A_{Rem}, \tag{3.9}$$

where

$A_{Avg, Max, Rem}$ = activity (dpm/100 cm^2) and

$(A_{Avg, Max})_{New}$ = new activity (dpm/100 cm^2) .

For volumetric contamination, the only decontamination process available is melt refining. The decontamination factor for melt refining is determined by the radionuclide partitioning factors. The decontamination factor for a specific radionuclide (DF_i) is estimated by multiplying the individual radionuclide concentration (A_i) by the radionuclide partitioning factor for the metal type. Equation 3.10 provides the methodology for estimating decontamination factors for melt refining:

$$DF_i = A_{Rem_i, Avg_i, Max_i} \times PF_i, \tag{3.10}$$

where

PF_i = radionuclide partitioning factor for the i^{th} radionuclide, and

$A_{Rem, Avg, Max}$ = activity (dpm/100 cm^2 [surface contamination], pCi/g [volumetric contamination]).

3.4.4.3 Step 4: Module 3 — Recycle (Metal Melt)

The Recycle (Metal Melt) Module is used when the non-real property is recycled through remelting for use in products for public use. Because the material is assumed to be free released in the Recycle (Metal Melt) Module, radiological doses are estimated to members of the public for each process and end-use product selected in the Recycle (Metal Melt) Module. Tables 3.3 and 3.4 list the processes and end-use products available in P2Pro(RSM). The unit dose factors for each process and end-use product were developed from the RESRAD-RECYCLE computer code (Yu et al. 1993). A further description of each process and product can be found in Cheng et al. (1999). The economic portion of the Recycle (Metal Melt) Module includes input for the sale of the non-real property. P2Pro(RSM) estimates a net income from the sale by multiplying the mass of the non-real property by a unit sale price ($/MT). The unit sale price may be modified by the user.

Radiological doses are estimated for both a MEI and the collective population for both processing and end-use products. The collective population dose is estimated by

Table 3.3 Process Steps for Recycle Module

Preprocessing	Resmelting	Manufacturing
Scrap cutter	Baghouse processor	Warehouse worker
Scrap loader	Furnace operator	Coil handler
Scrap truck driver	Ingot caster	Coil maker
	Ingot loader	Product loader
	Ingot truck driver	Product truck driver
	Scrap processor	Sheet assembler
	Slag worker	Sheet handler
	Small objects caster	Sheet maker
	Resmelter loader	Storage yard worker
	Resmelter yard worker	

Table 3.4 End-Use Products Available in P2Pro(RSM)

Product	Restrictions
Bridge	Unrestricted use
Frying pan	Unrestricted use
Home furniture	Unrestricted use
Automobile	Unrestricted use
Office furniture	Unrestricted use
Parking lot	Unrestricted/restricted use
Appliance	Unrestricted use
Room/office	Unrestricted use
Shield block	Restricted use
Building rebar	Restricted use
Waste container	Restricted use

multiplying the radionuclide-specific unit dose factor, obtained from RESRAD-RECYCLE, by the mass of the non-real property and the radionuclide concentration. For surface and volumetrically contaminated property, doses are estimated for "average" and "maximum" contamination levels. Equation 3.11 provides the methodology for estimating the collective population dose (person-rem) for both the processing phase and end-use products:

$$CPD_{process, product} = \sum_j \sum_i Con_i \times DF \times NF_i \times PF_i \times UDF_{i,j} \times M, \qquad (3.11)$$

where

Con_I = concentration of the i[th] radionuclide (pCi/g),
DF = decontamination factor,
NF_i = decontamination factor for i^{th} radionuclide (metal-melt only),
PFi = radionuclide partitioning factor for the i^{th} radionuclide,

$UDF_{i,j}$	=	unit dose factor (person-rem/MT/pCi/g) for radionuclide i and process/product j, and
M	=	mass (MT).

The MEI dose is estimated in a similar manner. However, for the MEI dose, there will be a point at which the dose will remain constant because the MEI would spend an entire year processing or using the recycled non-real property. The amount of non-real property required to maximize the dose is defined as the "threshold mass." The "threshold mass" varies for each process and product. The methodology for estimating the dose (mrem/yr) to the MEI from either processing or using the recycled non-real property is presented in Equations 3.12, 3.13, and 3.14:

$$MEI_{process} = \sum_i Con_i \times DF \times PF_i \times UDF_{i,j} \times M / 1{,}000 , \qquad (3.12)$$

for $M \leq M_{Threshold}$

or

$$MEI_{process} = \sum_i Con_i \times DF \times PF_i \times UDF_{i,j} \times M_{Threshold} / 1{,}000 , \qquad (3.13)$$

for $M > M_{Threshold}$

and

$$MEI_{product} = \sum_i Con_i \times DF \times PF_i \times UDF_{i,j} . \qquad (3.14)$$

3.4.4.4 Step 4: Module 4 — Transportation

The Transportation Module estimates the costs associated with transporting the non-real property, secondary wastes from decontamination, as well as packaging wastes and volume reduction wastes. The costs are estimated with the methodology from Chen et al. (1996). The number of shipments for each material type is estimated on the basis of the total amount of material, packing density (estimated in the Surveying & Volume Reduction Module), and transportation mode. Radiological doses associated with transporting the non-real property were estimated in the Recycle (Metal Melt) Module.

3.4.4.5 Step 4: Module 5 — Reuse

The Reuse Module estimates the radiological doses associated with reusing the non-real property. The main difference between the Reuse and the Recycle (Metal Melt) Modules is that the Reuse Module does not assume that the non-real property undergoes a metal melt. It is assumed that the non-real property is reused in the same manner as it was originally used. P2Pro(RSM) does allow for the non-real property to be surface decontaminated prior to reuse. The methodology for estimating the radiological doses associated with reuse is similar to that used for the Recycle (Metal Melt) Module.

Equations 3.15 and 3.16 provide the methods for estimating the radiological doses to the collective population and MEI under the Reuse Module:

$$CPD_{Reuse} = \sum_i Con_i \times DF \times UDF_i \times M \times N, \quad (3.15)$$

where

N = number of exposed persons

and

$$MEI_{Reuse} = \sum_i Con_i \times DF \times UDF_i . \quad (3.16)$$

3.4.4.6 Step 4: Module 6 — Burial

The Burial Module estimates the costs and risks associated with burial of the non-real property in a radioactive waste landfill. The radiological doses are only estimated for a future resident because it is assumed that the landfill workers would be radiation workers already subject to radiation monitoring and ALARA practices. The costs associated with disposal are estimated by multiplying a unit cost factor ($/ft^3) by the volume of the non-real property (obtained through intermediate calculations in the Survey & Volume Reduction Module) .

Similarly, the radiological dose to a future resident is estimated with unit dose factors developed from the RESRAD computer code. Equation 3.17 provides the methodology for estimating the annual radiological dose (mrem/yr) to an MEI associated with the Burial Module:

$$BD = \sum_i UDF_i \times Con_i \times DF \times DF_i \times M . \quad (3.17)$$

The Burial Module is used to estimate the costs and risks associated with disposal of the radioactive scrap metal. The cost for disposal is estimated by multiplying the total amount of scrap metal by the unit burial cost. The user may edit the unit cost for burial ($/ft^3) to incorporate site-specific cost data. The total volume is estimated on the basis of the package density and the total amount of radioactive scrap metal involved. Radiation doses associated with placement of the radioactive scrap in the landfill are not calculated because the workers are assumed to be radiation workers.

Section 4
References

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Appendix
Sample Problem

A.1 Introduction

This appendix provides the user of P2Pro(RSM) with an example of a hypothetical authorized release of surface-contaminated structural steel. The problem is described, alternatives for the authorized release process are developed, and an example is provided of the report that is to be submitted with the application for authorized release. The non-real property is described in Section A.2, the alternatives are described in Section A.3, and the results are displayed in Section A.4.

A.2 Property Description

The hypothetical case involves 125 metric tons of steel surface contaminated with uranium-238, -235, and -234 isotopes. The initial contamination levels are above those specified in U.S. Department of Energy (DOE) Order 5400.5 and are listed in Table A.1.

Table A.1 Radionuclide Concentrations for Sample Problem

	Surface Contamination Levels (dpm/100 cm^2)		
Radionuclide	Average	Maximum	Removable
U-234	1,256	6,635	565
U-235	2,285	8,757	1,000
U-238	4,589	10,500	3,585

The authorized limits requested by this application would apply to recyclable steel expected to have the following physical attributes:

- Typically consists of structural member and supports system metal (surface-to-mass ratio 0.115 ft^2/lb),
- All material is common carbon steel,
- All accessible external surfaces have been painted many times throughout the life of the material,
- Some paint may be lead based, and
- Small areas of surface rust and oxidation are visible on most surfaces.

All material released under proposed release limits is expected to have been contaminated as a result of the deposition of airborne radioactivity, spills, or buildup from low levels of contamination. Therefore, contamination is expected to be either surficial and loosely adhered, or fixed via oxidation or applied paint.

A.3 Description of Alternatives

Because the recyclable steel is mostly contaminated on its surface with loosely adhered or fixed contaminants, decontamination methods such as abrasive blasting, and/or high-pressure water washing were identified as reasonable techniques for reducing surface contamination levels.

The alternatives considered included:

- Alternative 1: Unrestricted Release — Recyclable steel would be sold as scrap metal without restrictions provided that the contamination levels are not above those specified in Table A.1.

- Alternative 2: Unrestricted Release after Melt Refining — Recyclable steel would be melt-refined and cast into ingots for sale as scrap metal without restriction.

- Alternative 3: Unrestricted Release after High-Pressure Water Wash — Recyclable steel would be decontaminated by a high-pressure water wash to remove the "Removable" contamination and reduce the "Average" and "Maximum" contamination levels.

- Alternative 4: Burial at a Low-Level Radioactive Waste (LLW) Facility — The non-real property would be buried at a LLW landfill.

A.3.1 Alternative 1: Unrestricted Release

Alternatives 1 implements the Survey & Volume Reduction and Recycle (Metal Melt) Modules in P2Pro(RSM). Because the non-real property is assumed to be free released without surface decontamination, radiological surveys would be performed on the material before its release. Other than standard packaging procedures, additional volume reduction measures would not be performed.

The Recycle (Metal Melt) Module is used to estimate the doses from all 22 worker scenarios and all 7 end-use product scenarios. The default partitioning factors were used for the assessment. A sale price of $1 per ton was assumed for the non-real property; this selling price assumes that all transportation costs would be incurred by the purchaser of the non-real property.

To set up Alternative 1, the user would check the Survey & Volume Reduction Module and the Recycle (Metal Melt) Module in the Module Selection Window (boxes 1 and 3 [Figure 2.7]). By default, the material is sectioned prior to transport. For this alternative, the user must click the button "Non-Real property will NOT be sectioned prior to transport." Because the material is not volume reduced prior to transport, the user should change the packaging density from \$45 lb/ft^3 to \$20 lb/ft^3 to account for reduced packaging efficiency. The remaining parameters in the window are defaulted to the correct settings; the user can press the "Forward" button to continue (Figure 2.8).

Figure 2.10 provides an example of the Recycle (Metal Melt) Module. All the recycle operations and end-use products are considered for this alternative; the user can click the "More" button to continue. Since default radionuclide partitioning factors are going to be used for this alternative, the only parameter the user must change is the sale price for the metal. To perform this task, the user must click on the box "Check to edit the value of the Non-Real Property" and enter \$1 for the metal sale price. After the data have been entered and the user presses the "Forward" button, the user is returned to the as-low-as-reasonably-achievable (ALARA) analysis setup window (Figure 2.6).

A.3.2 Alternative 2: Unrestricted Release after Melt Refining

Alternative 2 implements the Survey & Volume Reduction, Decontamination, and Recycle (Metal Melt) modules in P2Pro(RSM). The non-real property is assumed to be surveyed before decontamination. Volume reduction is performed to decrease the number of shipments to the off-site decontamination facility. After decontamination, the ingots are free released and sold to the steel industry. The Recycle (Metal Melt) Module is set up to assume that the ingots are remelted and manufactured into unrestricted end-use products. Because the non-real property is cast into ingots prior to free release, the scrap loader, scrap processor, and scrap truck driver are omitted from the Recycle (Metal Melt) Module. After melt refining, the ingots are sold for \$80 per ton. Costs associated with transporting the non-real property to the off-site decontamination facility and costs associated with transporting secondary decontamination wastes are assumed to be included in the decontamination cost.

To set up Alternative 2, the user would check the first three boxes in the Module Selection Window (Survey & Volume Reduction, Decontamination, and Recycle). After clicking on the "Forward" button, the user must enter the data for the Survey & Volume Reduction Module.

Since it is assumed that the non-real property is going directly for melt refining, additional surveys, quality assurance activities, and management costs would not apply to this alternative. By default, P2Pro(RSM) sets the Survey & Volume Reduction Window to select volume reduction, so the user can click the "Forward" button to continue building the alternative without making changes to this window.

The Decontamination Module (Figure 2.9) follows the Survey & Volume Reduction Module for data entry. The user must click "Melt Refining" from the Decontamination Category to view a list of additional decontamination methods (subcategories). The user should then select Melt Refining from this list to view the properties associated with melt refining. For this alternative, the user will accept the defaults and click the "Forward" button to proceed.

The Recycle (Metal Melt) Module follows the Decontamination Module. By default, all 22 processes are selected. To remove a process from consideration, the user must click on the process and the check mark next to it will be removed. For this alternative, all of the preprocessing activities are not considered. To continue, the user should press the "More" button. To change the sale price of the metal, the user follows the steps outlined in Section A.3.1. Pressing the "Forward" button will return the user to the ALARA analysis setup window.

A.3.3 Alternative 3: Unrestricted Release after High-Pressure Water Wash

Alternative 3 implements the Survey & Volume Reduction, Decontamination, Recycle (Metal Melt), and Transportation Modules in P2Pro(RSM). The non-real property is assumed to be surveyed after it undergoes decontamination with a high-pressure water wash. The decontamination module assumes that only the "Removable" surface contamination is completely removed. The average and maximum contamination levels are reduced by the removable amount. Transportation costs of the non-real property are assumed to be incurred by DOE and are not considered part of the decontamination fee. The non-real property must be transported 100 miles to a minimill after on-site decontamination. The wastes from decontamination and volume reduction are assumed to be transported by truck to a LLW disposal area 500 miles from the DOE site. The recycle module estimates the doses associated with the 22 worker operations and the 7 end-use products. After decontamination, the non-real property is sold for $5 per ton.

To set up Alternative 3, the user would check the first four boxes in the Module Selection Window. The Survey & Volume Reduction Module is set up in the same manner as in the first alternative. The Decontamination Module is set up in a similar manner as the second alternative, except that "Water Washing" is selected for the decontamination category, and high-pressure water wash is selected for the decontamination subcategory. For this alternative, all defaults are accepted. The Recycle (Metal Melt) Module is set up in the same manner as Alternative 1, except that the metal sale price is set at $5 per ton.

The Transportation Module follows the Recycle (Metal Melt) Module (Figure 2.10). The user must click on each material to set all of its parameters. By default, the transportation mode is set to truck, and the transportation distance is set to 100 mi. For this alternative, the non-real property is transported 100 miles by rail; therefore, the user must click on the button next to rail. The user must click the next material for transport ("Secondary Waste-Decon") to set its properties. The only required change for this material is the distance traveled, which must be set to 500 miles. Modifications to the "Packaging Waste" properties are made in the identical manner as those made to

"Secondary Waste-Decon." After setting the properties of all the materials for transport, the user must click the "Forward" button to return to the ALARA analysis setup window.

A.2.4 Alternative 4: Burial at a LLW Facility

The Survey & Volume Reduction, Transportation, and Burial modules are implemented in P2Pro(RSM) for Alternative 4. No radiological surveys are performed on the non-real property prior to transport. To decrease transportation costs, the material is assumed to be volume reduced. Burial is assumed to take place at a LLW disposal facility 1,500 miles from the DOE site. Disposal costs are \$75 ft^3.

To set up Alternative 4, the user must check the Survey & Volume Reduction, Transportation, and Burial modules. The Survey & Volume Reduction Module is set up properly for Alternative 4 by default. The user must click the "Forward" button to move to the Transportation Module.

The Transportation Module is set up similar to Alternative 3. The only exception is that the properties for "Non-Real Property" and "Packaging Waste" have to be set. For Alternative 4, the user would modify the distance traveled from 100 to 1,500 miles for both the "Non-Real Property" and "Packaging Wastes." The user would then click the "Forward" button to continue.

The Burial Module follows the Transportation Module. The only parameter required is the burial cost. To set this parameter, the user would check the box "Check to enter unit burial cost (\$/ft^3)" and then enter the unit burial price. To return to the ALARA analysis setup window, the user would click the "Forward" button.

A.4 P2Pro(RSM) Results

To view the results of the dose assessment and cost analysis for the four alternatives analyzed, the user would click the "Results" button on the ALARA analysis setup window. The user could then view the results from P2Pro(RSM) or print a hardcopy to include in the application for authorized release.

The results of the analysis for this sample case are presented in the following computer report.

P2Pro(RSM) Ver 1.2 Beta

A Computerized Management Tool for Implementing DOE Authorized Release Process for Radioactive Scrap Metals

File Name: **Sample Problem** 6/10/99 11:40:10AM

Describe the Non-Real Property

Physical Characteristics

Property Type	Amount (MT)	Surface to Volume Ratio (ft^2/lb)
Good Steel	125.00	0.12

Radiological Characteristics

	Surface (DPM/ 100 cm^2)			Volumetric (pCi/g)	
Radionuclide	Average	Maximum	Removable	Average	Maximum
U234	1,256.00	6,635.00	565.00		
U235	2,285.00	8,757.00	1,000.00		
U238	4,589.00	10,500.00	3,585.00		

File Name: Sample Problem 6/10/99 11:40:10AM

Perform ALARA Analysis

Alternative Number	Alternative Name	Alternative Description
1	Unrestricted Release	Recyclable steel would be sold as scrap metal without restriction.
2	Unrestricted Release after Melt Refining	Recyclable steel would be melt-refined and cast into ingot for sale as scrap metal
3	Unrestricted Release after High Pressure Water Wash	Recyclable steel would be decontaminated by a high pressure water wash to remove the removable surface contamination
4	Burial at a LLW Facility	RSM will be disposed at a LLW facility

Selected Modules

Alternative	Survey & Vol Red	Decon	Recycle	Transport	Reuse	Burial
1	X		X			
2	X	X	X			
3	X	X	X	X		
4	X			X		X

File Name: **Sample Problem** 6/10/99 11:40:10AM

Survey & Volume Reduction

Alternative	Survey	Survey QA	Survey Management	Packaging Density (lb/ft^3)
	Selected Components			
1	X	X	X	20.00
2				45.00
3	X	X	X	20.00
4				45.00

Decontamination Module

Alternative	Decontamination Method	Decontamination Factor	Decontamination Cost	
2				
	Melt Refining	See Radionuclide Partitioning Factors	1,100.00	/melted ton
3				
	Ultra High Pressure	Removable Contamination	2.00	/ft^2

File Name: Sample Problem 6/10/99 11:40:10AM

Recycle Module

Alternative	Selected Process Workers
1	Baghouse Processor
	Coil Handler
	Coil Maker
	Furnace Operator
	Ingot Caster
	Ingot Loader
	Ingot Truck Driver
	Product Loader
	Product Truck Driver
	Remelting Loader
	Remelting Yard Worker
	Scrap Cutter
	Scrap Loader
	Scrap Processor
	Scrap Truck Driver
	Sheet Assembler
	Sheet Handler
	Sheet Maker
	Slag Worker
	Small Objects Caster
	Storage Yard Worker
	Warehouse Worker
2	Baghouse Processor
	Coil Handler
	Coil Maker
	Furnace Operator
	Ingot Caster
	Ingot Loader
	Ingot Truck Driver
	Product Loader
	Product Truck Driver
	Remelting Loader
	Remelting Yard Worker
	Scrap Processor
	Sheet Assembler

Alternative	Selected End Use Product
1	Appliance
	Automobile
	Bridge
	Frying Pan
	Home Furniture
	Office Furniture
	Parking Lot
	Room/Office
2	Appliance
	Automobile
	Bridge
	Frying Pan
	Home Furniture
	Office Furniture
	Parking Lot
	Room/Office
3	Appliance
	Automobile
	Bridge
	Frying Pan
	Home Furniture
	Office Furniture
	Parking Lot
	Room/Office

File Name: Sample Problem 6/10/99 11:40:10AM

	Sheet Handler
	Sheet Maker
	Slag Worker
	Small Objects Caster
	Storage Yard Worker
	Warehouse Worker
3	
	Baghouse Processor
	Coil Handler
	Coil Maker
	Furnace Operator
	Ingot Caster
	Ingot Loader
	Ingot Truck Driver
	Product Loader
	Product Truck Driver
	Remelting Loader
	Remelting Yard Worker
	Scrap Cutter
	Scrap Loader
	Scrap Processor
	Scrap Truck Driver
	Sheet Assembler
	Sheet Handler
	Sheet Maker
	Slag Worker
	Small Objects Caster
	Storage Yard Worker
	Warehouse Worker

File Name: **Sample Problem** 6/10/99 11:40:10AM

Recycle Module

Alternative	Radionuclide	Metal	Partitioning Factors Slag	Baghouse
1				
	U234	0.01	0.97	0.02
	U235	0.01	0.97	0.02
	U238	0.01	0.97	0.02
2				
	U234	0.01	0.97	0.02
	U235	0.01	0.97	0.02
	U238	0.01	0.97	0.02
3				
	U234	0.01	0.97	0.02
	U235	0.01	0.97	0.02
	U238	0.01	0.97	0.02

Transportation Module

Alternative	Category	Transportation Mode	Shipments	Distance (mi)
3				
	Non-Real Property	Rail	12.00	100.00
	Packaging Waste	Truck	1.00	500.00
	Secondary Waste-Decon	Truck	54.00	500.00
4				
	Non-Real Property	Truck	7.00	1,500.00
	Packaging Waste	Truck	2.00	1,500.00
	Secondary Waste-Decon	Truck	0.00	100.00

Page 6 of 8

File Name: **Sample Problem** 6/10/99 11:40:10AM

Reuse Module

Alternative	Product

Burial Module

Alternative	Burial Quantitiy (ft^3)	Unit Disposal Cost $/ft^3)
4	6,111.11	45.00

Dose Assessment Results

by contamination levels

Alternative	Receptor	Product/ Process	MEI Avg	MEI Max	Population Avg	Population Max
1						
	Worker	Slag Worker	5.08E-04	1.63E-03	3.12E-06	1.04E-05
	Public	Parking lot	1.46E-05	5.03E-05	1.86E-05	6.37E-05
2						
	Worker	Slag Worker	5.08E-06	1.63E-05	5.18E-09	1.67E-08
	Public	Parking lot	1.46E-07	5.03E-07	1.86E-07	6.37E-07
3						
	Worker	Slag Worker	1.92E-04	1.32E-03	1.28E-06	8.52E-06
	Public	Parking lot	6.93E-06	4.26E-05	7.53E-06	5.38E-05
4						
	Public	Future Resident	3.00E-03	8.63E-03	0.00E+00	0.00E+00

MEI dose is in mrem
Population dose is in person-rem
Population doses to future residents living near a landfill are not estimated

Page 7 of 8

Cost Assessment Results

Alternative	Module	Cost
1		
	Survey Cost	-$61,566.84
	Sectioning Cost	$0.00
	Sale of Metal	$137.50
	Alternative Total	-$61,429.34
2		
	Survey Cost	$0.00
	Sectioning Cost	-$45,375.00
	Decon- Melt Refining	-$4,018,437.50
	Sale of Metal	$11,000.00
	Alternative Total	-$4,052,812.50
3		
	Survey Cost	-$61,566.84
	Sectioning Cost	$0.00
	Decon- Ultra High Pressure	-$599,014.75
	Sale of Metal	$687.50
	Transportation- Non-Real Property	-$11,784.00
	Transportation- Packaging Waste	-$1,050.00
	Transportation- Secondary Waste-Decon	-$182,520.00
	Alternative Total	-$855,248.09
4		
	Survey Cost	$0.00
	Sectioning Cost	-$45,375.00
	Transportation- Non-Real Property	-$17,360.00
	Transportation- Packaging Waste	-$4,960.00
	Transportation- Secondary Waste-Decon	$0.00
	Direct Burial	-$275,000.00
	Alternative Total	-$342,695.00