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ES/ER/TM-165

ENVIRONMENTAL RESTORATION PROGRAM

D&D Screening Risk Evaluation Guidance

ENERGY SYSTEMS ER

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DEPARTMENT OF ENERGY
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D&D Screening Risk Evaluation Guidance

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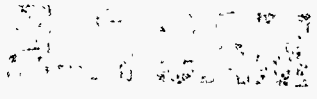

PREFACE

This D&D Screening Risk Evaluation Guidance provides guidance on conducting screening-level risk assessments for D&D facilities. The document was prepared under Work Breakdown Structure 1.4.12.2.3.04 (Activity Data Sheet 8304, Technical Support) and provides risk assessors with guidance on how to develop screening-level risk information to assist D&D project managers in prioritizing and justifying specific D&D facility actions.

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EXHIBITS

ACRONYMS

BRE	Baseline Risk Evaluation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRI	Current Release Index
CRM	Center for Risk Management
DARE	D&D Alternatives Risk Evaluation
D&D	Decontamination and Decommissioning
DF	Dose Factor
DFG	D&D Facility Groups
DOE	United States Department of Energy
DOE-OR	United States Department of Energy Operations Office, Oak Ridge
DVR	D&D Risk-reduction Verification Report
Energy Systems	Lockheed Martin Energy Systems, Inc.
EPA	United States Environmental Protection Agency
ER	Environmental Restoration
FRI	Future Release Index
HI	Hazard Index
HQ	Hazard Quotient
K-25 Site	Oak Ridge K-25 Site
LS	Location Score
MLE	Most Likely Exposure
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PA/SI	Preliminary Assessment/Site Investigation
PHI	Physical Hazard Index
RA	Remedial Action
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
S&M	Surveillance and Maintenance
SAR	Safety Analysis Report
SARUP	Safety Analysis Report Update Program
SF	Slope Factor
SRE	Screening Risk Evaluation
TPS	Toxic Potential Score
WEI	Worker Exposure Index
Y-12 Plant	Oak Ridge Y-12 Plant

EXECUTIVE SUMMARY

The Screening Risk Evaluation (SRE) guidance document is a set of guidelines provided for the uniform implementation of SREs performed on decontamination and decommissioning (D&D) facilities. Although this method has been developed for D&D facilities, it can be used for transition (EM-60) facilities as well.

The SRE guidance produces screening risk scores reflecting levels of risk through the use of risk ranking indices. Five types of possible risk are calculated from the SRE: current releases, worker exposures, future releases, physical hazards, and criticality. The Current Release Index (CRI) calculates the current risk to human health and the environment, exterior to the building, from ongoing or probable releases within a one-year time period. The Worker Exposure Index (WEI) calculates the current risk to workers, occupants, and visitors inside contaminated D&D facilities due to contaminant exposure. The Future Release Index (FRI) calculates the hypothetical risk of future releases of contaminants, after one year, to human health and the environment. The Physical Hazards Index (PHI) calculates the risks to human health due to factors other than that of contaminants. Criticality is approached as a modifying factor to the entire SRE, due to the fact that criticality issues are strictly regulated under DOE. Screening risk results will be tabulated in matrix form, and Total Risk will be calculated (weighted equation) to produce a score on which to base early action recommendations. Other recommendations from the screening risk scores will be made based either on individual index scores or from reweighted Total Risk calculations. All recommendations based on the SRE will be made based on a combination of screening risk scores, decision drivers, and other considerations, as determined on a project-by-project basis.

1. INTRODUCTION

1.1 PURPOSE OF THE SCREENING RISK EVALUATION METHODOLOGY

The purpose of this document is to provide guidelines for conducting screening risk evaluations (SREs) for D&D facilities. The SREs produce relative risk scores to provide support for D&D action, prioritization, and decision-making. The goal of the SREs is to provide an inexpensive, prompt, and efficient tool to help prioritize project actions; identify early mitigation needs; aid in identifying additional data requirements; and reduce D&D project costs and delays.

1.2 BACKGROUND OF THE D&D RISK ANALYSIS STRATEGY

The United States Department of Energy (DOE) Office of Environmental Restoration (EM-40 or ER) is responsible for cleaning up DOE sites contaminated with radioactive and hazardous materials. These sites contain buildings and other structures collectively referred to as facilities. Retired, possibly contaminated, facilities are placed in ER D&D programs for final disposition. More than 400 facilities are currently included in ER D&D programs distributed among 38 installations in 18 states. The inventory of D&D facilities has grown steadily since the inception of the first formal DOE D&D Program in 1978. Much of this growth was spurred by the end of the cold war, and the trend is expected to continue.

The Center for Risk Management (CRM) at Oak Ridge National Laboratory (ORNL) is working closely with the Lockheed Martin Energy Systems, Inc. (Energy Systems) Central ER Program to develop and implement a systematic risk-based D&D strategy. The strategy comprises a set of tools designed to optimize the reduction of risks to workers, local residents, and the environment from D&D facilities given available budgets and capabilities.

Generally, buildings (facilities) have been viewed as containers that delay or prevent exposures and associated risks. Contaminated facilities are currently inspected, maintained, and monitored to ensure that containment is preserved. A more permanent solution must be found for many of these facilities for several reasons:

- Surveillance and maintenance (S&M) activities result in a certain amount of risk. Even when the best and safest work practices are used, it is impossible to completely eliminate all health, safety, and environmental risks.

- Risks posed by facilities are exacerbated by facility degradation which cannot be fully prevented given reasonable S&M budgets. This problem will increase as the number of D&D facilities continues to grow and as facilities age.

- Facility degradation substantially increases both the risks and costs of maintaining, characterizing, and remediating facilities. Therefore, the longer a permanent solution is delayed, the more costly it becomes to implement.

- Potentially, a building could be decontaminated and removed from the ER D&D Program for another use (or for an alternate use in the ER D&D Program), but because actions are not taken, the building may fall into a state where it can no longer be reused.

This does not preclude the use of long-term continuous S&M as the preferred alternative for some facilities. In some cases, long-term continuous S&M may be the best solution. For example, if the costs and/or risks associated with remediation are much greater than those associated with S&M activities and S&M can adequately prevent facility degradation and loss of containment, then obviously S&M would be the sensible choice. The application of long-term continuous S&M only to selected facilities will allow for more complete maintenance of these facilities to free up money for actions where they are needed elsewhere.

The CRM was tasked by Central ER to develop a set of tools to assess the risks associated with facilities. There was a need to standardize an approach to facility risk for Oak Ridge Operations. Recently, D&D was placed under CERCLA. In light of this administrative development, some of the tools explicitly provide guidelines on how to address risks for facilities within the CERCLA guidelines. Other tools are used for program-level decision making.

The CRM has developed four risk analysis tools. Each tool is designed to provide input tailored to meet the risk information requirements of a critical decision juncture within D&D. The evaluations include screening and baseline estimates of potential risks from facilities, followed by estimates of potential reductions and/or increases in public, ecological, and worker risks that may be expected from the application of specific D&D alternatives. The information derived from risk evaluations can be combined with project cost estimates and other decision criteria to determine the cost-benefit and other tradeoffs necessary to make program- and project-level decisions. The tools designed can supply information for many different needs of D&D.

The following paragraphs summarize the four tools for risk evaluation:

Screening Risk Evaluation provides a semiquantitative program-level screening of facilities. The SRE is not a CERCLA document. Its intent is to provide a quick and efficient means of evaluating current and future risks from D&D facilities using existing historical, process, occurrence, monitoring, and compliance data. The SRE aids in identifying additional characterization requirements and the level of effort needed for subsequent risk evaluations. The SRE identifies the existence or potential for current releases, future releases, worker exposures, physical hazards to workers, and criticality risks at facilities. The SRE is designed to provide D&D management with information to help prioritize and justify specific facility D&D actions. It will help managers identify early action projects to reduce risks and S&M costs. In addition, the SRE also will help managers select the most appropriate project goals and strategies.

Baseline Risk Assessment (BRA) is a quantitative, project level evaluation of a facility that uses more detailed characterization data than the SRE to estimate potential current and future human health and environmental risks from the facility under examination. These risks are compared to a predetermined acceptable level for overall protection of human health and the environment. This assessment includes consideration of risks to facility S&M and other site workers or visitors as well as the off-site public when appropriate. The BRA methodology is based upon the risk assessment guidelines provided by the United States Environmental Protection Agency (EPA) for CERCLA. This method of risk assessment is unique in that it includes a tiered approach (levels 1,2, or 3) for the purpose of saving time and effort at facilities that do not warrant a rigorous baseline risk assessment (for more information, see Energy Systems 1995).

D&D Alternatives Risk Assessment (DARA) of the risk analysis strategy is an integral component of the CERCLA approach. It supports the design and implementation of specific D&D alternatives. The DARA evaluates worker safety, human health, and ecological impacts associated with each remedial alternative thereby providing the risk assessment portion of the Feasibility Study

or the streamlined risk assessment for an engineering evaluation/cost assessment. The DARA considers expected risk reduction and short-term environmental and human health and safety risks and includes consideration of specific recycling, reuse, and/or disposal facility and waste management options. Risk and cost information are integrated to support decision-making for D&D alternatives. Additional issues such as waste transport risks evaluated in the DARA provide risk managers with the information necessary for making informed decisions regarding the appropriate D&D endpoint. Like the BRA, the DARA also includes a tiered approach so that the level of effort is commensurate with the needs of the assessment.

D&D Risk-reduction Verification Report (DVR) is designed to document the results of D&D project activities in terms of reduced (or increased) risks to human health, the environment, and worker safety. This document will close the D&D risk analysis loop, provide lessons learned, and perform a verification for the Record of Decision (ROD) closure under CERCLA. The DVR may also be used to verify achievement of specified clean-up goals such as those under removal actions and provide a performance-oriented basis for ongoing monitoring and remediation plans, if required. This methodology is currently under development.

1.3 SCREENING RISK EVALUATION OBJECTIVES

The SRE is designed to fulfill a large variety of program/project needs. Facility-specific objectives must be determined prior to initiation of the SRE process. Common objectives may include:

- Prioritization of facilities for future resource allocations. The SRE allows for prioritization based on a variety of factors including the need for early action and the magnitude of potential future risks.

- Facility characterization. In many cases the SRE may provide all of the risk characterization needs for the facility, and no BRA or other characterization efforts to support risk assessment will be necessary. The SRE may also fulfill other characterization needs. For example, the SRE may meet the objectives of a preliminary assessment/site investigation (PA/SI) at some facilities.

- Identification of facility reuse options. The results of the SRE will aid in evaluating the feasibility of facility reuse options. For example, if the SRE indicates that a facility poses a high risk to worker safety (due to physical hazards) and health (due to contaminant exposures), reuse for office space may require extensive cleanup and repairs.

- Identification of data needs for additional characterization. Collection and evaluation of existing data provided by the SRE will enable the identification of data gaps for additional characterization efforts. This will expedite efforts and make future investigations more efficient.

- Selection of appropriate level-of-effort for future risk characterization. The SRE will be useful in determining whether or not additional risk characterization is needed at a facility (i.e., BRA and/or DARA). If additional risk characterization is necessary, the SRE will provide information necessary for determining the most appropriate level of effort for future work.

- Identification of S&M requirements. The results of the SRE will provide a basis for the evaluation of both long-term and enhanced S&M requirements. This will allow the most efficient use of S&M resources.

- Justification of removal action. The results of the SRE may provide a basis for implementing a removal action by identifying potential risks at a facility.

- Use for facilities in the transition program (EM-60). The SRE may help prioritize facilities awaiting acceptance for D&D by identifying the types of problems associated with the facilities. It will also provide managers with risk information necessary for funding decisions.

Guidance is presented in Chapter 4 of this document for applying the SRE results to these objectives. One of the most important objectives of the SRE, and one which encompasses many of the specific objectives listed previously, is to expedite the D&D of facilities and maximize the efficiency of resource allocations. This is accomplished by providing a comprehensive evaluation of the data currently available for the facility and the types of problems which may exist. It is this broad overview of the facility that makes the SRE useful in meeting a variety of project needs.

1.4 OVERVIEW OF THE SRE METHODOLOGY

The SRE is a screening tool which is semiquantitave in nature and uses existing data; therefore, the results have a higher level of uncertainty than that of a BRA. Despite this high uncertainty, it is useful for providing a first glimpse of the risk associated with a facility and an evaluation of the existing data for a facility.

By using existing data, the SRE may ultimately decrease or minimize future characterization efforts. The SRE is not intended to be a quantitative risk assessment in compliance with EPA's risks assessment guidance (EPA 1989). This screening tool is not considered a CERCLA document, but its use is for initial identification of problems and for planning and can be used as input into CERCLA risk assessment documents.

The SRE process is illustrated in Fig. 1.1. The process begins with data assessment, followed by identification of risks. Results are used to provide recommendations for the future disposition and/or further characterization of the facility. The SRE uses existing data to calculate a relative measure of five types of potential risks presented by inactive buildings:

- Current human health and environmental/ecological risks resulting from the release of contaminants from the facility to the surrounding environment [Current Release Index (CRI)].

- Health risks to workers from exposure to chemical or radioactive contaminants in the facility [Worker Exposure Index (WEI)].

- Future human health and environmental/ecological risks from potential future release of contaminants from the facility to the surrounding environment [Future Release Index (FRI)].

- Current human safety hazards associated with physical conditions at the facility [Physical Hazard Index (PHI)].

- Potential for and magnitude of a criticality event (Criticality).

These indices (along with the criticality analysis) provide a semiquantitative estimate of risks at the facility. The use of five separate risk types assists in identifying the most important issues at a facility (e.g., current worker risks, criticality hazard, etc.). Because the SRE is semiquantitative, quantitative data are used to calculate numeric risk indices; however, unlike in a completely

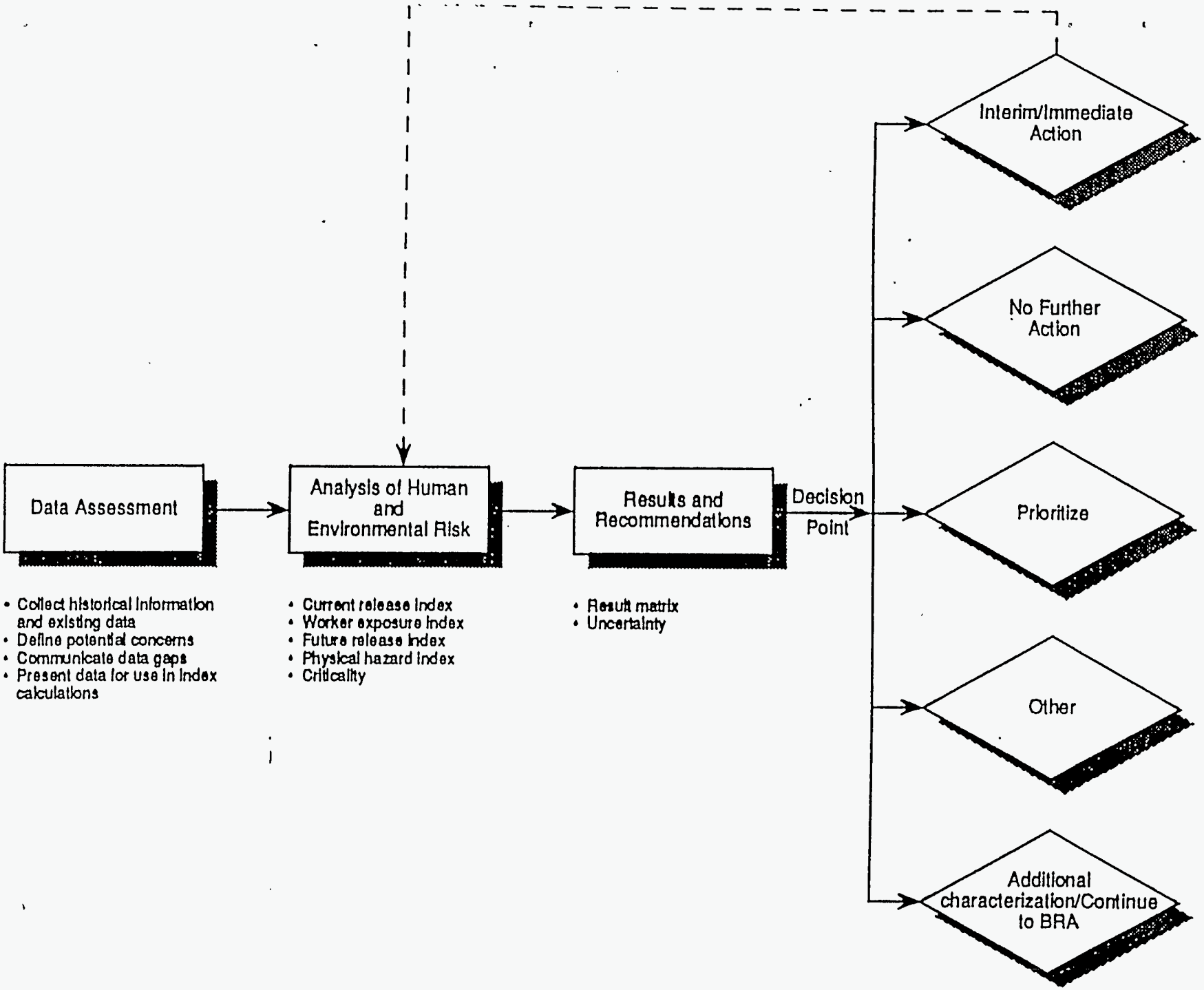

Fig. 1.1. Screening Risk Evaluation Process.

quantitative risk evaluation, these values cannot stand alone but must be evaluated in the context of the supporting data. They provide a relative measure of risk, i.e., is the risk high or low and how does it compare to the risk at other facilities?

The SRE uses existing data, i.e., no new sampling efforts are required for the purpose of the SRE (although minor sampling efforts can be undertaken for the SRE if the risk analyst and project manager consider them necessary). In addition to minimizing the cost and time required for the SRE, this approach, by providing a comprehensive evaluation of existing data, increases the efficiency of future work. The SRE identifies specific data gaps that need to be filled and can identify facilities that do not require any additional investigation. It will not be possible to complete an SRE at some sites because existing data are not adequate. However, a partial SRE, consisting of less than five risk types, may often be possible. If further characterization is required, the SRE will provide the information necessary for scoping future work, identifying data needs, and selecting the appropriate level of effort for the BRA and/or DARA. If a BRA is required, it will build on the results of the SRE, i.e., the data collected for the SRE will be used in the BRA so no effort is wasted.

1.5 SCOPE OF THE SRE METHODOLOGY

Chapter 1 of this report describes the objectives of the SRE and also provides the overall purpose and background of the D&D Risk Analysis Process. Chapter 2 provides guidance for data assessment, including collection of existing data and evaluation of the data quality and sufficiency for completion of the SRE. Chapter 3 provides guidance for calculating the risk indices which make up the SRE. Chapter 4 provides guidance for interpreting and applying the results of the SRE to decision-making. Finally, Sect. 5 provides instructions for presentation of the SRE report.

2. DATA ASSESSMENT

The first phase of the SRE is collection and evaluation of facility characterization data. The objective of the data assessment is to acquire chemical and radiological inventory, release, exposure, and facility condition data for use in determining the potential contaminant exposure risks and physical hazards associated with the facility. The data collected in these searches will be both quantitative and qualitative. The integration of the data collection and evaluation phase within the SRE process is illustrated in Fig. 1.1.

EPA guidance for data collection and evaluation at CERCLA sites [e.g., EPA, 1994, *Guidance for Planning for Data Collection in Support of Environmental Decision Making Using the Data Quality Objectives Process, Interim Final*; EPA, 1993, *Guidance on Implementing the Data Quality Objectives for Remedial Activities, Development Process* EPA/540/R-93/071; EPA, 1990a, *Guidance for Data Useability in Risk Assessment, Interim Final.* EPA/540/G-90/008; and EPA, 1992, *Guidance for Data Useability in Risk Assessment, Part B, Final (Draft)* EPA 9285.7-09B]) specifically addresses data from environmental media (air, soil, water, biota) and is designed for thorough characterization of contaminated sites already on the National Priority List. Little guidance is available for applying EPA methodology for screening level characterization and characterization of the structural media and bulk material present at D&D facilities. The concepts and principles presented in the guidance documents listed previously have been considered in this methodology.

The data collection and evaluation process for the D&D SRE is shown in Fig. 2.1. The steps within this process are summarized as follows.

- Collect existing data and conduct facility inspection. Consolidate all possible quantitative and qualitative data available.
- Evaluate data quality.
- Determine sufficiency of data to calculate SRE indices.
- Present data.

This section provides a description of the data requirements for the SRE (Sect. 2.1), guidance for the collection of available data (Sect 2.2), an evaluation of the quality and sufficiency of these data for use in the SRE (Sect 2.3), calculation of contaminant inventories (Sect 2.4), and presentation of the data (Sect. 2.5). It is important that the risk analyst be familiar with the entire SRE methodology before trying to apply the concepts within the data assessment. An understanding of the use of the data will aid the analyst in collecting and evaluating these data.[1]

2.1 DATA NEEDS

A complete understanding of the calculations presented in Sect. 3, Analysis of Human and

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[1] *Note on Security Concerns*: During the process of gathering data for the SRE, security concerns may arise. There are many areas and many forms of information that are classified under U.S. government protocol. For example, some processes are under classification status; therefore, equipment, schematics, and process knowledge would not be available to an uncleared researcher. If this type of situation arises, *L*, or in some cases *Q*, clearance will be necessary to obtain and "sanitize" the classified information or gain access to the restricted area.

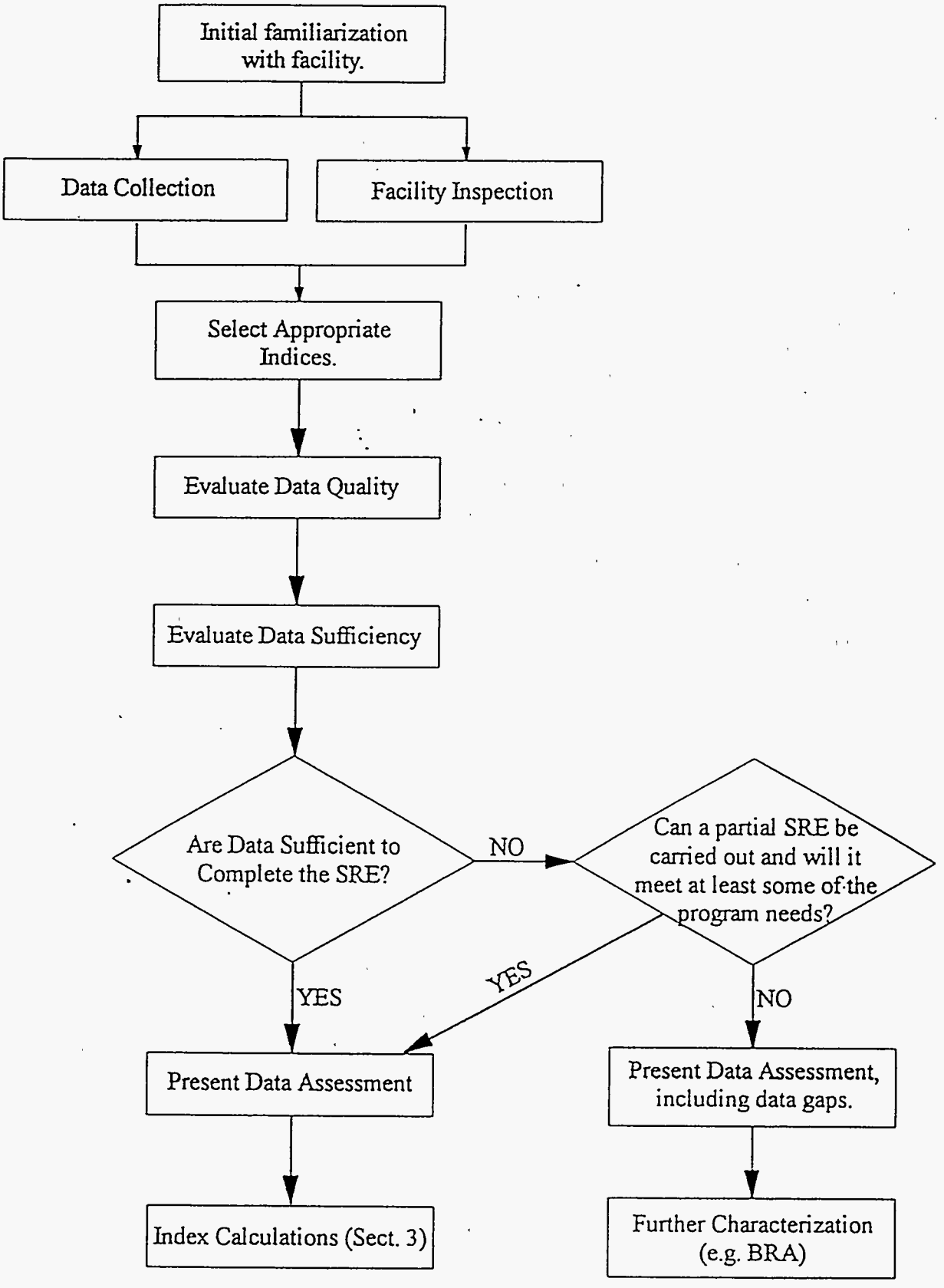

Fig. 2.1. SRE data assessment process.

Environmental Risk, and the application of the results presented in Chapter 4, Results and Recommendations, is required for a complete understanding of the data needs of the SRE. The risk analyst must, therefore, become familiar with the entire SRE process prior to data collection at a facility. The data requirements for the SRE are described in the following subsections. The general information needs are presented first, followed by the specific data requirements of each of the five indices that make up the SRE. Data needs are summarized in Fig. 2.2. A data collection worksheet is provided for the four indices and criticality (Fig. 2.3 and Appendix A). In most cases, the data collection worksheet may be completed by the facility manager with help from the risk assessment team. At some facilities, more in-depth data collection may be required followed by assessment/consolidation of these data to complete the worksheets. The information in these worksheets will feed directly into the risk index calculations presented in Chapter 3. The nature of the SRE methodology lends itself well to a spreadsheet application. A sample spreadsheet used to calculate the SRE indices using information from the data collection worksheet is presented in Appendix B.

2.1.1 General Facility Information

General information must be collected for all facilities to provide a basic description of the facility, identify the types of hazards that may exist (e.g., are contaminants likely to be present?) and from this to determine which of the four indices (and criticality) are applicable to the facility. General information includes:

- What was this facility used for?
- How old is it?
- Have chemicals or radionuclides ever been used or stored there?
- What chemicals or radionuclides have been used or stored there?
- Is the area contaminated (i.e., could this facility be a source of contaminant release?)?
- Has this facility been investigated in the past for any other reason (e.g., RCRA compliance, OSHA compliance, SARUP, past clean-up efforts, S&M)?

The answers to these questions will assist the risk analyst in determining what types of information are needed, what types of information are available, and potential sources of information.

2.1.2 Current Release Index (CRI)

The CRI provides a measure of the potential risk to human health and the environment associated with current contaminant releases from a facility. The CRI is based on:

- the location of the facility relative to potential transport media and human and ecological receptors
- the rate of contaminant release from the facility, and
- the toxicity of the contaminants being released.

SRE Index	Information Required	Example of data to meet requirement
CRI	Evidence of a contaminant release	Evidence may include documentation of a release, outside monitoring information, or observation
	Identity of contaminants being released.	Sampling data, documentation of release.
	Rate of contaminant release.	Discharge records.
	Location of facility.	Map of area with other facilities, potential receptors (e.g., active work sites, residential areas, critical wildlife habitat), and transport media (e.g., surface water).
	Toxicity of contaminants being released.	IRIS database, HEAST (EPA, current), Biomedical and Environmental Information Analysis Section (BEIAS) at ORNL.
WEI	Identity of contaminants present at facility	Process records, sampling data.
	Location of contaminants within the facility	Process records, sampling data.
	Concentration of contaminants	Sampling data.
	Location of potential receptors within the facility	Description of worker activities.
	Activity patterns (e.g., time/day spend in an area) of workers at facility	Description of worker activities.
	Toxicity of contaminants	IRIS database, HEAST (EPA, current), BEIAS.
FRI	Identity of contaminants present at facility	Process records, sampling data.
	Quantity of contaminants contained within the facility	Process records, sampling data.
	Location of contaminants within the facility (e.g., in structure itself, in secondary containment)	Process records, sampling data.
	Structural integrity of the facility	Engineering reports, facility inspection, building specifications.
	Integrity of secondary containment structures	Facility inspection.
	Location of facility.	Map of area with other facilities, potential receptors (e.g., active work sites, residential areas, critical wildlife habitat), and transport media (e.g., surface water).
	Toxicity of contaminants	IRIS database, HEAST (EPA, current), BEIAS.

Fig. 2.2. Data Requirements for SRE.

PHI	Location of physical hazards within the facility	Facility inspection.
	Time frame for hazards (i.e., current hazard, potential future hazard)	Facility inspection.
	Magnitude of potential injury associated with hazard.	Facility inspection.
Criticality	Evidence of fissile material	Process records, facility manager.
	Estimate of impact of criticality event	Facility manager, SARUP program.

Fig. 2.2. (continued)

Fig. 2.2 (continued).

FACILITY LOCATION

1.Provide a map (or several maps) identifying the location of the facility and the location of:

a.other buildings in the area
b. critical ecological habitats in the area (surface water, wetlands, undisturbed natural habitats)
c.closest uncontrolled area (i.e., site boundary)
d.closest residential area

2.Are there any threatened or endangered species known to live within 2 miles of the facility?_____

What endangered species are present and where?_____

3. Are workers present in buildings surrounding the facility? _____

FACILITY USE INFORMATION

1.Is the facility currently in use?_____

2.If the facility is currently in use:
a.What portion of the facility is used?_____
b.What is it used for?_____
c.How frequently is the facility used?_____
d.How many workers are in the building on a normal day?_____

3.If the facility is not in use:
a.Do workers have access to the facility or parts of the facility?_____
b.Are workers required in the facility for any reason (e.g., S&M, tours, monitoring)?___
c.How often do workers enter the facility?_____
d.What types of activities are performed?_____
e.Where in the facility are these activities performed?_____

RELEASE INFORMATION

1.Have there been releases (intentional or unintentional) of contaminants from this facility in the past? _____

2.If there have been past releases:
a. What was released? _____
b. When were the releases? _____
c. Were releases routine or accidental? _____
d. How did releases occur?_____

Fig. 2.3. Data Collection Worksheet

3.Are contaminants currently being released from the facility?

- ☐ Contaminants are definitely being released
- ☐ Contaminants are probably being released
- ☐ Not sure
- ☐ There is probably no contaminant release at this time
- ☐ There is definitely no contaminant release at this time

NOTE: Releases may be intentional or unintentional, routine or isolated incidents. For example - if the roof is contaminated, releases are likely to occur during storm events.

4.Has monitoring for releases been performed in the past?_____

5.If monitoring has been performed:
a.What type of monitoring has been performed?_____
b.When was monitoring conducted?_____
c.Where was monitoring conducted?_____
d.What, if anything, has been found during monitoring?_____

6.Is monitoring for releases currently being performed?

7.If monitoring is being performed:
a.What type of monitoring is being performed?_____
b.Where is monitoring conducted?_____
c.What, if anything, is being found during monitoring?_____

8.If a release is known or suspected:
a.What is being released?_____
b. How long has this release been occurring?_____
c.How often does the release occur (e.g., everytime it rains or continuously during working hours)?_____
d.How is the release occurring?_____
e.What is the approximate magnitude of the release?_____
f.How was this release estimate determined?_____

CONTAMINANT INFORMATION

1.Are contaminants (chemical or radioactive) present in the facility?_____

Fig 2.3. (continued)

2.What contaminants are present:

Contaminant	Location[a]	Amt or Conc.[b]	Data Availability[c]	Comments[d]

[a]Where in the facility is the contamination located - include physical location (e.g., north cell) and form (e.g., bulk material in waste containers, residue on walls).

[b]Total amount (mass or volume) of the contaminate, or concentration of contaminant in a medium (e.g., pCI/cm^2 on walls).

[c]Are analytical data available to identify and/or quantify this contaminant. What type of data are available?

[d]Additional comments regarding this contaminant (e.g.,).

CONTAINMENT INTEGRITY

1. Building construction:

☐ Reinforced Concrete ☐ Concrete/Masonry Block ☐ Brick
☐ Steel Frame ☐ Wood

☐ Other (specify):_____

2. Building condition:

☐ Excellent - The structure is new (< 10 years) and shows no visible deterioration.
☐ Good - The structure is older (> 10 years) and shows no visible deterioration.
☐ Fair - The structure shows the first signs of deterioration.
☐ Poor - The structure shows noticeable deterioration with visible cracks or openings.
☐ Very Poor - The structure shows advanced deterioration and/or is currently releasing contaminants

3. Roof condition:

☐ Good - The roof is new (< 5 years) and has no visible deterioration.
☐ Fair - The roof is older (> 5 years) and has visible signs of age. The roof may have minor leaks.
☐ Poor - The roof is visibly deteriorated and has been breached in some way (holes, cracks, serious leaks).

Fig 2.3. (continued)

4.If roof condition is poor, have corrective measures been taken to protect the roof/building (e.g., a tent erected over the facility with a leaky roof to prevent water from entering the building)?_____

5.Are contaminants present within a secondary containment structure (e.g., tank, drum)?_____

6. What type of secondary containment structure is present?_____

7. What is the current condition of the secondary containment?_____

PHYSICAL HAZARDS

1.Have any hazard assessments been performed on the facility (e.g., SAR, OSHA)?_____

2.Have any accidents/incidents occurred at this facility in the past 5 years?_____

3.If any accidents/incidents have occurred:
a. When did the incident occur?_____
b. Where did the incident occur?_____
c. Describe the incident_____
d. What injuries were sustained (if any) as a result of the incident(s)? _____

CRITICALITY

1.Is there any fissile material present in the facility?_____

2.Is there adequate fissile material in the facility for a criticality to occur if there was an initiating event?_____

3.What type of initiating event would be required for a criticality to occur?_____

4.If a criticality were to occur, how large an area would be effected?
☐Exposures within the facility only
☐Exposures to personnel outside the facility but on DOE property
☐Exposures could reach off-site of DOE property

Fig 2.3. (continued)

In many cases, there may be evidence of contaminants outside the facility and *suspicion* of a release but no data to confirm or quantify the release. Without release rate information, the CRI cannot be calculated. This does not necessarily indicate that there is no risk due to current release, only that it cannot be quantified and only be speculated qualitatively. This speculation should attempt to approach the most conservative estimate given the quality and certainty of the data. Data for the CRI should be compiled on the data collection worksheet (Fig. 2.3).

2.1.3 Worker Exposure Index (WEI)

The WEI provides a measure of the potential health risk to workers at a facility group. The WEI is based on:

- the concentration of contaminants within the facility,
- worker activities within the facility, and
- the potential toxicity of the contaminants.

Data for the WEI should be compiled on the data collection worksheet (Fig. 2.3).

2.1.4 Future Release Index (FRI)

The FRI provides a measure of the potential for future contaminant releases from facilities and the potential magnitude of the impact of these releases on human health and environment. The FRI is based on:

- the location of the facility relative to potential transport media and human and environmental/ecological receptors,
- the potential for contaminant release (structural integrity/secondary containment) from the facility,
- the quantity of contaminants available for release (inventory), and
- the toxicity of the contaminants available for release.

The potential for contaminant release from a facility is based on the structural integrity of the facility and any secondary containment structures present. Data for the FRI should be compiled on the data collection worksheet (Fig. 2.3).

2.1.5 Physical Hazard Index (PHI)

The PHI provides an evaluation of potential threats to human safety not related to contaminant exposure. Data for the PHI are acquired from a walk-through investigation of the facility. Information gathered during the facility group inspection can be used to satisfy this requirement as long as the information gathered satisfies the requirements of the Findings Report included in Appendix C.

2.1.6 Criticality

A criticality event occurs when there is sufficient fissile nuclear material present to support a

self-sustaining nuclear chain reaction. The criticality score provides a measure of the potential for, and magnitude of, a criticality at a facility. Scoring for criticality is based on:

- the existence of fissile material
- the quantity and location of the fissile material

Data for the criticality evaluation should be recorded on the data collection worksheet (Fig. 2.3). The priority of criticality issues is strictly outlined in DOE Orders 5480.5 and 5480.24.

2.2 DATA COLLECTION

The result of the data collection step will be the completion of all data collection worksheets for each applicable index. The task of data collection will take the majority of time and effort within the SRE. Collecting a set of data that provides sufficient, appropriate information for the SRE calculations is essential in correctly analyzing the risk of a facility. The first step in the data collection process is a familiarization with the facility and the type of information needed to characterize it. This initial familiarization is necessary for the risk assessor to determine what types of hazards may exist and therefore need to be characterized, to determine what types of data may exist and where, and locate sources of information (e.g., past workers). The facility manager can help to establish what type of information exists for a facility and in what capacity it was used. An initial facility visit is also helpful in becoming familiar with the facility.

Following this initial familiarization with the facility, the search for information may continue with a search through the installation's database system. Most databases provide at least a rough listing of hazard surveys, monitoring, health physics work, etc. These databases may also help in locating documents such as characterization reports. Previous studies and reports such as Environmental Impact Statements (EISs) and Environmental Reports produced for a facility or for a larger site that includes the facility are an excellent source of information. Plant and site managers are good sources of information and guides for searching the correct places to obtain the desired information.

Guidance for collecting historical process information, historical release information, and a facility inspection are presented in the following paragraphs. Collection of historical process and release information is critical for evaluating risks associated with contaminants present at or migrating from the facility (CRI, WEI, FRI). The facility inspection is necessary for determining the physical hazards at the facility (PHI), evaluating the overall condition of the facility and its contents with regard to contaminant containment (FRI), and identifying potential concerns that may be undocumented or for which documentation is difficult to find (e.g., evidence of a spill or contaminated materials in an area thought to be "clean"). Good records maintenance during data collection will greatly reduce complications when the data are applied to the risk calculations.

Historical Process Information. Each facility was intended to provide some type of service such as a production process, storage, administrative housing, etc. Understanding the function of each facility is essential in characterizing the facility. Information regarding operational process and other historical facility uses is available from a variety of sources and in any number of forms. Site characterization reports, preliminary site investigations, and hazard surveys generally contain records of processes that have occurred or are occurring at a facility. If the process was one that included any form of hazardous chemical or radioactive substance, then process records must be reviewed to determine potential contaminant identities and estimate inventories.

The review should include records of all previous and on-going processes, schematics of actual process lines and a description of the process itself, and records of all chemicals and radionuclides used and produced (e.g., delivery and disposal records), past and present. The type of equipment used and the duration of the actual process should be considered, as well as the activities of workers at the facility. Types and material makeup of containment devices should be investigated to determine if potentially hazardous materials have been adequately contained. All materials used and stored in the facility and the type of containment must be included. The date the facility was built and the dates of any modifications or equipment installations are also required.

Historical Release Information. Any facility that contains, or has contained, chemicals or radionuclides has the potential for a past release of these materials. Releases may occur accidentally (e.g., a spill or a tank rupture) or intentionally (e.g., discharge to surface water or via a smokestack). In many cases, clear documentation of past releases will be available. Documentation of release is a part of proper health and safety procedures at any facility. If the release was large enough to require immediate action, documentation will almost always be available. However, many small releases and some large releases are undocumented or poorly documented. If an undocumented release is suspected, the risk analyst may obtain information about the release from interviews with plant managers, engineers, workers, or maintenance personnel. In any case, the most documented and credible data should be that which are evaluated for risk analysis matters. Release information gathered for the SRE should include:

- the composition and amount of each release,
- the amount recovered in any clean-up actions,
- the location of the release, and
- the date of the release.

If this information is obtained via personal interviews, the interview must be documented. Figure 2.4 illustrates a sample communication log which should be used to document all interviews.

Facility Inspection. The facility inspection will allow a firsthand view of any obvious potential problems that now exist or might occur at the facility. Facility inspections will supply data for the Findings Report, located in Appendix C, which is an integral part of the PHI. The Findings Report must be completed during the facility inspection. In some cases, the risk analyst may wish to visit the facility twice (if schedule and budget permit), once to familiarize himself with the facility, and again to conduct the formal facility inspection.

The facility inspection should be conducted after the risk analyst has become familiar with the facility but before all other data collection activities are complete. An understanding of the facility and the activities that occurred there will allow the risk analyst to look for specific information during the inspection. For example, if the facility was used to store waste material but has since been emptied, the risk analyst may look specifically for staining or other evidence of contamination in the areas where materials were stored. The facility inspection should be conducted before the data collection is complete because clues found during the inspection may guide further investigation. For example, at a facility whose only documented use has been storage of files and office furniture, evidence of pesticide storage, drum heads, and unlabeled gas cylinders are found during the facility inspection. Based on this evidence, the risk analyst must find additional information regarding exactly what was stored at the facility and/or document the uncertainty caused by this apparent discrepancy between the official use of the facility and the findings of the facility inspection.

Date and Time of the Interview _____

Name of Person Contacted: _____ Signature _____

Position of Person Contacted: _____

Name of Person Conducting the Interview _____ Signature _____

Address and Phone # of Person Contacted:

Reason for Contact:

Facility Group, Building, and Plant Location:

Information Obtained:

Fig. 2.4. Sample Communication Log

The facility inspection should be documented for personnel, date, and general appearance of the facility and its contents. The facility inspection documentation should also include a review of notable surroundings, i.e., close proximity to population, water-supply type, water flow (surface, groundwater, recreational, tributary, etc.), soil and/or area topography, surrounding buildings of note, etc. Any physical hazards inside the buildings should also be noted in detail. Gridmaps of the facility showing potential contamination or physical hazards should be included in the information gathered. Finally, an opinion section should be included in the inspection documentation where ideas concerning potential problems and general concerns are discussed. Information to be gathered is listed in the facility inspection checklists shown in Fig. 2.5.

If a facility inspection has been conducted for another reason (outside the SRE) near the time of the SRE, then an evaluation as to its completeness should be made to avoid an additional unnecessary inspection. If all issues are addressed in a previous inspection that would be addressed in an inspection specifically conducted for the SRE and no significant changes have occurred at the facility since the previous inspection, then the previous inspection's data may be used in place of a scheduled facility group inspection. This does not negate the need for the risk analyst to become familiar with the facility group through a site visit. The Findings Report (Appendix C) must be completed from the information derived through the prior inspection.

2.3 DATA EVALUATION

After collection of all available data, these data must be evaluated to determine which are of acceptable quality for use in the SRE and whether sufficient data are available to complete the SRE. Three steps are included in the data evaluation process:

- selection of applicable indices,
- evaluation of data quality, and
- evaluation of data sufficiency.

These steps are described in the following subsections (2.3.2–2.3.4). The data quality requirements of the SRE are also presented (Subsect. 2.3.1).

2.3.1 Data Quality Requirements

The SRE is a screening level evaluation based on existing data; these data will be of widely varying quality. Generally, all data can be used in the SRE as long as their uncertainties are clearly described. Therefore, there are only three data quality requirements for the SRE:

- The data used must be the best data available, i.e., if more than one data set exists for the same information, the data with the highest quality should be used.
- Uncertainties in the data must be presented with the data.
- The data must be applicable to current conditions at the facility.

- Date and Time of facility group inspection
- Name of Facility Group, Building Number, and Location
  (example: Powerhouse Group, K770, K-25)
- Specific Location within the group's particular plant arena
- Name of Person(s) Inspecting Facility Group
- Name of Person(s) Receiving Inspection Effort
- Outward Physical Appearance
  –building material used
  –size/dimensions
  –geological foundation; i.e., clay, silt, sand, etc.
- Noteable Outlying Characteristics in 3-mile radius
  –creeks
  –forests
  –population
  –lakes
  –schools
  –business districts
  –recreation areas
  –groundwater table
  –drainage areas
  –general topography
  –floodplains
  –dams
- List of Potential Contamination Areas
- Materials Presently on Inventory at the facility group, amounts, and toxicity information
- Processes Presently Conducted at the facility group
- Materials Previously Stored or Used at the facility group
- Past Processes Conducted at the facility group
- Records of Spills or Releases planned or unplanned at the facility group
- Records of any Physical Safety Problems
  (examples: exposures, broken bones, radiation illness)
- Outward Signs of any Potential Radiological or Chemical Significant Concerns
  (examples: leaking drums, chemical smell, spills, cracks in building)
- Outward Physical Hazard Signs
  (examples: lack of chemical showers, eye baths, no extinguishers, signs of facility degradation, faulty flooring, drums stacked too high)
- Building Occupancy, occasional or permanent (specify), and number of occupants
- Number of S&M workers, average number of days a week worked, average number of hours a day worked
- Proximity of facility group to facilities with occupancy
- Opinions/Discussion

Fig. 2.5. Facility Inspection Checklist.

The final requirement is needed because of the age of many facilities. Data that are no longer applicable may often be found in databases. For example, surface wipe data may exist for equipment that has previously been removed from the facility.

2.3.2 Selection of Applicable Indices

All four SRE indices and criticality may not be calculated for every facility for one of two reasons: (1) an index is not applicable at the facility (e.g., existing data indicate that no contamination is currently being released from the facility; therefore, no CRI will be calculated) and (2) lack of data may prohibit the calculation of an index (e.g., contaminants are known to be present in the facility but no concentration data exist to calculate the WEI). After all available data have been collected for a facility, the risk analyst must review these data to determine which indices are applicable to the facility. Figure 2.6 illustrates the selection process. Indices that cannot be calculated due to lack of data will be identified during the evaluation of data sufficiency (Subsects. 2.3.3–2.3.4).

2.3.3 Evaluation of Data Quality

Data quality refers to the degree of quality assurance/quality control (QA/QC), level of analytical analysis, and the overall confidence the risk analyst has that the data provide a true representation of conditions at the facility. The evaluation of data quality serves two purposes for the SRE. First, data that are unusable are identified and eliminated from the SRE, and second, the quality of the data and therefore the uncertainties associated with those data are documented. As noted previously, very little data will be rejected due to poor quality. This makes the documentation of data quality and uncertainty even more important.

Data may be eliminated from the SRE for two reasons: (1) better data are available to provide the same information or (2) the data do not apply to current conditions at the site. However, even if data are eliminated from the SRE for either of these reasons, they may still be used in interpreting results and evaluating uncertainty.

If more than one data set exists to address a data need (e.g., exposure concentration of a contaminant on building surfaces for calculation of the WEI), the risk analyst must decide how to make the best use of the available data. One data set may be selected as superior to the other, or the two sets may be combined. For example, the existing data set for a facility may consist of a thorough, comprehensive, random grid surveying of the entire building dating from 15 years ago and a small, sporadic, nonuniform sampling event that was recently completed. Obviously, the most recent data are more likely to reflect the current contaminant levels on the premises; however, the more comprehensive survey is less likely to have omitted or overlooked any small areas of high contamination. If overlap of survey locations exists between the two data sets, conclusions concerning the change in contaminant concentrations over time can be made. This could determine whether the more recent data are consistent with the older data, both lending support to the other, or whether the previously observed levels appear to have diminished or increased. A general rule for data application would be to select the most conservative data set (higher concentrations) for use in the SRE methodology unless information exists that the higher values are no longer present at the site due to decay or interim clean-up or removal actions.

After eliminating unusable data, the quality of the remaining data must be documented. Sampling data should be evaluated for two factors:

- Results of Quality Control—if quality control samples have been analyzed, the results of this analysis should be reported (e.g., were blank samples contaminated?).

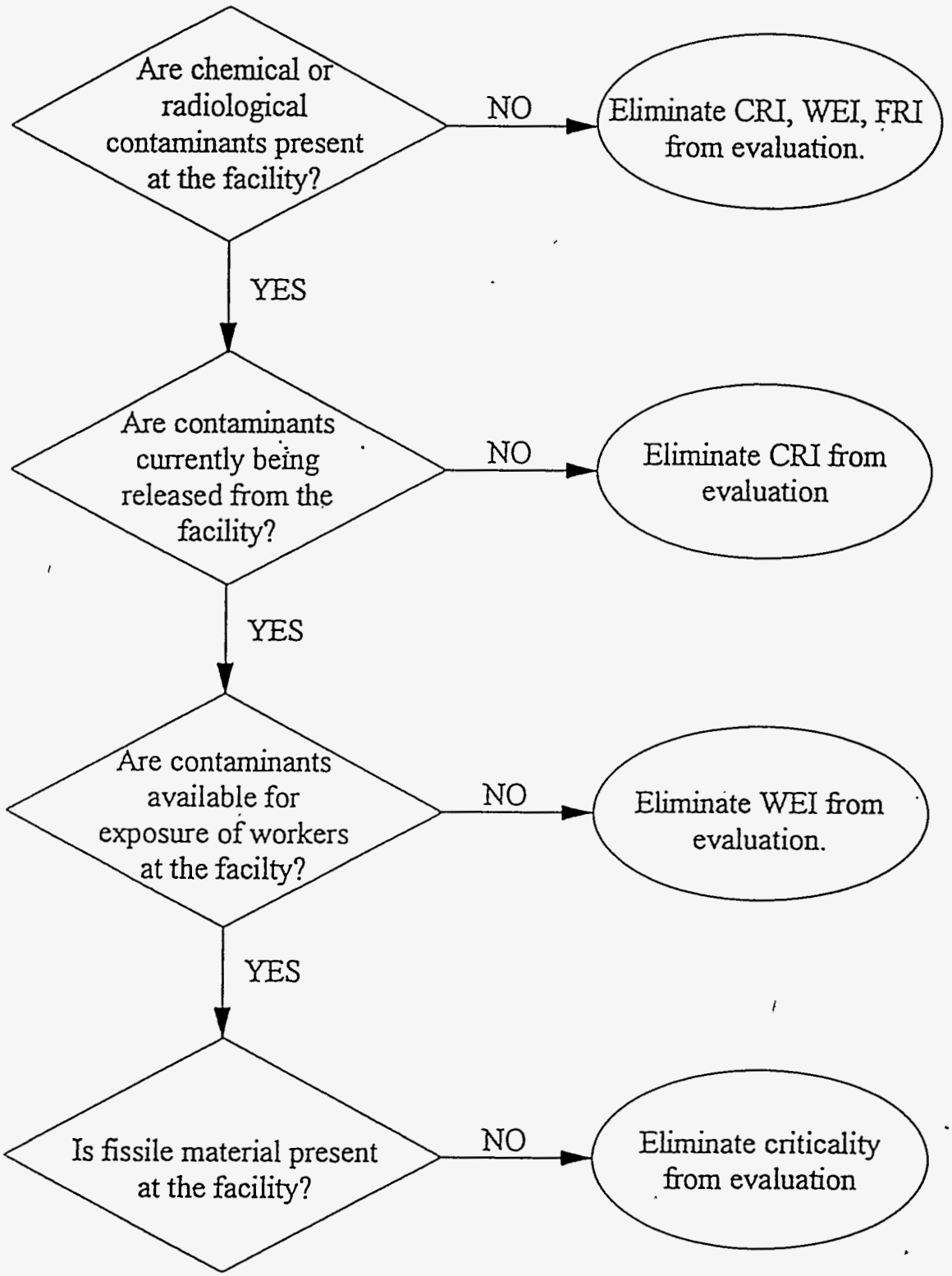

Fig. 2.6. Elimination of Indices not applicable to a facility.

- Representativeness—A description of how well the data set represents actual conditions at the facility is critical. Data may not be representative for a variety of reasons; they may be out of date, there may be an insufficient number of samples to adequately characterize a large or varied area, or analysis may have been limited to only a few compounds. The evaluation of representativeness should include a discussion of the possible impact on the facility characterization. For example, if an old data set must be used, but some remediation has occurred since the samples were taken, the contaminant concentrations may be overestimated from this data set.

Analytical data collected prior to 1993 may have a quality level designation. These quality levels are based on previous EPA DQO guidance (EPA, 1987, *Data Quality Objectives for Remedial Activities, Development Process.* EPA/540/G-87/003). This past guidance allowed for five quality levels. EPA level I refers to field screening data using portable instruments. Level II data include field analysis performed using advanced portable analytical instruments and , in some cases, instruments set up in mobile labs. EPA levels III, IV, and V data are laboratory data with increasing levels of quality control and documentation.

The quality of nonanalytical data must also be evaluated and documented. This evaluation is much more difficult and more subjective than that for analytical data. Generally, the most important factor affecting the quality of nonanalytical data is the source of that data. For example, information taken from a map (e.g., distance to surface water) is likely to be of high quality unless a very old map is used. Information from interviews will be of varying quality. As a general rule, the older the information, the greater the uncertainty (e.g., descriptions of operational practices from 40 years ago will have a higher level of uncertainty than descriptions of on-going operations). Secondhand information (i.e., the interviewee never actually saw the procedure but heard about it or it was "common knowledge") will have a higher degree of uncertainty.

2.3.4 Evaluation of Data Sufficiency

After evaluating the quality of the available data, the risk analyst must determine whether sufficient data exist to meet the needs of the SRE indices applicable to the facility (See Subsect. 2.3.2 for selection of applicable indices). If data gaps exist, the risk analyst must evaluate the potential impact of these gaps. Data gaps for the SRE fall into three categories:

- Data gaps that can be filled with assumptions or default values.
- Data gaps that increase the uncertainty of the SRE indices.
- Data gaps that prohibit the calculation of one or more SRE indices.

Data gaps can be filled in some cases with preassigned default values that will allow the calculation to continue, assuming a worst-case scenario. Data gaps can also be filled through assumptions made from either supporting information, professional judgment, or a combination of the two. In some cases, however, data gaps cannot be filled with default values or assumptions. In this case, an index may have to drop out of the calculations, or a decision can be made to collect additional data if the risk analyst and the project manager consider it necessary. If an index cannot be calculated due to insufficient data, this must be clearly documented. The result for that index is reported as none, not as 0, and will not be included in the calculations.

2.4 INVENTORY ESTIMATES

As noted previously (Subsect 2.1.4), calculation of the FRI requires an estimate of contaminant inventory at the facility. In some cases, this information may be available directly (i.e., a previous study may have reported total inventory). However, at many facilities, inventories must be estimated from other data. Contaminant inventories may be estimated from historical records and process information, from sampling data, or from a combination of the two. Guidance is presented in the following paragraphs for estimating contaminant inventories.

Historical Records/Process & Release Information. The most straight-forward use of historical records is the estimation of the potential amount of a contaminant at a location based on the amount received by the facility and the amount removed from the facility (from waste manifests and/or discharge records). For example, if shipping manifests indicate that 1000 kg of mercury were received at a facility and 700 kg were disposed of, there are potentially 300 kg of residual mercury at the facility. This is likely to be an overestimate because it does not take into account the amount of mercury consumed by the process for which it was received.

Sampling Data. In general, the amount of a contaminant present in sampled material may be calculated from concentration data as:

$$M_i = (C_{ij})(A_j)$$

where

M_i = mass or activity of contaminant I (mg) or (pCi).
C_{ij} = concentration of contaminant I in medium j (mg/kg, mg/m^3, mg/cm^2) or (pCi/kg, pCi/m^3, pCi/cm^2).
A_j = amount of medium j (kg, m^3, cm^2).

For example, if a concentration of 5 mg/kg of mercury is measured embedded in the concrete structure of a facility and there are an estimated 100,000 kg of contaminated concrete, the total mercury embedded in the structural concrete of the facility is estimated to be 500,000 mg (500 kg).

Extreme care must be used in applying this formula with limited sampling data. Over- or underestimates of total inventory may result.

- Overestimates—Total inventory will be overestimated if sampling data obtained primarily from "hot spots" are extrapolated to a larger area. For example, a measured concentration of 5 mg/kg mercury is obtained from a 1 kg sample of concrete. The actual area of contamination includes 1000 kg of concrete (for a total mass of mercury in concrete of 5000 mg). The total mass of concrete in the facility is 100,000 kg. If all this concrete is assumed to be contaminated with 5 mg/kg mercury, the estimated inventory of mercury in the concrete is 500,000 mg. This would result in a gross overestimate of total inventory in this medium.

- Underestimates—Inventory may be underestimated if sampling has missed a significant area of contamination. For example, data obtained from surface chips of floor material indicate a concentration of 0.01 pCi/kg for ^{235}U. Assuming the total floor material is 1000 kg, the total inventory of ^{235}U in this material is 10 pCi. If the surface of the floor had previously been cleaned, i.e., the top 100 kg removed, to reduce worker exposure to ^{235}U, and the concentration in the 900 kg of material below the surface is 0.1 pCi/kg, the actual total inventory of ^{235}U in the floor material is 91 pCi. In this scenario, the total inventory would be significantly underestimated.

Both of these sources of error will be common at D&D facilities. It is common for sampling efforts to have concentrated on areas with the greatest potential for contamination. It is important, therefore, that the size of the contaminated area and volume or mass of contaminated material be considered carefully before calculating the inventory. For example, if samples have been gathered from a hot spot, the mass of material assumed to make up that hot spot must be estimated rather than extrapolating to the entire structure or piece of equipment. In some cases of unacceptable uncertainty, limited characterization will be needed to assess the facility.

Past clean-up efforts and the behavior (mobility) of contaminants must also be carefully considered when applying this formula. Past clean-up efforts often included washing exposed surfaces and easily accessible areas and/or covering contaminated areas (e.g., with paint, dry wall, floor tile). Surface samples taken after such clean-up efforts will tend to result in underestimates of inventory unless higher subsurface concentrations are taken into account. Subsurface concentrations may be accounted for by making assumptions about the effectiveness of the cleaning technique.

Contaminant mobility will also affect the accuracy of inventory estimates. For example, surface samples taken from a porous medium may underestimate deeper concentrations if the contaminant is volatile and has been lost from the surface through volatilization but is present and trapped in deeper layers of the material. The same surface samples may overestimate deeper concentrations of a contaminant that adsorbs strongly at the point of contact and does not move deeper into the medium. Contaminant records and process knowledge should be used to evaluate the potential error in inventory estimates calculated by this method.

One of the most common sources of contaminant data at D&D facilities will be radiological surveys. Radiological survey results may include smear samples and fixed measurements for alpha and beta/gamma-emitting radionuclides. These data may be used to estimate inventories of specific radionuclides if enough is known about the facility to make a judgment on the potential radionuclides present.

Integration of Inventory Information. Inventory information obtained from historical records/process & release information and sampling data should be used together whenever possible to provide the best educated estimate of the amount of material potentially available for release from a facility. If limited information is available, the most conservative estimate should always be applied. The two types of information can be used to compliment each other in the following ways:

- The maximum potential inventory estimated from the amount of material received and disposed of provides a "reality check" for media-specific inventories estimated from sampling data. If the total inventory estimated from sampling data is greater (or unrealistically smaller) than the maximum potential inventory from shipping records, the assumptions used to estimate inventory from sampling data must be re-evaluated. For example, using existing sampling data, the total inventory of mercury in a facility is estimated to be 200,000 kg. Historical records indicate that 1,400,000 kg of mercury was delivered to this facility and 1,300,000 kg were transferred to other facilities or disposed of as waste. Only 100,000 kg of mercury are unaccounted for; therefore, the estimated inventory of 200,000 kg is in error and must be re-evaluated.

- Comparisons of inventories estimated from sampling data and historical records can provide an estimate the potential direction of error (over- or underestimates).

- Estimates of inventories for different parts of the facility may use different types of data. For example, historical records may be used to estimate the total inventory of a contaminant in a piece of equipment (with assumptions made as to the potential form of the contaminant), while

existing sampling data may be used to estimate the inventory of contaminants in and on structural components of the facility.

- Historical records may be used to determine the radionuclides most likely to be present at the facility. This information can then be used in estimating radionuclide inventories from radiation survey data.

3. ANALYSIS OF HUMAN AND ENVIRONMENTAL RISK

The purpose of this chapter is to present the SRE methodology for applying the data in Sect. 2 to the development of risk-based ranking scores for DOE D&D facilities.

3.1 INTRODUCTION TO THE SCREENING RISK EVALUATION

Prioritizing D&D facilities requires estimating their potential for causing adverse impacts on human health and the environment. Adverse impacts may result from the presence of hazardous chemicals, radioactive substances, or physical hazards within the facility. The SRE is designed to provide a relative measure of five types of potential risks presented by inactive buildings:

1. Current human health and environmental risks resulting from the release of contaminants from a facility to the surrounding environment (Current Release Index, Sect. 3.2).

2. Current health risks to workers from exposure to chemical or radioactive contaminants in a facility (Worker Exposure Index, Sect. 3.3).

3. Future human health and environmental risks from potential future releases of contaminants from a facility to the surrounding environment (Future Release Index, Sect. 3.4).

4. Current human safety hazards associated with physical conditions at a facility (Physical Hazard Index, Sect. 3.5).

5. Potential for a criticality event to occur at a facility (Criticality, Sect. 3.6).

These five risk types provide the basis for prioritizing facilities and facility groups, as well as for other risk-based decision making. The use of five separate risk types will also assist in focusing future studies on the most important issues at a particular facility (e.g., current worker risks, criticality hazard, etc.). For many facilities, there may not be adequate data to calculate all five risk types. In these cases, the SRE should include numeric values for the indices that can be calculated and a discussion of the indices that were omitted because of lack of data. It should be noted that the risk scores for a particular facility are screening-level scores rather than strict, quantitative measures of risk; these scores are to be used to prioritize sites for further evaluation.

The methodologies for calculating each of the four indices and criticality are presented in Sects. 3.2 through 3.6. Index scores may be determined for individual facilities or portions of facilities, as considered appropriate according to Sect. 2. Individual facility scores may be combined to provide a facility group score. Recommendations for applying these indices and criticality to decision making are given in Sect. 4.

3.2 CURRENT RELEASE INDEX (CRI)

The CRI provides a means for prioritizing D&D facilities according to their potential risk to human health and the environment from current contaminant releases.

The CRI is based on a method developed and used to prioritize inactive underground storage tanks at ORNL (Chidambariah et al, 1984). The CRI uses two scoring criteria: (1) the location of the

building and (2) the toxic potential of the contaminants. A D&D facility is scored for each of these criteria on a scale of 1 to 5. For this index, toxic potential is assigned three times the weight of the location score; the weighted average of the two scores is the CRI. A set of facilities can be scored then prioritized according to individual CRIs.

3.2.1 CRI Scoring Criteria

3.2.1.1 Building location (Location Score)

The location of the facility affects both the likelihood that a human or ecological receptor will be affected by a release and the potential extent of contaminant migration through the environment. The location of the facility will also effect the potential for release resulting from natural disasters; the location score (LS) is relatively high if the facility is located on a floodplain, on an earthquake fault, or in an area prone to tropical storms, hurricanes, or other severe weather events. The LS is site-specific and is based on the proximity of the facility to receptors (the site boundary and potentially sensitive ecological habitats) and transport media (groundwater and surface water). Facilities are scored higher if they are located near public receptors (e.g., the site boundary) or near large numbers of site workers (e.g., if there is an active facility with a large concentration of workers nearby). The LS is used to evaluate potential risks to environmental receptors by applying a higher score to facilities located near potentially sensitive or threatened habitats (e.g., surface water or wetlands) or sensitive species (e.g., endangered species living in, feeding at, or migrating through the potentially affected area).

3.2.1.2 Toxic potential

Determining the potential risks to human health and the environment from contaminant exposure requires information about the toxicological characteristics of the contaminants being released and the magnitude of the release. Two factors are considered in establishing the toxic potential of the contaminants: (1) the toxicity of the contaminants as determined by the reference dose (RfD) for chemicals with systemic effects or the cancer slope factor (SF) for nonradioactive carcinogens and radionuclides and (2) the amount of each contaminant being released. These factors are combined into a single, dimensionless number called the toxic potential score (TPS).

3.2.2 Risk Scoring Process

The following sections provide guidance for determining numeric values for the LS and TPS.

3.2.2.1 Location score

Buildings are assigned a higher LS if they are located relatively close to surface water, groundwater, potentially sensitive ecological receptors, the site boundary, or large populations of workers. There is no generic methodology for scoring LS from one DOE installation to another; these criteria are site-specific. Scoring criteria for each of the three U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) sites are given in Appendix D, Location Scoring Criteria. Scoring criteria for other DOE sites must be developed on a site-specific basis.

3.2.2.2 Toxic potential score

The TPS for the contents of a facility is scored according to the contents' toxicity, the magnitude of the release, and the rate at which the contaminants are being released. A discussion of the steps necessary to calculate the TPS follows.

Dose factor. The first step in estimating the toxic potential is to calculate the dose factor (DF) for each contaminant being released from the facility. The RfDs for noncarcinogenic chemicals and SFs for carcinogenic chemicals and radionuclides are converted into DFs. Standard default exposure and risk factors issued by the U.S. Environmental Protection Agency (EPA) are used to determine DFs. Toxicity values should be taken from the Integrated Risk Information Systems (IRIS) and/or the *Health and Environmental Affects Summary Table* (HEAST), which are periodically updated for general DOE sites. Within the ORR, the values used should be obtained from the Biomedical and Environmental Information Analysis Section of the Health Sciences Research Division at ORNL. If standard toxicity values are not available for a particular contaminant, the risk analyst should consult a toxicologist to determine whether:

- the contaminant is potentially toxic at environmental levels, or
- a proxy value similar to an RfD or SF can be estimated by comparison to a similar compound for which an RfD or SF is available.

For the SRE, release periods are measured in years. Therefore, DFs are expressed in mg/year for nonradioactive chemicals and pCi/year for radionuclides.

Contaminants that cannot be scored. If the contaminant is considered nontoxic (e.g., sodium sulfate, magnesium hydroxide), it should be eliminated from the calculation of the CRI. Some nontoxic contaminants may be hazardous due to their reactivity, flammability, etc. These physical hazards will be addressed by the PHI. If the contaminant is toxic and no proxy value can be estimated, it cannot be included in the CRI. The results must then note that the CRI is an underestimate because all toxic contaminants are not included. The magnitude of this underestimate will depend on the amount of the contaminant being released from the facility and its potential toxicity.

DF for noncarcinogenic chemicals. For noncarcinogenic chemicals, the DF is the total amount of a chemical a 70-kg person would take in if exposed to the RfD over a 70-year lifetime. This corresponds to a Hazard Index of 1 (EPA, 1991). An example of the calculation of DF is calculated as follows:

$$DF = (RfD)(70\ kg)(70\ years)(365\ d/year)$$

where the oral RfD is expressed in mg/kg·d, the reference body weight is 70 kg, average lifetime is 70 years, and a conversion factor of 365 d/year is used. In most cases, the oral toxicity data is most available and represents a basis from which the inhalation values are derived.

DF for nonradioactive, carcinogenic chemicals. For nonradioactive, carcinogenic chemicals, the DF is the total exposure a 70-kg person would receive in a 70-year lifetime if exposed to a chronic daily intake equivalent to the 10^{-6} lifetime risk level.

DF for radionuclides. For radionuclides, the DF is the total amount radioactivity a 70-kg person would take in if total exposure over a 70-year lifetime produced a 10^{-6} lifetime risk level. The following equation should be used to calculate DF for radionuclides:

$$DF = \frac{(10^{-6})}{(SF)}$$

where DF is expressed in pCi and SF is the ingestion slope factor expressed as pCi^{-1}.

Toxic Release Potential (TRP). The TRP takes into account the toxicity of the contaminant being released from a facility, the amount of contaminant being released, and the time period over which its release is measured. The first parameter required in deriving the a contaminant's TRP is the release rate, *rr*.

Release rate data may be reported in many forms [e.g., lb/d, gallons (at a certain concentration)/year, m^3 of soil (at a certain concentration)/10 years]. These rates will generally be gross estimates. For this calculation, release rates must be converted to mg/year or pCi/year.

Following is the calculation for *rr*:

$$rr_x = \frac{Q_x}{t}$$

where

Q_x = the quantity of contaminant *x* released from the facility (in mg or pCi)
t = time over which Q_x was measured (in years)

The *rr* is calculated for each carcinogenic or noncarcinogenic chemical and radionuclide being released. Once the *rr* for contaminant *x* has been determined, the TRP for *x* is calculated by dividing the *rr* by its corresponding DF:

$$TRP_x = \frac{rr_x}{DF}$$

The total TRP for all noncarcinogenic chemicals being released from the facility, TRP_{nc}, is calculated as follows:

$$TRP_{nc} = TRP_{CHEM_{nc_1}} + TRP_{CHEM_{nc_2}} + \ldots + TRP_{CHEM_{nc_i}}$$

The total TRP for all nonradioactive carcinogenic chemicals from the facility, TRP_c, is determined similarly:

$$TRP_c = TRP_{CHEM_{c_1}} + TRP_{CHEM_{c_2}} + \ldots + TRP_{CHEM_{c_i}}$$

Finally, the total TRP for all radionuclides from the facility, TRP_r, is calculated as follows:

$$TRP_r = TRP_{CHEM_{r1}} + TRP_{CHEM_{r2}} + \ldots + TRP_{CHEM_{rl}}$$

The largest of these TRP sums, either TRP_{nc}, TRP_c, or TRP_r, is used to determine the facility's TPS.

TPS (Toxic Potential Score). To assign the TPS for a facility, use the largest of the facility's TRP sums (TRP_{nc}, TRP_c, or TRP_r) and select the corresponding TPS from Table 3.1.

Table 3.1. Toxic potential scoring

Facility TRP (either TRP_{nc}, TRP_c, or TRP_r)	Toxic Potential Score
≥10	5
7–9	4
4–6	3
1–3	2
<1	1
0[a]	0

[a]If no contamination is present, a TP of 0 is assigned.

This ranking will be reevaluated and modified as necessary after TPs are calculated for the D&D facilities.

3.2.3 Calculating the CRI

Building location is considered the least important parameter of the CRI. Location is only important if the contaminants released are of sufficient quantity and toxicity to adversely affect potential receptors. Therefore, LS is assigned a weight of 1.

Toxic potential is considered more important than building location in determining the CRI. This is because the release of a relatively highly toxic material or of a relatively large quantity of material is of more concern than the release of a low-toxicity material, even if the latter is released close to potential receptors or transport media. Therefore, TPS is assigned a weight of 3.

The CRI is calculated from the LS and TPS as follows:

$$CRI = \frac{(1)(LS)+(3)(TPS)}{4}$$

The D&D facilities are ranked in descending order according to their CRI scores; facilities that have the same or similar scores can be grouped together. A high CRI indicates the facility may currently be contributing to environmental degradation and/or human health risk. Facilities with the highest scores are given first priority for further evaluation of worker risks and possible removal actions.

3.2.4 Uncertainty

The CRI approach groups D&D facilities into a set of scoring categories based only on available data. These data often include gross estimates of contaminant releases; therefore, the uncertainties associated with any one CRI value are likely to be large. However, grouping the scored facilities into broad scoring categories generally reduces the overall uncertainty of the ranking system. This numeric scoring method is adequate as a quick, risk-based approach to prioritizing facilities for further evaluation. It does not provide a strict, quantitative estimate of current risk.

3.3 WORKER EXPOSURE INDEX (WEI)

The WEI provides a method approach for prioritizing D&D facilities according to the current potential health risk to people working in those facilities. This ranking takes into account risks associated with exposure to chemical and radiological contaminants via ingestion, inhalation, dermal contact, and external radiation exposure. The WEI assessment is limited to the evaluation of current exposures within the building, and provides the risk manager with information concerning the relative risk to on-site workers. The results of the WEI can be used to identify which facilities do or do not pose an immediate threat to facility workers from contaminant exposure within the building. The potential for future contaminant transport from the building to the environment is accounted for by the Future Release Index (Sect. 3.4).

3.3.1 Worker Exposure Index Scoring Criteria

The WEI assessment follows the methodology outlined in *Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A)* (EPA 1989). The WEI assessment considers four exposure routes:

- ingestion,
- inhalation,
- dermal exposure, and
- external exposure to radiation

The three scoring criteria used in this methodology are:

- intake factor, which provides an estimate of intake per unit concentration of the potential contaminant exposure under defined conditions;
- risk characterization, in which the toxicity and concentration of each contaminant present are combined with the intake factor to calculate a risk value; and
- usage factor, a weighting factor to account for differences in worker activity among facilities.

3.3.2 Scoring Process

3.3.2.1 Intake factors

Standard occupational exposure parameters were used to develop intake factors for each of the four exposure routes. The derivation of the unit intake factors is presented in this subsection.

The equations in Table 3.2 for intake factors are taken from the exposure equations recommended by the EPA (1989).

Table 3.2. EPA equations for intake factors

Exposure Pathway	Contaminant Type	Intake Factor Equations
Ingestion of dust	Chemicals	$IF_{ic} = \frac{(IR)\ (EF)\ (ED)}{(BW)\ (AT)}$
	Radionuclides	$IF_{ir} = (IR)\ (ED)\ (EF)$
Inhalation of dust	Chemicals	$IF_{ac} = \frac{(IR)\ (EF)\ (ED)}{(BW)\ (AT)}$
	Radionuclides	$IF_{ar} = (IR)\ (ED)\ (EF)$
Dermal contact with dust	Chemicals	$IF_{d} = \frac{(SA)\ (AF)\ (ABS)\ (ED)\ (EF)}{(BW)\ (AT)}$
Dermal contact with contaminated surfaces	Chemicals	$IF_{s} = \frac{(SA)\ (ABS)\ (ED)\ (EF)}{(BW)\ (AT)}$
External exposure to gamma radiation	Radionuclides	$IF_{g1} = (EF)\ (ED)\ (ET)$ $IF_{g2} = (ED)\ (T_e)\ (1-S_e)$

Notes:

ABS = absorption factor (unitless)
AF = skin adherence factor (unitless) ($cm^2/kg \cdot d$)
AT = averaging time
BW = body weight (kg)
ED = exposure duration (yr)
EF = exposure frequency (d/yr)
IF_{ic} = intake factor for ingestion of dust ($kg/kg \cdot d$ or kg)
IF_{ac} = intake factor for inhalation of dust ($m^3/kg \cdot d$ or m^3)
S_e = gamma shielding factor (unitless)
IF_d = intake factor for dermal absorption from dust ($kg/kg \cdot d$)
IF_s = intake factor dermal contact with contaminated surfaces
IF_{g1} = intake factor for external exposure to gamma radiation (h)
IF_{g2} = intake factor for external exposure to gamma radiation (yr)
IR = ingestion rate (kg/d) or inhalation rate (m^3/d)
SA - skin surface area available for contact (cm^2/d)
T = exposure time (hr/d)
T_e = gamma exposure time factor (hr/hr)

Exposure parameters for the four pathways are provided in Table 3.3. These exposure parameters are used with the previous equations to calculate standard occupational intake factors.

Table 3.3. Exposure values*

Exposure Route	Units	Value
Ingestion		
Ingestion rate (*IR*)	kg·d	5.00E-05
Inhalation		
Inhalation rate (*IR*)	m^3/d	20
Dermal absorption		
Surface area (*SA*)	cm^2	3120
Hands	cm^2	820
Arms	cm^2	2300
Adherence factor (*AF*)	kg/cm^2	1.00E-06
Absorption factor (*ABS*)		
Organics	unitless	0.01
Inorganics	unitless	0.001
External exposure		
Exposure time factor (T_e)	unitless	8/24
Shielding factor (S_e)	unitless	0.2
All exposures		
Exposure time (*ET*)	h/d	8
Exposure frequency (*EF*)	d/year	250
Exposure duration (*ED*)	years	25
Body weight (*BW*)	kg	70
Averaging time (*AT*)		
Carcinogens	d	25550
Noncarcinogens	d	9125

*Exposure parameters are based on occupational values provided by the EPA (1991)

The intake factors derived using these equations are listed in Table 3.4.

Table 3.4. Intake factors

Exposure Pathway	Intake Factor	Units
Ingestion of dust		
Chemical carcinogens	1.75E-07	kg/kg·d
Chemical noncarcinogens	4.89E-07	kg/kg·d
Radionuclides	3.13E-01	kg
Inhalation of dust		
Chemical carcinogens	6.99E-02	m^3/kg·d
Chemical noncarcinogens	1.96E-01	m^3/kg·d
Radionuclides	1.25E+05	m^3
Dermal exposure to organics in dust and on surfaces		
Chemical carcinogens	1.08E-07	kg/kg·d or cm^2/kg·d
Chemical noncarcinogens	3.03E-07	kg/kg·d or cm^2/kg·d

Table 3.4. (continued)

Exposure Pathway	Intake Factor	Units
Dermal exposure to organics in dust and on surfaces		
Chemical carcinogens	1.08E-08	kg/kg·d or cm²/kg·d
Chemical noncarcinogens	3.03E-08	kg/kg·d or cm²/kg·d
External exposure to gamma radiation		
Radionuclides (mrem)	5.00E+04	h
Radionuclides (pCi/g)	6.68E+00	yr

3.3.2.2 Risk Characterization

The following equations are used to calculate potential risks associated with contamination in a D&D facility. This risk characterization is performed for each of the exposure pathways listed above in Table 3.4.

Chemical and Radiological Carcinogens. For each exposure pathway (except external exposure to gamma radiation, which is calculated separately), excess cancer risk, ECR, is calculated as follows:

$$ECR = (C)(IF)(SF)$$

where

ECR = excess cancer (incidence) risk, expressed as a unitless probability
C = concentration in exposure medium (mg/kg, pCi/kg, mg/m^3, pCi/m^3, mg/cm^2)
IF = intake factor (kg/kg·d, kg, m^3/kg·d, m^3, cm^2/kg·d)
SF = slope factor (mg/kg·d)$^{-1}$, pCi^{-1}, or risk·g /pCi·yr (from EPA, current)

Daughter products should be considered for all SF for radionuclides.

External gamma exposures for dose in mrem are calculated as follows:

$$ECR = (DR)(IF_g)(RC)$$

where

ECR = risk of cancer incidence, expressed as a unitless probability
DR = dose equivalent rate (mrem/h)
IF_g = intake factor (h)
RC = cancer risk coefficient (mrem^{-1}) (ICRP, 1991)

The exposure concentration or dose equivalent rate for external gamma exposure is derived from monitoring data from the facility. As discussed in Chapter 2, these measurements will be of varying quality (e.g., laboratory analytical data sufficient to calculate an average exposure concentration, field screening results sufficient to estimate an average concentration, a few screening results sufficient only to report a range, etc.). In all cases, the best available data should be used in the WEI calculation.

For a given pathway through which a receptor is simultaneously exposed to several carcinogens

(both chemical and radiological), the following equation is used to sum the excess cancer risk:

$$ECR_p = ECR_{chem_1} + ECR_{chem_2} + \ldots + ECR_{chem_i}$$

where

ECR_p = total risk of cancer incidence for the particular pathway
$chem_i = i^{th}$ carcinogen

The total risk associated with chemical and radiological carcinogens is determined by summing the risks for all pathways, p, as shown in the following equation:

$$ECR_{total} = ECR_{p_1} + ECR_{p_2} + \ldots + ECR_{p_i}$$

Chemical Noncarcinogens. The hazard quotient, HQ, is calculated for each exposure pathway.

$$HQ = \frac{(C)(IF)}{RfD}$$

where

HQ = hazard quotient (unitless)
C = concentration in exposure medium (mg/kg, mg/m^3, or mg/cm^2)
IF = intake factor (kg/kg·d, kg, m^3/kg·d, m^3, or cm^2/kg·d)
RfD = reference dose (mg/kg·d) (EPA, current)

For a given pathway through which a receptor is simultaneously exposed to several noncarcinogenic chemicals, a hazard index (HI) is calculated as the sum of the HQs for each of these contaminants:

$$HI_p = HQ_{chem_1} + HQ_{chem_2} + \ldots + HQ_{chem_i}$$

where

HQ_i = hazard quotient for the i^{th} toxicant

The total risk associated with noncarcinogenic chemicals is determined by summing the risks for all pathways as shown below:

$$HI_{total} = HI_{p_1} + HI_{p_2} + \ldots + HI_{p_i}$$

In some cases, no monitoring data of any kind will be available. If inventory data are available, exposure concentrations can sometimes be estimated. For example, if it is estimated that 500 kg of mercury are present throughout the structure of the building and assumed to be primarily on unpainted surfaces, and the total unpainted surface area within the building is 2×10^5 cm^2, the assumed exposure concentration on surfaces is 2.5×10^3 mg/cm^2.

If an exposure concentration cannot be estimated for a contaminant, that contaminant cannot be included in the WEI, and the results must note that the WEI is underestimated because all contaminants are not included. The magnitude of the underestimate will depend on the toxicity and

the amount of the contaminant present. If exposure concentrations cannot be estimated for any of the suspected contaminants at the facility, a WEI cannot be calculated.

3.3.2.3 Usage factor

The usage factor is a weighting factor used in estimating worker risks according to the amount of time workers are exposed to potential health hazards. Usage factor is based on the assumption that the worker is exposed a maximum of 8 h/d, 5 d/week, 50 weeks/year, for 25 years. This exposure assumption is designed to provide health-protective estimates of risk for an active facility.

Worker activities at the D&D facilities vary widely. Some facilities (e.g., Building 9201-4 at Y-12 Plant) have full-time workers present while others (e.g., the K-700 Switch House at the K-25 Site) receive only an occasional visit. Therefore, the risk estimates are weighted according to the usage factors shown in Table 3.5:

Table 3.5. Worker activity levels

Level of Activity	Usage Factor
High	1
Medium	0.5
Low	0.1

These usage factors are multiplied by the estimated worker risk to give the weighted risk used in scoring. For further description of usage of a facility, a more detailed description of usage modifiers can be derived for a specific building.

3.3.3 WEI Calculations

The buildings are assigned WEI scores based on their weighted risks. Tables 3.6 and 3.7 are used to score estimated excess cancer risks and hazard quotients:

Table 3.6. Weighted excess cancer risk

Weighted Excess Cancer Risk	Score
$> 10^{-2}$	5
10^{-2} to 10^{-4}	4
10^{-4} to 10^{-6}	3
$< 10^{-6}$	0

Table 3.7. Weighted hazard quotient

Weighted Hazard Index	Score
> 10	5
10 to 1	3
< 1	0

The scores in these tables are based on the EPA (1990b) recommendation that cancer risks below 10^{-6} are negligible, risks between 10^{-6} and 10^{-4} may be acceptable, and risks above 10^{-4} are generally unacceptable. The hazard quotient scoring in Table 3.7 is based on the assumption that an HQ less than 1 is negligible and that any HQ greater than 1 may indicate a problem. The larger the HQ, the more likely that a problem actually exists (i.e., HQs barely greater than 1 may be artifacts of the conservative analysis).

The larger of the two risk scores (i.e., excess cancer risk score or hazard quotient score) is used as the WEI for prioritizing the facility according to current health risks to workers. If it is known or can be assumed that no contamination is present in the facility, the WEI has a value of 0. If no WEI can be calculated because of a lack of data, then no WEI is reported.

The WEI provides a ranking based on current health risks to workers in D&D facilities. The D&D facilities can be ranked in descending order according to their WEI scores. Facilities having the same or similar scores can be grouped together. Facilities with the highest scores will be given first priority for further evaluation of worker risks and possible removal actions.

3.3.4 Uncertainty

The WEI approach groups buildings into various scoring categories based on available data. These data often include gross estimates of contaminant concentrations; therefore, the uncertainties associated with any one WEI score are likely to be large. However, grouping the scored facilities into wide scoring categories generally reduces the overall uncertainty of the ranking system. This numeric scoring method is adequate as a quick, risk-based approach for prioritizing facilities for further evaluation. It does not provide a strict, quantitative estimate of current worker risk.

3.4 FUTURE RELEASE INDEX

Whereas the CRI (Sect. 3.2) and WEI (Sect. 3.3) provide means for prioritizing D&D facilities according to their potential risk to human health and the environment from current contaminant releases, the Future Release Index, FRI, measures the risk from those same D&D facilities according to their potential for future contaminant release.

Both the CRI and FRI consider a D&D facility's current inventory of chemical and/or radioactive contaminants. Both indices are calculated using parameters for the potential risk from contaminant releases as well as the magnitude of the effect these releases might have on human health and the environment. However, the FRI adds an evaluation of the structural integrity of the building and the secondary containment (if any) in which the contaminants are now located. This makes it possible to make a qualitative, risk-based prediction about which D&D facilities are at the

greatest risk of deteriorating some time in the future, to the point at which they can no longer contain or retard the release of their inventory of contaminants.

This evaluation should be performed for D&D facilities that are currently releasing as well as those that are not. Facilities that are currently releasing have presumably already suffered a building or secondary containment breach; therefore, these facilities will receive relatively high FRI scores. This will place such facilities at or near the top of a FRI-based prioritization list.

The FRI is based on a method developed and used to prioritize inactive underground storage tanks at ORNL and on the "Field Evaluation Method (for building integrity)," from the *Natural Phenomena Application Guide*, Safety Analysis Report Update Program (SARUP), CSET-5, 1991. The FRI uses three major scoring criteria: (1) the release potential, RP, of the containment structure (e.g., the facility and equipment); (2) the LS (location score) for the facility; and (3) the TPS (toxic potential score) of the contaminants. The three criteria are scored on a scale of 0 to 5. The FRI is a weighted average in which TPS is given a weighting of 3, RP is assigned a weight of 2, and LS has a weighting of 1. A set of facilities can then be ranked according to their individual scores.

This section provides guidance for calculating the FRI. The LS and TPS are derived and the FRI is calculated.

3.4.1 FRI Scoring Criteria

3.4.1.1 RP (release potential)

The RP is a conservative, qualitative assessment of the likelihood that contaminants will be released from a facility to the environment at some point in the future. Scoring for facility RP is based on the facility's construction, condition, and estimated ability to withstand stresses such as high winds and earth tremors and on the presence and type of any secondary containment for the contaminants.

3.4.1.2 Building location (Location Score)

The location of the facility affects both the likelihood that a human or ecological receptor will be affected by a release and the potential extent of contaminant migration through the environment. The location of the facility will also affect the potential for release resulting from natural disasters; the LS is relatively high if the facility is located on a flood plain, on an earthquake fault, or in an area prone to tropical storms, hurricanes, or other severe weather events. The LS is site-specific and is based on the proximity of the facility to receptors (the site boundary and potentially sensitive ecological habitats) and transport media (groundwater and surface water). Facilities are scored higher if they are located near public receptors (e.g., the site boundary) or near large numbers of site workers (e.g., if there is an active facility with a large concentration of workers nearby). The LS is used to evaluate potential risks to environmental receptors by applying a higher score to facilities located near potentially sensitive or threatened habitats (e.g., surface water or wetlands) or sensitive species (e.g., endangered species living in, feeding at, or migrating through the potentially affected area). The same LS is used for both the CRI and the FRI.

3.4.1.3 TPS (toxic potential score)

Determining the potential risks to human health and the environment from contaminant exposure requires information about the toxicological characteristics of the contaminants being released and the potential magnitude of the release. Two factors are considered in establishing the

TP of the contaminants: (1) the toxicity of contaminants as determined by the RfD for chemicals with systemic effects or the SF for chemical carcinogens and radionuclides and (2) the amount of each contaminant available for release. These factors are combined to yield a single, dimensionless number, the TPS.

3.4.2 Risk Scoring Process

3.4.2.1 Release potential

The potential for contaminant release from a facility depends primarily on the type of containment the facility provides. Contaminants may be contained within the building itself (e.g., a spill on the floor) or in another containment vessel (e.g., a drum or process equipment) within the building. These two types of containment are considered in the Facility Integrity Score (FIS) (Table 3.8) and the Secondary Containment Integrity (SCI) score (Table 3.9).

As a facility deteriorates over time, containment will be lost and contaminants may be released to the environment. Facility deterioration is a function of the type of structure, its current condition, and the forces acting on it.

When contaminants are present in equipment or other secondary containers within a facility, the potential for their release to the environment depends on the integrity of both the facility structure and the container(s). The poorer a facility's structural integrity, the more important secondary containment becomes. The facility SCI is based on the potential that secondary containment will fail.

Table 3.8. Facility Integrity Score

		Facility Condition[3]				
Construction Type[1]	Roof Condition[2]	Excellent	Good	Fair	Poor	Very Poor
Brick/Concrete with similar roof	Good	1	1	2	3	4
	Fair	1	2	3	4	5
	Poor	2	2	3	5	5
Brick/Concrete with wood/shingle roof	Good	1	2	3	4	5
	Fair	1	2	3	4	5
	Poor	2	3	4	5	5
Wood Frame with similar roof	Good	1	2	3	4	5
	Fair	2	3	4	4	5
	Poor	3	3	4	5	5
Metal/Modular/Trailer	Good	2	3	4	4	5
	Fair	3	3	4	5	5
	Poor	3	4	4	5	5

[1]Construction Type - These construction types are representative of structural strengths. If a facility does not fall directly into one of these categories, a category should be selected that best represents the potential strength of the actual structural type.

Table 3.8. (continued)

[3]Roof Condition:	Good - The roof is new (<5 years) and has no visible deterioration. Fair - The roof is older (>5 years) and has visible signs of age. The roof may have minor leaks. Poor - The roof is visibly deteriorated and has been breached in some way (holes, cracks, serious leaks).
[3]Facility Condition:	Excellent - The structure is new (<10 years) and shows no visible deterioration. Good - The structure is older (>10 years) and shows no visible deterioration. Fair - The structure shows the first signs of deterioration. Poor - The structure shows noticeable deterioration with visible cracks or openings. Very Poor - The structure shows advanced deterioration and/or is currently releasing contaminants

This is a conservative parameter, scored for the weakest secondary containment within the facility. The SCI rating is determined from Table 3.9.

Table 3.9. Equipment and storage containment rating

Secondary Containment Integrity	Rating
Very weak	4
Weak	3
Fair	2
Moderate	1
Strong	0

When evaluating the facility SCI, the inspection team should remember that a containment vessel can only be considered as strong as its weakest component. For example, if a piece of equipment is made of heavy steel but has a rubber gasket between two parts, it will fail at the gasket first. Consideration should also be given to such factors as the presence of liners or dyking, and signs of corrosion at valves, joints, welds, etc.

3.4.3 Release Potential Score

The FIS and SCI show which containment factor (facility integrity or secondary containment integrity) is most likely to control a future contaminant release. For example, assume that a contaminant is stored in a drum (weak, SCI = 3) within a concrete building with a concrete roof in excellent condition (FIS = 1). The drum is likely to fail before the building, but the contaminant will remain isolated from the environment until the building fails. Conversely, if a contaminant is contained within a heavy, stainless steel vault (strong, SCI = 0) located in a modular building in fair condition (weak, FIS = 4), the building is likely to fail before the vault, but the contaminant will remain isolated until the vault fails. The interdependence of these two factors is reflected in the RP calculation. However, because the facility is the ultimate contaminant "container," the equation is based on the assumption that facility integrity is the most important containment factor.

The RP is a weighted average of the FIS and the SCI. To reflect the interdependence of facility integrity and secondary containment integrity, two variable weights, x and y, are associated with the FIS and the SCI, respectively. These weights vary inversely with one another from 2 to 0 in increments of 0.5. This variable weighting makes it possible to emphasize the influence the stronger of the two containments (primary or secondary) has on controlling a release. As it is assumed that facility integrity is the most important containment factor, the FIS value controls the selection of weights for x and y. Table 3.10 contains the five FIS ratings and the corresponding weights for x and y to be used in calculating the facility RP.

Table 3.10. Variable weights x and y for calculating the RP

FIS	x	y
1	2.0	0
2	1.5	0.5
3	1.0	1.0
4	0.5	1.5
5	0	2.0

The equation for determining the RP is:

$$RP = \frac{(x)FIS + (y)SCI}{2}$$

Because RP is a conservative, screening-level parameter, non-whole answers should be rounded up to the next whole number.

The following two examples further illustrate the effect of the variable weights: A certain facility is assigned an FIS of 1, from Table 3.25, $x = 2$ and $y = 0$. In this case, the facility is thought to be capable of withstanding an earthquake or high wind; therefore, should a container or piece of equipment inside the building be breached, the building will likely contain the subsequent release [i.e., if the building is strong enough, the strength of the container(s) inside becomes relatively insignificant in controlling a release]. A second facility has an FIS of 2, so $x = 1.5$ and $y = 0.5$. When the RPs from these two examples are compared, the trend in results shows that as a building becomes less capable of withstanding an earthquake or high winds, the integrity of the secondary containment becomes increasingly important in controlling a release.

3.4.4 Risk Scoring Criteria for Location and Toxic Potential

3.4.4.1 LS (location score)

Buildings are scored higher if they are located closer to surface water, groundwater, potentially sensitive ecological receptors, the site boundary, or large populations of workers. It is also important to consider the floodplain (100-year, 500-year, etc.) and earthquake zone in which the facility exists. Buildings farther removed from these considerations are scored lower in the location category. Scoring criteria for each of the three DOE ORR sites are given in Appendix D. Scoring criteria for other DOE installations must be developed on a site-specific basis.

Each scoring criterion is weighted based on its relative importance to the total FRI score. The location category carries a weight of 1. This category is considered the least important because location is only important if a release occurs and if the contaminants released are of sufficient quantity and toxicity to adversely impact potential receptors.

3.4.4.2 TPS (toxic potential score)

The TPSs of the contaminants contained in a facility are scored on the basis of their toxicity and the quantity available for release. The steps necessary to calculate TPS are given in the following text.

DF (Dose Factor). The first step in estimating the TPS is to calculate the DF for each contaminant contained in a facility and capable of being released from the facility. DFs are derived using the RfDs for noncarcinogenic chemicals and SFs for carcinogenic chemicals and radionuclides. Standard default exposure and risk factors issued by the EPA are used to determine dose factor. Standard EPA toxicity values should be obtained from the Biomedical and Environmental Information Analysis Section of the Health Sciences Research Division at ORNL. If standard toxicity values are not available for a particular contaminant, the risk analyst should consult a toxicologist to determine whether:

- the contaminant is potentially toxic at environmental levels, or
- a proxy value similar to an RfD or SF can be estimated by comparison to a similar compound for which an RfD or SF is available.

Contaminants that cannot be scored. If the contaminant is considered nontoxic (e.g., sodium sulfate, magnesium hydroxide), it should be eliminated from the calculation of the CRI. Some nontoxic contaminants may be hazardous due to their reactivity, flammability, etc. These physical hazards will be addressed by the PHI. If the contaminant is toxic and no proxy value can be estimated, it cannot be included in the FRI. The results must then note that the FRI is an underestimate because all toxic contaminants are not included. The magnitude of this underestimate will depend on the amount of the contaminant being released from the facility and its potential toxicity.

DF for noncarcinogenic chemicals. For noncarcinogenic chemicals, the DF is the total amount of a chemical a 70-kg person would take in if exposed to the RfD over a 70-year lifetime. This corresponds to an HI of 1 (EPA, 1991). An example of the calculation of DF is calculated as follows:

$$DF = (RfD)(70\ years)(70\ kg)(365\ d/year)$$

where the oral RfD is expressed in mg/kg·d, reference body weight is 70 kg, average lifetime is 70 years, and a conversion factor of 365 days/year is used. In most cases, the oral toxicity information is most available and represents a basis from which the inhalation values are derived.

DF for nonradioactive carcinogenic chemicals. For nonradioactive carcinogenic chemicals, the DF is the total exposure a 70-kg person would receive in a 70-year lifetime if exposed to a chronic daily intake equivalent to the 10^{-6} lifetime risk level. This DF is calculated as follows:

$$DF = \frac{(10^{-6})(70\ kg)(70\ years)(365\ d/year)}{SF}$$

where DF is expressed in mg, SF is the oral slope factor in $(mg/kg \cdot d)^{-1}$, and a conversion factor of 365 d/year is used. Again, in most cases, the oral toxicity information is most available and represents a basis from which the inhalation values are derived.

DF for radionuclides. For radionuclides, the DF is the total amount of radioactivity a 70-kg person would take in if total exposure over a 70-yr lifetime produced a 10^{-6} lifetime risk level. The following equation should be used to calculate DF for radionuclides:

$$DF = \frac{(10^{-6})}{(SF)}$$

where DF is expressed in pCi and SF is the ingestion slope factor expressed as pCi^{-1}.

TP (Toxic Potential). The TP considers both the toxicity of the contaminant and the total amount of the contaminant available for release from the facility. TP is determined by dividing the total mass (in mg) or activity (in pCi) of a particular contaminant in the facility by its DF:

$$TP = \frac{total\ mass\ (mg)}{DF\ (mg)} \quad \text{or} \quad TP = \frac{total\ activity\ (pCi)}{DF\ (pCi)}$$

TPS (Toxic Potential Score). The TPS scoring system used in calculating the FRI is shown in Table 3.11 Facilities are assigned a TPS for future releases between 1 and 5 based on their TPs. This index was developed based on the toxic indices calculated for inactive storage tanks at ORNL (Chidambariah et al. 1984).

Table 3.11. Toxic potential score

Facility TP	Toxic Potential Score (TPS)
$>10^{10}$	5
10^{10} to 10^{8}	4
10^{8} to 10^{6}	3
10^{6} to 10^{4}	2
$<10^{4}$	1
0[a]	0

[a]If no contamination is present in the facility, a TPS of 0 is assigned

This ranking will be re-evaluated and modified as necessary after TPs are calculated for the D&D Program facilities.

3.4.5 Calculating the FRI

The FRI for a facility is calculated from its RP, LS, and TPS as shown below:

$$FRI = \frac{(LS) + (2)(RP) + (3)(TPS)}{6}$$

Each scoring criterion for the FRI is weighted based on its relative importance to the total score. Building location is considered the least important parameter of the CRI. Location is only important if the contaminants released are of sufficient quantity and toxicity to adversely affect potential receptors. Therefore, LS is assigned a weight of 1. The TPS category carries a weight of 3. It is considered the most important parameter because the release of a relatively toxic material or relatively large quantity of material is of more concern than the release of a less toxic material, even one close to potential receptors or transport media. RP receives a weight of 2 because of the importance of structural integrity and containment in controlling a release.

The scored D&D facilities may be ranked in descending order based on FRI score. Facilities having the same or similar scores can be grouped together. Those with the highest scores will generally be given first priority for further evaluation.

3.4.6 Uncertainties Analysis

The FRI approach groups D&D facilities into various scoring categories based on available data. These data often include gross estimates of contaminant inventories; therefore, the uncertainties associated with any one value may be large. However, grouping the buildings into wide scoring categories generally reduces the overall uncertainty of the ranking system. This numeric scoring method is adequate as a quick, risk-based approach for prioritizing facilities for further evaluation. It does not provide a strict, quantitative estimate of future risk given the condition and inventory within the building.

3.5 PHYSICAL HAZARD INDEX

The D&D facilities may present risks not associated with contamination. As buildings deteriorate, physical hazards may pose a greater threat to the public (may include visitors or subcontractors) and worker safety than contaminant exposures. The PHI is designed to prioritize facilities based on these actual or potential physical dangers. The methodology for the PHI is derived in part from concepts presented in the *Risk Management Study for the Retired Hanford Site Facilities* (Coles et al, 1993). The PHI is based on an assessment of near-term (immediate to 5 years) and long-term (beyond 5 years) hazards gathered in walk-through inspections of D&D facilities. A set of D&D facilities can then be ranked in descending order according to PHI. Facilities with the highest scores are generally given first priority for further evaluation and possible corrective actions.

3.5.1 PHI Scoring Criteria

Existing and potential physical hazards are identified during a facility walk-through; documented in the Findings Report (Appendix C) according to consequence, likelihood, and hazard; and assigned hazard scores that are then used to derive the PHI.

3.5.2 Scoring Process and Index Calculations

The walk-through is performed by a team representing four professional disciplines: risk analysis, structural analysis, electrical engineering, and industrial hygiene. The findings of the walk-through are documented in the Findings Report provided in Appendix C and should be supported by photographs.

For each finding in a facility, the team completes the consequence and likelihood categories in the report's hazard assessment table (Exhibit C.1 in Appendix C). The total potential accident risks for a finding are calculated and summed to determine the finding's hazard score, PH. This score is a product of the seriousness and probability that the accident will occur. After the PHs (both near- and long-term) have been calculated for all physical hazard findings in a facility, they are averaged to provide the facility's total physical hazard score, PH_T:

$$PH_T = \frac{PH_1 + PH_2 + \ldots PH_i}{i}$$

where I is the i^{th} finding and PH_i is its physical hazard score.

The PH_T is assigned a PHI score from Table 3.12.

Table 3.12. Risk scores for selecting PHI

Hazard Category	Total Physical Hazard Score (PH_T)	Physical Hazard Index (PHI)
Critical	10^{-1} to 1	5
Serious	10^{-2} to 10^{-1}	4
Moderate	10^{-3} to 10^{-2}	3
Minor	10^{-5} to 10^{-3}	2
Negligible	$< 10^{-5}$	1

Facilities with a PHI of 5 pose a critical physical hazard risk and require immediate attention to reduce either the severity or likelihood of an accident. A PHI of 4 indicates that a facility poses a serious risk that may require immediate attention. PHIs of 3 to 1 indicate that the risk from physical hazards may be acceptable. However, facilities with PHIs very close to 3 may require closer evaluation to ensure that no unacceptable risks exist.

3.5.3 Uncertainty

The PHI approach groups buildings into five scoring categories based on facility inspections and professional judgment. The uncertainties associated with any one value are likely to be large; however, grouping buildings into wide scoring categories generally reduces the overall uncertainty of the ranking system. This numeric scoring method is adequate as a quick, risk-based approach to prioritize facilities for further evaluation. It does not provide a strict, quantitative estimate of risk from physical hazards.

3.6 CRITICALITY

The risks from criticality incidents will generally be greater than risks from other exposures at a facility. However, the potential for a criticality event is small or nonexistent at many buildings. Therefore, potential criticality will be treated as a modifying factor to the SRE. Presence of a criticality problem would immediately be covered by DOE Order 5480.5 and 5480.24 and would be addressed.

The modifying factor for criticality is based on two criteria: (1) the potential that an event will occur and (2) the magnitude of the potential exposure. Potential criticality is ranked high, medium, low, or nonexistent. The magnitude of potential exposure is ranked according to the location of the facility and the number of people potentially exposed, as shown in Table 3.13. This is a graduated scale with the highest ranking assigned for potential exposures to individuals off the ORR and the lowest assigned for potential exposures only to people inside the building.

Table 3.13. Ranking criteria for criticality events

Potential for Criticality Event	Magnitude of Potential Exposures		
High	Offsite exposures (5)	Exposures to DOE personnel (4)	Exposures within building (3)
Medium	Offsite exposures (4)	Exposures to DOE personnel (3)	Exposures within building (2)
Low	Offsite exposures (3)	Exposures to DOE personnel (2)	Exposures within building (1)
Nonexistent	NA (0)	NA (0)	NA (0)

3.7 REPORTING RESULTS

The SRE results must be presented in a concise and understandable manner. The results section of the SRE report should be arranged so that all information supporting the screening risk scores, combined with the scores themselves, can be taken into consideration for decision-making. The application of the SRE indices in decision-making is described in Chapter 4 of this guidance.

The calculations for each index should be presented in both text that describes all assumptions, data sources, and uncertainties, and tables that summarize the calculations. An example of an index calculation table is provided in Exhibit 3.1.

The results of the SRE should also be presented in both text and a table summarizing the index scores, data and assumptions used, and uncertainties. The SRE report must include:

- the calculations used for each index,
- the numeric values used in the calculations,
- all important data sources (e.g., type of contaminant data used) [in some cases, the data will include assumptions to be used in place of missing data (e.g., proxy toxicity values); this must be indicated in the report and table],
- all assumptions that significantly affect the uncertainty of the index,
- the index score,
- the uncertainty associated with each index [this must include an estimate of both the potential magnitude of the uncertainty (low, moderate, or high, as defined below in Table 3.14) and the direction (e.g., over- or underestimation of the index); some rationale for the estimate should also be provided].

Table 3.14. Uncertainty levels for SRE indices

Uncertainty Level	Definition
High	Uncertainty is great enough to limit the usefulness of this result in decision-making.
Moderate	Does not significantly affect decision-making. Moderate uncertainty is usually acceptable if buildings are grouped into broad scoring categories for prioritization (rather than placing emphasis on each facility's individual index scores).
Low	Result is reliable enough that uncertainty will not affect decision-making.

An outline of the SRE report is provided in Chapter 5 of this guidance document. An example SRE results table is shown in Exhibit 3.2.

Intermediate Calculation	Result	Inputs	Data Source
Noncarcinogen Dose Factor (DF) DF = (RfD)(1)(70kg)(365d/yr)	Mercury DF = 7.67 mg/yr Toluene DF = 5110mg/yr	Mercury RfD = 3.00E-04 mg/kg-day Toluene RfD = 2.00E-01mg/kg-day	IRIS
Radionuclide Dose Factor (DF) DF = 10^{-6}/(SF)(70yrs)	U^{235} DF = 892.86 pCi/yr	$^{235+D}U$ SF= 1.6E-11 risk/pCi	IRIS
Release Rate (rr) rr = Q/t	Mercury rr = 2.0E06 mg/yr Toluene rr = 1.0E05 mg/yr U^{235} rr = 5.0E3 pCi/yr	Mercury Q = 2.0E06 mg/yr: t = 1 yr Toluene Q= 1.0E05 mg/yr: t = 1 yr U^{235} = 5.0E4 pCi/yr: t = 10 yrs	Assumptions from worker interviews
Toxic Release Potential (TRP) TRP = rr/DF	Mercury TRP = 2.6E05 Toluene TRP = 19.6 U^{235} TRP = 5.6	Intermediates from equations above	NA
Noncarcinogen Total TRP (TRP_{nc}) $TRP_{nc} = TRP_1+TRP_2+...TRP_i$	TRP_{nc}= 2.6E05	Intermediates from equations above	NA
Radionuclide Total TRP (TRP_r) $TRP_r = TRP_1+TRP_2+...TRP_i$	TRP_r = 5.6	Intermediates from equations above	NA
Toxic Potential Score (TPS)	TPS = 5	Highest total TRP	Table 3.1
Location Score (LS)	LS = 2	None	Appendix B
Current Release Index (CRI) CRI = [(1)(LS)+(3)(TPS)]/4	CRI = 4.25	Intermediates from equations above	NA

Exhibit 3.1. Example calculation table for the CRI for a facility releasing mercury, toluene, and uranium-235.

Index	Result	Data	Assumptions	Uncertainty
CRI	0	No release data.	No contaminants are currently being released.	Low; location of contaminant and historic information indicate no current release.
WEI	NC[a]	No concentration data available.	NA[b]	NA
FRI	2	Radiological survey data from 1 room.	Available data extrapolated to entire building.	Moderate; index may be overestimated because the rest of the building is likely to be less contaminated than the 1 room surveyed.
PHI	3	Walk-through observations.	All hazards were identified during the walk-through. Material in storage is flammable.	Moderate; index may be overestimated if material is not flammable as assumed, or underestimated if hazards went unnoticed during the walk-through.
Criticality	0	Historical use information.	The facility has never contained fissionable material.	Low; both historical information and current observations indicate no risk.

[a] NC = not calculated because of insufficient data
[b] NA = not applicable

Exhibit 3.2. Example results table for the SRE.

4. APPLICATION OF THE SRE

The purpose of this section is to provide guidance for the application of SRE results to decision-making at D&D facilities. SRE applications include prioritization of facilities for future actions, selection of reuse options, determination of S&M requirements, determination of further characterization requirements, and input to larger decision models. The number and types of conclusions drawn from the SRE will depend upon the needs of the program or project (i.e., the facility-specific objectives of the SRE) and the availability of data to complete the SRE. As the quality of the data set improves, the number of conclusions that can be drawn and confidence in those conclusions will generally increase. Because decision drivers and considerations differ for every project, D&D facility goals and strategies must be first determined to begin the recommendation process for any decisions other than that of early action.

All conclusions and recommendations made in the SRE are based only on risk. Other factors such as cost, regulatory drivers, public perception, etc., must be considered in making final decisions. In general, nonrisk decision drivers will play a larger role where strong risk-based recommendations cannot be made (e.g., an index of 3, or extremely uncertain data).

Risk based recommendations can be made based on a single SRE index (e.g., the FRI) or on a combination of indices. Potential uses of each index are described in Subsect 4.1. Applications using multiple indices are described in Subsect. 4.2. Program-, project-, or facility-specific objectives may result in additional applications. An understanding of the individual indices (Subsect. 4.1) will allow the risk analyst to combine these indices (and their supporting data) to fulfill specific decision needs.

4.1 APPLICATION OF SRE INDICES

Each of the four SRE indices and criticality provides a different type of information important for determining future actions. The following subsections provide guidance on how each index can be used.

4.1.1 Current Release Index

The CRI provides an indication of whether or not a facility is currently releasing contaminants to the environment and the magnitude of the potential risk associated with this release. The CRI does take into account the susceptibility of contaminant exposure to human health and ecological receptors (i.e., the location score, LS) and may range from 0 to 5. A CRI of 0 indicates no current release or risk; a CRI of 5 indicates a current release with potentially high human and/or ecological risks. No CRI is assigned if a current release is known or suspected but cannot be quantified with existing data. The CRI and associated data are useful in determining the need for immediate or early remedial actions and the need for further investigation. These recommendations are described in more detail in the following text.

Early Action. A high CRI may result in a recommendation for early action to mitigate the release. How high the CRI must be to warrant early action will depend upon the situation at the facility. For example, while a CRI of 4 or 5 will generally result in a recommendation for early action, a value of 2 or 3 will require more scrutiny (e.g., are there known current receptors?, are the contaminants highly mobile?, etc.). The uncertainty in the data will also affect the recommendation.

A facility may have a relatively low CRI (e.g., a 2), but due to high uncertainty in the data used to calculate the CRI, it could actually be anywhere between 1 and 4; therefore, early action or further investigation may be recommended. In this last example, other (nonrisk) decision drivers may play a large role. For example, early action may be selected over further investigation if the action needed to mitigate the release is inexpensive.

The data used in calculating the CRI will assist in determining the type of action required. For example, the location of the contaminants being released may target the removal or the mode of release may be corrected (e.g., cracks in a floor that can be sealed).

Further Investigation. Further investigation may be recommended if no CRI can be calculated due to lack of data. Further investigation may also be recommended if a CRI has been calculated but there is very large uncertainty in the data. The consequences of a poor recommendation for or against action must be considered in the decision for further investigation. For example, if a low CRI has been calculated but large uncertainty in the data indicates that this number may actually be much higher, a recommendation of further investigation may be prudent.

4.1.2 Worker Exposure Index

The WEI provides a measure of the potential risk to workers currently exposed to contamination within the facility. The WEI may range from 0 to 5 or none. A WEI of 0 indicates no current risk due to lack of contamination or lack of receptors; a WEI of 5 indicates potentially high risks to workers. No WEI is assigned if contamination is known or suspected in the facility but exposures cannot be quantified with existing data.

The WEI is similar to the CRI in that it provides an estimate of current risk. Like the CRI, the WEI is useful in determining the need for immediate or early remedial actions and the need for further investigation. The WEI may also be used to recommend the use of personal protective equipment, exclusion zones, or other safety measures by workers in the facility. The data used in calculating the WEI will assist in determining the type and location of remedial actions and/or additional sampling.

4.1.3 Future Release Index

The FRI provides an indication of the potential for and the magnitude of future contaminant releases from a facility and the potential risk associated with these releases. The FRI may range from 0 to 5. An FRI of 0 indicates no potential for release or risk; an FRI of 5 indicates a potentially large release and/or potentially high human or ecological risks associated with the release. No FRI is assigned if a release is possible but cannot be quantified with existing data.

The FRI and associated data are useful in determining the need for remedial actions, the potential time frame for these actions, and the need for further investigation. The need for remedial action is indicated by a high FRI. The data supporting this index may be used to determine the time frame for action. For example, two facilities may have the same high FRI (FRI=4). One facility may have a high FRI because it has a large quantity of very toxic contaminants with a strong containment system. In this case, remediation may be delayed because the potential for a release in the near future is low (even though the risk associated with that release is high). Conversely, another facility may

have a smaller volume of less toxic contaminants but the same FRI because the containment system is in imminent danger of being breached. Remediation in the near-term may be appropriate in the latter case due to the potential for loss of containment.

4.1.4 Physical Hazard Index

The PHI provides an indication of the potential for, and magnitude of, current or future physical hazards (e.g., tripping, falling materials) associated with conditions at the facility. The PHI may range from 0 to 5. A PHI of 0 indicates no current or future hazards exist at the facility; a PHI of 5 indicates a large current or future hazard. A PHI will be estimated for every facility.

The PHI and associated data are useful in determining the need for correction of hazards or exclusion of workers from certain areas and the potential time frame for these actions.

4.1.5 Criticality

Criticality is scored based on the potential that a criticality event could occur and the magnitude of potential exposure associated with such an event. The criticality score may range from 0 (no fissile material present) to 5 (high potential for event with off-site exposures). DOE orders 5480.5 and 5480.24 require that any situation which could result in a criticality be mitigated. Therefore, if the criticality value is greater than 0, appropriate personnel must be notified and immediate action taken.

4.2 APPLICATION OF SRE TO SUPPORT DECISION MAKING

The four SRE indices (and criticality) and the supporting data can be used in combination to fulfill a large variety of project needs. SRE applications are described in the following subsections. Not all applications will be appropriate for all SREs. This is true for two reasons: (1) data gaps may make some applications impossible and (2) the facility-specific objectives of the SRE will drive the recommendations. Facility-specific objectives may also result in additional applications.

4.2.1 SRE as a prioritization tool

The results of the SRE may be used as a tool for prioritizing facilities for the allocation of resources. As mentioned previously, this SRE method can be applied to transition facilities (EM-60) as well. Each of the individual SRE indices may be used to prioritize facilities based on a single aspect of risk. For example, the PHI provides a ranking of facilities based on potential physical hazards and the need for structural upgrades. The indices may also be combined to produce a total risk score for use in prioritization. The method of combining the individual indices is dependent upon the needs of the project (i.e., the reason for the prioritization of facilities). Calculation of total risk scores for prioritization based on two common objectives (time critical actions and future work) are detailed in the following text. The risk scoring coefficients provided in these equations are specifically designed to meet one objective (i.e., early action or future actions). If the Total Risk score is to be used for other decisions, coefficients must be altered appropriately. Coefficients are assigned for a group of facilities to prioritize actions within the group. Coefficients are not modified for individual facilities.

Early Actions. Facilities may be ranked based on their time dependent need for action. The objective of this ranking is to determine which facilities should be dealt with first to minimize potential risks. A total risk score for this ranking is calculated as shown:

$$\text{Total Risk} = 10(\text{CRI}) + 10(\text{WEI}) + 1(\text{FRI}) + 5(\text{PHI})$$

This Total Risk score is designed to give a higher ranking if there is a possibility of a current release of contaminants or a worker exposure problem. These are two of the three most important early actions that may need to be dealt with on an immediate basis to ensure general safety (the third being criticality). Physical hazards hold a lesser degree of importance in considering early actions because a physical hazard may often be dealt with by avoiding the hazard until the situation is resolved. The final index factored into Total Risk is that of future release. The FRI is included in this total score because it provides an indication of the magnitude of potential releases, if nothing is done, and the time frame of the potential release (i.e., a higher score may indicate a potential release in the near future due to poor containment). The FRI has the smallest weighting factor because it reflects potential future risks, and this total risk score is designed to give priority to those facilities which should be addressed for early action.

Criticality is not included in this equation because there is no leeway for decision-making where a criticality risk is involved. If the potential for a criticality exists at a facility, it must be addressed immediately. The facility may then be ranked for further actions based on its other four risk scores.

Future Actions. The prioritization of facilities based on their need for future action is based on a total risk score calculated as shown:

$$\text{Total Risk} = 3(\text{FRI}) + 1(\text{CRI})$$

The objective of this ranking is to give priority to those sites likely to present the greatest future risk. This ranking is based on two factors: the potential magnitude of a release and associated risk and the likelihood of the release or how soon the release may occur since all contaminants will be released eventually if given enough time. The FRI is weighted heavily since it reflects both the magnitude of the potential release (inventory) and the likelihood of a release (integrity of the containment structure). The CRI is included in the equation since facilities currently releasing contaminants are more likely to also be releasing them in the near future.

4.2.2 Selection of Early Action

Early actions can take place at D&D facilities for a number of different reasons. The decision for early action may be based on risk (i.e., the facility poses an imminent risk to human populations or the environment), but many decisions for early action will be based on other considerations. For example, if a small area of contamination exists in an otherwise clean facility, early remediation of this area may allow the facility to be transferred out of the ER Program. Early actions may include a quick cleanup of minimal contamination, a time-critical removal indicated by a hazardous or emergency situation, or mitigation of a potential criticality. After early action is complete, the facility may be removed from or downgraded on the priority list, remain on continued S&M, transferred out of the ER Program, or undergo other decision options. A total risk score may be calculated to rank facilities based on their need for early action. This prioritization is based solely on risk and does not take other decision drivers into account. If the risk scores, in conjunction with supporting data,

indicate a minor, contained, or isolated contamination problem or physical hazard problem, then early actions may be recommended for the purposes of removing the immediate problem and allowing the otherwise "clean" and "safe" facility to be downgraded or removed from the list. After an early action takes place, it is important that the corrected data (reflecting the early action) be re-entered into the entire SRE process and evaluated again. The new risk scores can be used to make additional recommendations.

When determining early actions based on Total Risk, it is important to remember that even a moderate or low score may indicate a problem when viewed with all supporting data. The majority of Total Risk scores, as a bell-curve might indicate, should fall within the middle, mean range. When Total Risk scores fall into this middle category, supporting data and other decision drivers play a much larger role in making recommendations.

4.2.3 Facility Reuse Screening

One alternative for many D&D facilities is reuse of the facility for another purpose. Implementation of this alternative may be as simple as re-assigning the facility to a new program, or some cleanup, repair, and/or upgrading may be necessary. The results of the SRE may be used to decide whether or not reuse is feasible and what types of remediation and/or repairs are required for reuse to occur.

Recommendations regarding facility reuse should be made in two steps: (1) is any reuse practical and (2) what type of upgrades or restrictions may be necessary. The decision of whether or not reuse is practical is based primarily on the WEI and PHI. If either of these scores is very high, reuse is less likely to be a practical option. Recommendations for upgrades or restrictions must come from an evaluation of the data supporting the WEI, PHI, and FRI.

The WEI and PHI will be critical in reuse decisions. The WEI will provide information regarding possible risks to future workers at the facility based on current exposures. A high or moderate WEI generally indicates that some type of remediation must occur before the facility can be assigned to any use requiring routine worker exposure. A facility with a moderate WEI may be suitable for some uses, such as storage, where workers will only enter the facility occasionally. There will generally be little or no restriction on reuse of a facility with a low or 0 WEI. The risk analyst must look at the components of the WEI as well as the index itself when making recommendations. The WEI is a measure of current worker risk based on contaminant concentration and toxicity and a usage factor to account for worker activity at the facility. A contaminated facility may have a low WEI if there is very little worker activity. Reuse of this facility may be inappropriate if worker activity levels will significantly increase with the new use.

The PHI will provide information regarding possible physical hazards to future workers at the facility. A PHI above 0 generally indicates that some type of repair or upgrade must occur before the facility can be put into use. Facilities with low PHIs may require only minor repairs; as the PHI increases, generally so will the magnitude and/or number of required repairs. Again the risk analyst must review the components of the index in making recommendations. A facility may have a high PHI due to a very hazardous situation which is easy to correct or due to structural problems which make the facility too expensive to repair.

The risk analyst should also consider the FRI when making reuse recommendations. A facility with a high FRI may be useable for a while, but the potential for contaminant release in and around the facility may discourage long-term use.

Recommendations for reuse should take the following form:

- The facility cannot be reused due to extensive contamination and/or structural damage.
- The facility may be reused following remediation and/or repairs. This recommendation should include a description of the type of remediation and/or repairs required. The decision of whether or not to reuse the facility will then depend on factors such as cost of cleanup or repair and the availability of other facilities for the desired use.
- The facility may be released for limited reuse, e.g., as a storage facility with limited worker activity, or a portion of the facility must be restricted.
- The facility may be freely released for reuse.

4.2.4 Selection of D&D Project Pathways

The D&D strategy is designed to provide the necessary risk characterization information in the most cost- and time-efficient manner possible. This is accomplished by providing a choice of how rigorous a characterization is performed. A facility may require an SRE only or move on to a Level 3 (least rigorous), Level 2, or Level 1 (most rigorous) BRA. A DARA may also be performed at three levels of effort. The decision of how rigorous the characterization of a site should be is dependent upon the complexity and magnitude of the contamination at the facility.

Contamination problems at D&D facilities can range form very simple (a drum of hazardous waste on a loading dock) to very complex (chemicals and radionuclides embedded in structural material and equipment). Generally, as the complexity increases, the level of effort required to understand the problem and determine a solution will also increase. The magnitude of the contamination problems refers simply to the volume and toxicity of contaminants present. Facilities with little contamination or with relatively nontoxic materials will generally require less study to determine a solution than facilities with large quantities of highly toxic material. Magnitude and complexity generally go hand-in-hand; as the magnitude of contamination increases, the complexity will often also increase.

The magnitude of contamination may be evaluated from the FRI. This index is heavily dependent upon the volume and toxicity of contamination present. Supporting data for the FRI and WEI may be used to evaluate the complexity of the contamination (e.g., where and in what form is the contamination present?).

Other factors that will influence the selection of project pathways are the number and type of solutions or alternatives being considered, public or DOE pressure for characterization of a high profile site, and the need for risk communication and documentation.

Recommendations for the selection of project pathways in the SRE will be based on the magnitude and complexity of contamination. Types of recommendations that may result from the SRE include:

- Adequate data are available to conclude that the facility is clean and no further study is required (CRI, WEI, and FRI are 0 or very low). Characterization may stop with the SRE.

- The facility appears clean (CRI, WEI, and FRI are 0 or very low) based on limited data. Additional characterization should be performed to confirm this conclusion. The site may progress to a Level 3 BRA with some additional sampling to fill data gaps. If this additional sampling uncovers further contamination, the site may progress to a Level 2 or Level 1 BRA.

- The facility has limited contamination (low to moderate FRI, WEI, and/or CRI) and should proceed to a Level 3 or Level 2 BRE.

- The facility is highly contaminated (FRI, WEI, and/or CRI are high) and/or complex and requires a Level 1 BRA.

- Adequate data are not available to draw conclusions about the facility. Additional sampling and a Level 3 BRA should be performed before any decisions can be drawn.

4.2.5 S&M Requirements

The results of the SRE may be used to evaluate the efficacy of current S&M activities and determine future S&M requirements. S&M activities fall into two categories: routine and enhanced. Routine S&M activities are the regular daily, weekly, monthly, etc., actions taken to monitor conditions at the site and prevent building decay (e.g., routine servicing of sump pumps). Enhanced S&M activities are additional (nonroutine) activities performed to correct a specific problem (e.g., replace a roof). Guidelines for the use of each of the SRE indices for evaluation of S&M needs are provided in the following paragraphs:

CRI—The results of the CRI provide an indication of whether or not a potentially significant release is occurring. If a release is occurring and causing potentially significant risks, this release may be mitigated through a change in S&M practices. A review of the supporting data (e.g., where and how is the release occurring) may provide a solution. For example, if a release is occurring because water is entering a leaky roof and carrying contaminants with it as it exits the facility, repair of the roof may stop the release.

WEI—The WEI may be very important in making S&M recommendations because it provides an indication of potential risks to S&M workers. If the WEI is high, the project manager may wish to seriously evaluate the necessity for S&M activities which may put workers at risk. The WEI may also result in recommendations for additional (or continued) monitoring of contaminant concentrations in high risk areas.

FRI—The results of the FRI provide an indication of whether or not a potentially significant release may occur. If a significant release is likely, this release may be prevented through a change in S&M practices. A review of the supporting data (e.g., where and how is the release expected to occur) may provide a solution. For example, if a release may occur if the roof collapses, maintenance of the roof

integrity may be a critical S&M activity. The FRI may also identify on-going or planned S&M activities that are not necessary. For example, current project plans may call for repairing the roof at a facility. However, if the results of the FRI indicate that potential contaminant release is not a problem (i.e., the roof can fail without causing a significant release) this repair may not be necessary.

PHI—The PHI is critical in determining S&M needs for maintaining safe conditions within the facility. If the PHI is nonzero, the risk analyst must review the supporting data to determine the types of corrective actions needed to eliminate hazards and the time frame for these actions (i.e., current vs. future hazards).

Steps for evaluating routing and enhanced S&M needs are described as follows:

Routine S&M—The evaluation of routine S&M requirements has two stages. First, the current S&M program should be reviewed. Each component of the current program should be evaluated based on the results of the SRE to determine whether or not it provides risk-reduction. For example, the current S&M program may include routine monitoring of radiation levels in a facility. If the WEI is 0 or very low and the FRI is moderate due to a potential release of radioactive release from the storage area, the rest of the facility does not need to be monitored. The result of this step will be to eliminate or modify any S&M activities not directly responsible for reducing risks at the facility. The objective of the second step in the evaluation is to identify any deficiencies in the program. The risk analyst should look at each of the nonzero indices and determine what risks may be reduced through application of routine S&M. The risk analyst will not be able to make specific recommendations for S&M activities but can point out areas that require action.

Enhanced S&M—The evaluation of enhanced S&M requirements follows the same two steps as those given in the previous paragraph. First, any planned activities must be evaluated to determine if they will reduce the risks identified by the SRE. Second, all nonzero results of the SRE must be evaluated to determine if risks can be reduced by an enhanced S&M action.

The results of the S&M evaluation will be a list of planned routine and enhanced S&M activities which may not be necessary to mitigate risks and a list of potential problems which are not addressed by the current S&M program.

4.2.6 Role of SRE in Fulfilling Site Characterization Requirements

The SRE can be part of a larger strategy as described in Chapter 1 of this document. However, in many cases the SRE may provide sufficient risk characterization information for the facility, and a BRA or other characterization efforts will not be necessary. This will generally be the case for facilities with limited contamination or with contamination that can be easily and effectively removed as part of an early action.

The decision of whether or not a BRA is needed is based on the complexity of the problem at the facility and the ability of the SRE to meet the needs of the decision makers at the site. Specific questions that can often be answered by the SRE alone include:

- Does the facility pose a risk to human health or the environment due to the presence of contamination?

- Does the facility represent a safety hazard?
- Is the facility a candidate for early action?
- What early action should be taken?

If the SRE is adequate to answer these questions with some certainty (i.e., there are sufficient data) and if the answer to question #1 is no or the contamination can be completely eliminated through early action, then a BRA may not be necessary for the facility. The process for making this decision is illustrated in Fig. 4.1. It must be noted that the decision not to proceed beyond the SRE can only be made if sufficient data are available. Sufficient data may not be available for the following reasons:

- One or more indices could not be calculated due to lack of data (e.g., there is evidence of contamination in a building but no way to estimate the inventory, exposure concentration, or release rate). In this scenario, three of the indices cannot be calculated, and the facility should move straight into a BRE to determine the contaminant concentrations and inventory.
- All indices have been calculated, but there is a high degree of uncertainty due to gaps in the data (e.g., the WEI is based on contaminant concentrations in only 1 room of a 10-room facility because no data exist for the other rooms).

The SRE may also be used to fulfill characterization needs outside the D&D strategy. For example, the SRE may meet the objectives of a PA/SI for many facilities. The objectives of a PA/SI are to determine the need for future investigation and/or remediation and to establish the priority for future work at the site. These objectives overlap with those of the SRE. The SRE will fulfill many of the requirements of a PA/SI and in some cases may satisfy all the requirements of a PA/SI. In all cases, the SRE will greatly simplify the PA/SI process. The components of a PA/SI and the ability of the SRE to fulfill the objectives of a PA/SI are discussed in the following paragraphs.

Preliminary Assessment (PA). The objective of a PA is to evaluate the need to conduct an SI and determine the sampling and analysis requirements if an SI is needed. A PA is based on existing data, site knowledge, and an evaluation of potential risk to on-site and off-site receptors. A PA should result in one or more of the following recommendations:

- no further investigation required (NFIR),
- obvious contaminant release to be characterized in an RI,
- an emergency removal action, or
- a non-time critical removal action.

A determination of NFIR is appropriate if the site has never received hazardous materials or the site is clearly not releasing and has no potential to release hazardous materials into the environment.

The PA, as is the SRE, is designed to evaluate the potential for risk based on existing data. The SRE will meet the objectives and fulfill the intent of the PA. This will eliminate the need for a PA

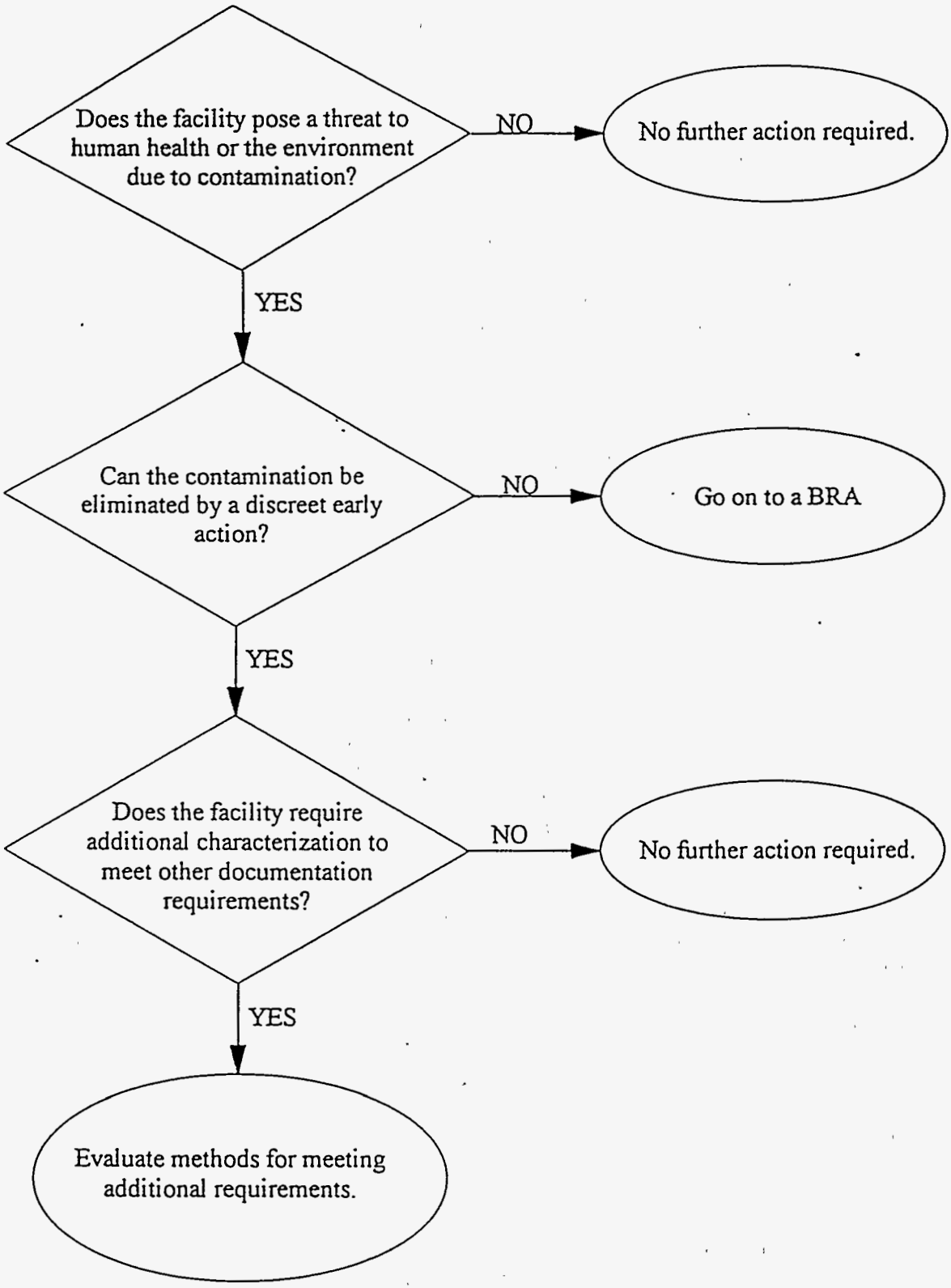

Fig. 4.1. Decision process for additional risk characterization.

at many facilities. If a Federal Facilities Agreement (FFA) or other regulatory order requires the submission of a formal PA report for a site, the SRE may not meet this documentation requirement. However, the SRE will include most of the information required for the PA report; therefore, the production of the PA report will be greatly simplified.

Site Investigation. The need for an SI is determined from the results of the PA; therefore, it will not be required at every site. An SI is not required if the PA results in a determination of NFIR or a determination that an RI is necessary. The objective of an SI is to gather additional data and evaluate the need for further investigation, immediate action, or an RI if such data were determined to be lacking in the PA. The facility walk-through is the only source of additional data that will be collected for the SRE. The SRE will fulfill the objective of the SI if the facility walk-through included in the SRE provides the data needed to make the appropriate recommendations for future action. If appropriate recommendations cannot be made from the existing data and the facility walk-through, an SI may necessary.

4.2.7 Delineation of Facility Groups

The results of the SRE may be used to identify facilities which can be logically grouped together for future action. Grouping facilities based on the types of future actions required can reduce the cost and time required for these actions by reducing redundant actions and taking advantage of the economies of scale. For example, it may be possible to treat a group of facilities with similar action and/or documentation requirements (e.g., no further action required) as a unit (similar to a CERCLA operable unit) and produce a single document for the group. Time and money can be saved by producing a single document for several facilities.

Facilities may be grouped based on similar risks (e.g., all facilities with a high WEI) or on similar actions (e.g., no further action, removal actions). The grouping of facilities may be accomplished in either of two ways depending on the needs of the program. The program or project manager may already have a desired grouping in mind (e.g., all facilities which require no further action or all facilities which require additional sampling and a BRA). The risk analyst can then select these facilities from the results of their SREs. Alternatively, the risk analyst may look at the results o f the SREs for a number of facilities to find common factors for grouping these facilities and make recommendations to the program manager.

4.2.8 Identification of Data Needs

The SRE will be extremely useful in identifying future data needs for the facility. Future data needs are based on two interdependent factors: risk characterization requirements of the facility and existing data. If adequate data exist to complete the SRE with an acceptable level of uncertainty and no additional risk characterization is required, then no additional data must be collected. If little data exist and a Level 1 BRA is to be conducted, then a great deal of additional data may be required. Most facilities will fall somewhere between these two extremes.

The SRE can be used to identify two types of data needs:

- Data gaps identified during the data evaluation generally must be filled. If assumptions or default values were used to fill these gaps in the SRE, the risk analyst must decide whether additional data are required or whether these assumptions are adequate.

- Data with high uncertainty may be confirmed or supplemented. For example, if data are very old or if only a few samples exist for a large area, the risk analyst may recommend that additional samples be taken to confirm that conditions have not changed or to supplement a sparse data set.

Recommendations for additional data gathering will depend on the level of effort required for risk characterization at the site. If decisions have not been made regarding future characterization, the recommendations will be more general than if the next step is known. The results of the SRE will be an important tool in scoping future characterization efforts.

5. DOCUMENTATION OF THE SRE

This section provides guidance for the documentation of the SRE. The EPA (1989) recommends three basic principles for documenting a risk assessment: "(1) address the main objectives of the [evaluation]; (2) communicate using clear, concise, and relevant text, graphics, and tables; and (3) use a consistent format." These same principles should be followed in presenting the SRE. A suggested outline for the SRE report is presented in this section. Use of this outline will ensure that all critical components of the SRE are presented. The outline generally follows the flow of the evaluation. Not all components of the outline are applicable to all SREs. For example, not all indices will be included in all SREs.

Suggested outline for the screening risk evaluation report

1. INTRODUCTION

1.1 BACKGROUND
- General description of the facility
- Location of the facility
- History and use of the facility

1.2 OBJECTIVES OF THE SRE
- Site-specific objectives of this SRE (i.e. how are the results going to be used)

1.3 ORGANIZATION OF THE REPORT

2. DATA ASSESSMENT

2.1 DATA COLLECTION
- Description of the data sources identified and what each source contains—i.e., annotated list of documents (EIS, SAR, etc.) and databases, list of personnel interviewed (interview forms should be included in an appendix), EM-60 checklist, waste manifests, etc.
- Discussion of the findings of the facility inspection.
- Description of the data stored in the SRE database.

2.2 DATA EVALUATION
- Discussion of the quality of the data and the potential uncertainty it will introduce into the SRE.
- Description of any data excluded from the SRE.
- Selection of SRE indices applicable to the facility.
- Discussion of the sufficiency of the data to meet the needs of the SRE.
- Description of data gaps.
- Description of SRE indices which cannot be calculated due to data gaps.

3. SRE INDEX CALCULATIONS

3.1 CURRENT RELEASE INDEX
- Data used in this calculation
- Assumptions used to fill data gaps.

- Intermediate calculations (e.g., dose factor).
- Uncertainty in the calculation (magnitude and direction of error).

3.2 WORKER EXPOSURE INDEX
- Data used in this calculation
- Assumptions used to fill data gaps.
- Intermediate calculations (e.g., hazard quotients).
- Uncertainty in the calculation (magnitude and direction of error).

3.3 FUTURE RELEASE INDEX
- Data used in this calculation.
- Assumptions used to fill data gaps.
- Intermediate calculations (e.g., dose factor).
- Uncertainty in the calculation (magnitude and direction of error).

3.4 PHYSICAL HAZARD INDEX
- Data used in this calculation.
- Assumptions used to fill data gaps.
- Intermediate calculations (e.g., individual physical hazard scores).
- Uncertainty in the calculation (magnitude and direction of error).

3.5 CRITICALITY

3.6 RESULTS MATRIX
- Reiterate from Sect. 2 indices which are not applicable to the facility and indices which cannot be calculated due to lack of data.

4. SUMMARY AND CONCLUSIONS

4.1 SUMMARY OF THE SRE
- Summary of what was found at the site.
- Summary of the indices calculated (i.e. what was done and what was not done).
- Summary of the purpose of the SRE and the specific questions being asked at this facility.
- Role of SRE in Fulfilling Site Characterization Requirements.

4.2 CONCLUSIONS
- Risk-based recommendations only—these must be combined with other inputs to make decisions.
- Specific conclusions/recommendations for this facility—subsections may include:
  - Prioritization/Ranking
  - Selection of Early Action
  - Facility Reuse Options
  - D&D planning and Characterization requirements
  - S&M requirements
  - Other site-specific issues

6. REFERENCES

Chidambariah, V., C.C. Travis, J. Trabalka, J. Thomas. 1984. *A Risk-based Approach to Prioritizing Inactive Low Level Liquid Radioactive Waste Underground Storage Tanks for Further Evaluation for Interim Corrective Measures*, ORNL/ER/84 .

Coles, G.A., M.V. Shultz, W.E. Taylor. 1993. *Risk Management Study for the Retired Handford Site Facilities*, Report No. WHC-EP-0619, Westinghouse Handford Company. for U.S. DOE. Contract No. AS06-87RL/0930.

EPA (United States Environmental Protection Agency). 1987. *Data Quality Objectives for Remedial Response Activities, Development Process*, EPA/540/G-87/003, OSWER Directive 9355.0-7B.

EPA. 1989. *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part A, Interim Final*, EPA/540/1-89/002.

EPA. 1990a. *Guidance for Data Useability in Risk Assessment*, Interim Final, EPA/540/G-90/008.

EPA. 1990b. *National Oil and Hazardous Substance Pollution Contingency Plan*, Federal Register 55(46): pp. 8666–8865.

EPA. 1991. *Risk Assessment Guidance for Superfund (Vol. 1), Human Health Evaluation Manual (Part B), Development of Risk-Based Remediation Goals. Interim Final* ,Publication 9285.7-01B, Office of Emergency and Remedial Response, Washington, D.C.

EPA. 1993. *Guidance on Implementing the Data Quality Objectives for Remedial Activities, Development Process*, EPA/540/R-93/071.

EPA. 1994 *Guidance for Planning for Data Collection in Support of Environmental Decision Making, Using the Data Quality Objectives Process*, EPA QA/G-4, Quality Assurance Management Staff, Washington, D.C.

ICRP (International Commission on Radiological Protection). 1991. *1990 Recommendations of the International Commission on Radiological Protection*, ICRP Publication No. 60, Pergamon Press, Inc. New York, NY.

Energy Systems (Lockheed Martin Energy Systems, Inc.). 1995. *Baseline Risk Assessment Guidance for D&D Facilities*, K/ER-153/R1.

Natural Phenomena Applications Guide. 1991. Field Evaluation Method. Safety Analysis Report Update Program, CSET-5.

ORNL (Oak Ridge National Laboratory). 1994. Nuclear Criticality Safety Procedures, *ORNL Facility & Nuclear Criticality Safety Manual*, NCS 1.0.

U.S. Air Force. 1984. System Safety Program Requirements, MIL-STD-882B, Specifications and Standards Branch, Wright-Patterson Air Force Base.

Appendix A

SRE DATA COLLECTION WORKSHEET

A. SRE DATA COLLECTION WORKSHEET—FACILITY LOCATION

1. Provide a map (or several maps) identifying the location of the facility and the location of:

   a. other buildings in the area
   b. critical ecological habitats in the area (surface water, wetlands, undisturbed natural habitats)
   c. closest uncontrolled area (i.e., site boundary)
   d. closest residential area

2. Are there any threatened or endangered species known to live within 2 miles of the facility?_____

What endangered species are present and where?_____

_____

_____

3. Are workers present in buildings surrounding the facility? _____

SRE DATA COLLECTION WORKSHEET—FACILITY USE INFORMATION

1. Is the facility currently in use?_____

2. If the facility is currently in use:
   a. What portion of the facility is used?_____

_____

_____

   b. What is it used for?_____

_____

_____

   c. How frequently is the facility used?_____

_____

_____

   d. How many workers are in the building on a normal day?_____

_____

_____

3. If the facility is not in use:
   a. Do workers have access to the facility or parts of the facility?_____

b. Are workers required in the facility for any reason (e.g., S&M, tours, monitoring)?_____

c. How often do workers enter the facility?_____

d. What types of activities are performed?_____

e. Where in the facility are these activities performed?_____

SRE DATA COLLECTION WORKSHEET—CONTAMINANT RELEASE INFORMATION

1. Have there been releases (intentional or unintentional) of contaminants from this facility in the past? _____

2. If there have been past releases:
   a. What was released?

_____

_____

   b. When were the releases?

_____

   c. Were releases routine or accidental?

_____

   d. How did releases occur?_____

_____

_____

_____

3. Are contaminants currently being released from the facility?

- ☐ Contaminants are definitely being released
- ☐ Contaminants are probably being released
- ☐ Not sure
- ☐ There is probably no contaminant release at this time
- ☐ There is definitely no contaminant release at this time

NOTE: Releases may be intentional or unintentional, routine or isolated incidents. For example - if the roof is contaminated, releases are likely to occur during storm events.

4. Has monitoring for releases been performed in the past?_____

5. If monitoring has been performed:
   a. What type of monitoring has been performed?_____

b. When was monitoring conducted?_____

c. Where was monitoring conducted?_____

d. What, if anything, has been found during monitoring?_____

6. Is monitoring for releases currently being performed? _____

7. If monitoring is being performed:
   a. What type of monitoring is being performed?_____

   b. Where is monitoring conducted?_____

   c. What, if anything, is being found during monitoring?_____

8. If a release is known or suspected:
   a. What is being released?_____

b. How long has this release been occurring?_____

c. How often does the release occur (e.g., everytime it rains or continuously during working hours)?

d. How is the release occurring?_____

e. What is the approximate magnitude of the release?_____

f. How was this release estimate determined?_____

SRE DATA COLLECTION WORKSHEET - CONTAMINANT INFORMATION

1. Are contaminants (chemical or radioactive) present in the facility?_____

2. What contaminants are present:

Contaminant	Location[a]	Amt or Conc.[b]	Data Availability[c]	Comments[d]

[a] Where in the facility is the contamination located - include physical location (e.g., north cell) and form (e.g., bulk material in waste containers, residue on walls).

[b] Total amount (mass or volume) of the contaminate, or concentration of contaminant in a medium (e.g., pCI/cm^2 on walls).

[c] Are analytical data available to identify and/or quantify this contaminant. What type of data are available?

[d] Additional comments regarding this contaminant (e.g.,).

SRE DATA COLLECTION WORKSHEET—CONTAINMENT INTEGRITY

1. Building construction:

☐ Reinforced Concrete ☐ Concrete/Masonry Block ☐ Brick
☐ Steel Frame ☐ Wood

☐ Other
(specify):_____

2. Building condition:

☐ Excellent - The structure is new (< 10 years) and shows no visible deterioration.
☐ Good - The structure is older (> 10 years) and shows no visible deterioration.
☐ Fair - The structure shows the first signs of deterioration.
☐ Poor - The structure shows noticeable deterioration with visible cracks or openings.
☐ Very Poor -The structure shows advanced deterioration and/or is currently releasing contaminants

3. Roof condition:

☐ Good - The roof is new (< 5 years) and has no visible deterioration.
☐ Fair -The roof is older (> 5 years) and has visible signs of age. The roof may have minor leaks.
☐ Poor -The roof is visibly deteriorated and has been breached in some way (holes, cracks, serious leaks).

4. If roof condition is poor, have corrective measures been taken to protect the roof/building (e.g., a tent erected over the facility with a leaky roof to prevent water from entering the building)?_____

_____

5. Are contaminants present within a secondary containment structure (e.g., tank, drum)?_____

6. What type of secondary containment structure is present?_____

_____

_____

7. What is the current condition of the secondary containment?_____

_____

_____

SRE DATA COLLECTION WORKSHEET—PHYSICAL HAZARD

1. Have any hazard assessments been performed on the facility (e.g., SAR, OSHA)?

2. Have any accidents/incidents occured at this facility in the past 5 years?

3. If any accidents/incidents have occured:
   a. When did the incident(s) occur?

   b. Where did the incident(s) occur?

   c. Describe the incident(s)

   d. What injuries were sustained (if any) as a result of the incident(s)?

SRE DATA COLLECTION WORKSHEET—CRITICALITY

1. Is there any fissile material present in the facility?_____

2. Is there adequate fissile material in the facility for a criticality to occur if there was an initiating event?_____

3. What type of initiating event would be required for a criticality to occur?_____

4. If a criticality were to occur, how large an area would be effected?
   - ☐ Exposures within the facility only
   - ☐ Exposures to personel outside the facility but on DOE property
   - ☐ Exposures could reach off-site of DOE property

Appendix B

SRE CALCULATION SPREADSHEET

B. SRE Calculation Spreadsheet

The SRE indices are calculated using an EXCEL spreadsheet linked to a reference file containing contaminant-specific toxicity data. The spreadsheet uses the information from the SRE Data Collection Worksheets and the equations and parameters outlined in this report. The user enters facility-specific information into the spreadsheet. This information includes general parameters (e.g., Location Score, Worker Usage Factor, etc.) as well as contaminant-specific information (e.g., CAS ID, contaminant concentration in soil, etc.).

The spreadsheet has been "document protected" and therefore will only allow a user to update information specific to a facility. Cells that contain formulas and constants cannot be changed without "unprotecting" the document. In addition, a number of rows and columns in the spreadsheet which contain intermediate calculations have been hidden. These cells can be unhidden if the document is unprotected. The worksheet normally displays a single column for inputting information specific to a contaminant. Columns for more contaminants can be added by unhiding the columns to the right of the first contaminant column. Once unhidden, these columns are ready to receive data. Double clicking on any of the cells containing a parameter name will open an onscreen dialog box giving a complete description of the parameter and guidance on where to obtain a value. Upon updating any parameter value, the rest of the spreadsheet is immediately updated. A place for including notes and references is provided to the right of the parameter values. The SRE indices appear at the bottom of the spreadsheet.

The SRE spreadsheet is linked to a reference file containing contaminant-specific toxicity data. This reference file can be updated as necessary to ensure that the most recent toxicity data are being used. It is necessary, however, that the reference file maintain its current format to remain properly linked to the calculation spreadsheet.

The SRE Calculation Worksheet and output are shown on the following page. The first two tables on the spreadsheet are filled in by the user. The third table contains the SRE output. As mentioned previously, the results of intermediate calculations can be shown by unhiding the rows in the second table.

SRE CALCULATION WORKSHEET

Facility:

Table 1 - General User Inputs

User Inputs	Value	Notes:
LS		
WUF		
FIS		
SCI		
Dose Rate (mrem/hr)		
Avg. PHI		
Criticality		
CRI Weight		
WEI Weight		
FRI Weight		
PHI Weight		

Table 2 - Contaminant-Specific Inputs

Parameter	Units	Contaminant 1
CAS ID	none	
Contaminant	none	
Amt. Released	mg, pCi	
Duration	yrs	
Conc. Soil	mg/kg, pCi/kg	
Conc. Air	mg/m^3, pCi/m^3	
Conc. Surface	mg/cm^2, pCi/cm^2	

Table 3 - SRE Index Calculations and Output

Parameter	Value
Max TRP	
TPS (CRI)	
CRI	
External ECR	
HI(total)	
ECR(total)	
Usage HI	
Usage ECR	
Weighted HI	
Weighted ECR	
WEI	
Var. Weight (x)	
Var. Weight (y)	
RP	
TPS(FRI)	
FRI	
PHI	
CI	
Total Risk	

Appendix C

FINDINGS REPORT, GUIDANCE, AND INSTRUCTIONS

C. FINDINGS REPORT INSTRUCTIONS

C.1 INTRODUCTION

This section contains the findings report for documenting and assessing physical hazards at D&D facilities that could adversely affect human safety. Information for this report is collected during walkthrough investigations of D&D facilities. Physical hazards within the facility are first identified. Then, the potential accidents these hazards might cause are assessed and scored for possible consequences and likelihood of occurrence in both the near- and long term. From these determinations, a hazard category (that reflects the accident's risk) and hazard score are assigned. The risk scores for all findings are used in calculating the facility's Physical Hazard Index (PHI) (Sect. 3.5.2).

The facility walkthroughs are performed by a team representing four professional disciplines: risk analysis, structural analysis, electrical engineering, and industrial hygiene. The investigators examine the facilities according to their appropriate disciplines to identify hazards including but not limited to those listed in Sect. C.2. Findings should be supported, where possible, by photographs.

For each hazard finding within a D&D facility, the team completes a Findings Report Summary Sheet, an example of which is included as Exhibit C.1 to this appendix. The Findings Report shall include:

- The name of the facility
- The date of the inspection
- The names of the investigators
- A brief description of the finding
- The hazard category to which the finding is assigned (Sect. C.2)
- The hazard location (Sect. C.3)
- Potential accidents the hazard could cause (Sect. C.4)
- Factors contributing to the likelihood that the hazard will cause an accident (Sect. C.5)
- A hazard assessment (Sect. C.6)

C.2 HAZARD CATEGORY

All team members should contribute to identifying as many physical hazards as possible. Select the hazard category from the following list or, if a finding cannot be applied to a category in this list, create a new hazard category for it.

- Falling (tripping, slipping, falling through, falling off)
- Blows or impacts (striking, being struck)
- Drowning
- Suffocation
- Electrical shock

- Exposure to chemical burn hazards (i.e., strong acids or bases, strong oxidizing agents)
- Exposure to thermal burn hazards (i.e., extremely hot or cold surfaces)
- Exposure to biological hazards (i.e., disease, bites)
- Temperature extremes (i.e., debilitating heat or cold)
- Fire (electrical and ignitable substances)
- Explosion

C.3 HAZARD LOCATION

This information should be specific so the hazard can be easily located again. At a minimum, identify both the building and the room. Where possible, add specific information such as whether hazard is located on the floor; ceiling; or north, south, east, or west wall. Where needed, supply specific measurements from a reference point to the hazard.

C.4 POTENTIAL ACCIDENTS

An accident involves a hazard that could cause harm or injury to a person. For each finding, all team members should contribute to identifying as complete an assessment as possible of potential accidents the hazard could cause.

C.5 CONTRIBUTING FACTORS

For each finding, all team members should contribute to as complete an assessment as possible of existing conditions or features affecting the likelihood that the hazard will result in an accident (for example, absence of a personnel barrier, poor lighting, limited personnel access, hallway is the only access into and out of the facility, etc.).

C.6 HAZARD ASSESSMENT

Once a physical hazard has been identified and the team has developed as complete a list as possible of the potential accidents attributable to it, the hazard assessment is performed. Each potential accident is assigned to a consequence category (catastrophic, severe, or minor) and a likelihood category (frequent, probable, occasional, remote, or improbable). The potential for each accident to occur is assessed for two time frames, near-term (within the next 5 years) and long-term (beyond 5 years); this takes into account the possibility that the consequence or likelihood associated

with a particular hazard may change with time. The consequence and likelihood are then used to assign a hazard category (which reflects the accident's risk) and hazard score to the potential accident. The sum of the hazard scores for a finding is the finding hazard score, PH. The PHs for all findings in a facility are averaged to give the total physical hazard score for the facility, PH_T. The PH_T is then used in Sect. 3.5.2 to assign the facility's PHI.

It is strongly suggested that a risk assessment specialist perform the hazard assessment, with the aid of the following guidance.

C.6.1 Consequences

The consequence categories in Table C.1 (catastrophic, severe, and minor) are a mechanism by which accidents can be grouped based on similarities of outcome so that different accident effects can be compared. Each category is assigned a weighting factor. This is a numerical normalizing tool that expresses societal attitudes about the effects of the accident; no absolute risks are given to these values.

Enter the assessment team's decision on consequence category in the hazard assessment table in Exhibit C.1.

Table C.1. Consequence category

Consequence Category	Effect on Person Involved	Consequence Weighting Factor
I Catastrophic	Loss of life	1
II Severe	Severe injury—personal disability or significant lost time accident.	0.1
III Minor	Minor injury	0.003

These consequence categories are further defined in the following paragraphs.

C.6.1.1 Category I— Catastrophic

This category addresses hazards that can produce or result in accidents that can cause death.

C.6.1.2 Category II— Severe

This category encompasses hazards for which an accident would produce or result in severe injury, significant lost work time, or long-term disability.

C.6.1.3 Category III— Minor

This category includes effects from biological hazards such as animal and insect bites or stings, or disease from contact with bird or bat droppings (note, however, that some animal or insect bites, such as a venomous snake bite, as well as some animal-borne diseases can result in severe consequences). Also included are minor occupational-type injuries such as scrapes, bruises, cuts, and strains. This category is provided to ensure that low-consequence hazards are not overlooked. Large

numbers of minor hazards can be an indicator that accidents with significant consequences may be a problem in the future; this should be considered in the long-term analysis.

C.6.2 Likelihood

The likelihood category provides an estimate of the likelihood that existing conditions or features present a hazard that could result in an accident. As noted above, an accident involves a hazard that could cause some harm to a person. Likelihood index is determined according to Table C.2. The values in this table were taken from MIL-STD-882B, System Safety Program Requirements (U.S. Air Force 1984).

Enter the assessment team's decision on likelihood category in the hazard assessment table in Exhibit C.1.

Table C.2. Likelihood category

Level	Index	Description	Likelihood
Frequent[a]	A	Likely to occur frequently	1
Probable	B	Likely to occur several times in the life of an item	1×10^{-1}
Occasional[b]	C	Likely to occur some time in the life of an item	1×10^{-2}
Remote	D	Unlikely but possible in the life of an item	1×10^{-4}
Improbable	E	So unlikely that it can be assumed occurrence will not be experienced	1×10^{-6}

[a] If an event has occurred in the past, the likelihood of a similar event occurring will be 1.
[b] If rigid administrative controls must be bypassed to result in an event, the likelihood of the event will be 10^{-2} or less.

Data to establish benchmarks for likelihood can be specific or generic. For example, because a fall through a roof panel has occurred, the likelihood of a similar accident involving a roof panel must be at least 1. If rigid administrative controls must be bypassed to result in an accident, then human reliability screening values such as 1×10^{-2} can be used to estimate likelihood.

C.6.3 Calculating the Hazard Score for a Finding, PH

This section describes how to calculate the hazard score (the total risk), PH, for a finding. This is calculated once the consequence scores and likelihood scores for all accidents associated with a particular finding have been entered in the hazard assessment table on the Findings Report Summary Sheet (Exhibit C.1). Calculate the risk for each accident (both near- and long-term) for a finding by multiplying the accident consequence score by its respective likelihood score. Sum these accident risks to obtain the PH for that finding. This score is returned to Sect. 3.5.2 where it is used to calculate a facility's total physical hazard score, which is then assigned a PHI score.

Table C.3 correlates consequence scores and likelihood scores with relative degrees of risk.

Table C.3. Hazard risk score

Likelihood Index	Consequence Category I Catastrophic		Consequence Category II Severe		Consequence Category III Minor	
	Hazard Category	Hazard Score	Hazard Category	Hazard Score	Hazard Category	Hazard Score
A	Critical	1	Critical	0.1	Moderate	1×10^{-3}
B	Critical	0.1	Serious	0.01	Minor	1×10^{-4}
C	Serious	1×10^{-2}	Moderate	1×10^{-3}	Minor	1×10^{-5}
D	Minor	1×10^{-4}	Minor	1×10^{-5}	Negligible	1×10^{-7}
E	Negligible	1×10^{-6}	Negligible	1×10^{-7}	Negligible	1×10^{-9}

Findings Report Summary Sheet

Facility: _____ Date: _____

Investigation Team: _____ _____

_____ _____

_____ _____

Finding: _____

Hazard Category: _____

Hazard Location: _____

_____

_____

Potential Accidents: _____

_____

_____

Contributing Factors: _____

_____

Exhibit C.1. Findings Report Summary Sheet and Hazard Assessment Table.

Hazard Assessment Table

Facility	Finding	Accident	Timeframe	Consequence Score	Likelihood Score	Accident Risk
			Near-term (within next 5 years)			
			Long-term (beyond 5 years)			
			Near-term (within next 5 years)			
			Long-term (beyond 5 years)			
			Near-term (within next 5 years)			
			Long-term (beyond 5 years)			
FINDING RISK, PH						

Exhibit C.1 (continued)

Appendix D

LOCATION SCORING CRITERIA FOR THE DOE OAK RIDGE RESERVATION

D. LOCATION SCORING CRITERIA FOR THE DOE OAK RIDGE RESERVATION

D.1 INTRODUCTION

The location score (LS) is a site-dependent score determined by a site's geography and population density. Scores ranging from 1 to 5 are assigned to a site depending on its distance to surface water, groundwater, and the DOE property boundary; and on the population density of workers in and around the site. It is recommended that a geologist and a risk assessment specialist participate in determining a site's LS. LS scoring criteria for evaluating facilities at other DOE sites must be developed on a site-specific basis.

D.1.1 Step 1—Geographical Location Scoring Criteria

Each of the three ORR sites [Oak Ridge National Laboratory (ORNL), the Oak Ridge Y-12 Plant, and the Oak Ridge K-25 Site) was broken into geographic areas and scored on a scale of 1 to 5 based on distance to surface water, groundwater, and the DOE property boundary, as well as the flood potential of the area. Surface water is likely to be an important transport and exposure medium at most of these facilities. Groundwater may also be an important transport medium. The DOE boundary was used to represent the nearest potential off-site (i.e., public) receptor.

Obvious groupings of buildings within the same geographic area were used as the locations. The scores for these locations were assigned using professional judgement and the criteria listed previously. Using maps of the three sites (the K-25 Site, the Y-12 Plant, and ORNL), the most hazardous (i.e., closest to surface water, DOE boundary, etc.) location was selected and assigned a Geographical Location Score (GLS) of 5. The least hazardous location was selected and assigned a GLS of 1. Scores for all other locations were then assigned between these two extremes. GLS scores are given in Table D.1.

Table D.1. Location scores for distance to surface water, groundwater, DOE boundary, and flood potential

K-25		Y-12		ORNL	
Location	Geographical Location Score (GLS)	Location	Geographical Location Score (GLS)	Location	Geographical Location Score (GLS)
Powerhouse area	5	Grid B-4	3	Hydrofracture area	3
K-33/K-31 and K-27/K-25 areas	4	Building 9201-4	2	HFIR/MSRE/ HRE Area	2
East of Avenue J	3			All other areas	1
South of Bear Creek Rd.	2				

D.1.2 Step 2—Population Density Scoring Criteria

In most cases, if a release occurs, it will have the greatest and most immediate impact on nearby (on-site) workers. Therefore, in Step 2, the geographical locations identified in Step 1 were scored based on the population density of workers in the area. As in Step 1 scoring, professional judgement was used to assign Population Density Scores (PDSs) of 5 and 1, respectively, to the most and least hazardous locations based on the proximity and number of on-site workers. Intermediate scores were then assigned within these two extremes. Where necessary, the geographic areas identified in Step 1 were further broken down to accommodate this scoring. The scores for worker population density are presented in Table D.2.

Table D.2. Location scores for worker population density

K-25		Y-12		ORNL	
Location	Population Density Score (PDS)	Location	Population Density Score (PDS)	Location	Population Density Score (PDS)
East of Avenue J - South of 8th St.	5	Grid B-4	5	All other areas	5
K-33/K-31 and K-27/K-25 areas	3	Building 9201-4	3	HFIR/MSRE/ HRE area	3
East of Avenue J - North of 8th St.	1			Hydrofracture area	1
South of Bear Creek Rd.	1				
Powerhouse area	1				

D.1.3 Step 3—Deriving the LS

To determine the LS, the GLS and PDS scores were added and divided by two; this yielded an LS with a range of 1 to 5. The total scores and LSs for the locations from Step 1 are shown in Table D.3.

Table D.3. Total score and Location Score (LS) for ORR locations

K-25			Y-12			ORNL		
Location	Total Score	Location Score (LS)	Location	Total Score	Location Score (LS)	Location	Total Score	Location Score (LS)
East of Avenue J - South of 8th St.	8	4	Grid B-4	8	4	All other areas	6	3
K-33/K-31 and K-27/K-25 areas	7	3.5	Building 9201-4	5	2.5	HFIR/MSRE/ HRE area	5	2.5

Table D.3 (continued)

K-25			Y-12			ORNL		
Location	Total Score	Location Score (LS)	Location	Total Score	Location Score (LS)	Location	Total Score	Location Score (LS)
Powerhouse area	6	3				Hydrofracture area	4	2
East of Avenue J - North of 8th St.	4	2						
South of Bear Creek Rd.	3	1.5						

D.1.4 Step 4—Adjusting the LS for Threatened or Endangered Species or Sensitive Ecological Habitats

If threatened or endangered species are present at the facility, one additional point must be added to the LS. In addition, one point must be added to the LS if a sensitive ecological habitat exists near the facility (e.g., wetland, endangered species refuge, estuary). Therefore, the total possible LS is $5 + 1 + 1 = 7$.

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