2.0 THE DECOMMISSIONING PROCESS

2.1 General

Decommissioning is an interactive process between the NRC and the licensee leading to the termination of a facility license and release of the facility for unrestricted use. This process may be simple or complex, depending upon the composite topography (the type and number of buildings, the amount of open or paved ground, or the combination of the two); the type of facility and its general use; the type and variety of radionuclides used in its processes and operations; and the extent to which the facility may have become contaminated. These same factors also affect the complexity of radiological surveys required to provide the necessary information to eventually demonstrate that residual radioactivity levels satisfy the criteria for license termination. The decommissioning process and the relationship of radiological surveys to that process are illustrated in flow chart format in Figure 2-1. This Manual is intended to assist the user in design and performance of surveys required for decommissioning, regardless of the level of complexity.

Responsibilities of the licensee are detailed in regulations concerning byproduct, source, and special nuclear materials as set forth in Title 10 of the Code of Federal Regulations (10 CFR); Parts 30.36 for byproduct material, 40.42 for source material, 50.82 for reactors, 70.38 for special nuclear material, and 72.54 for spent fuel and high-level waste storage facilities. These regulations provide that if a licensee does not renew a license, that licensee shall, on or before the expiration date of the license, perform the activities required for decommissioning a nuclear facility. The licensee must request in writing that the license be terminated. In most cases, this request must also be accompanied by a written decommissioning plan (see applicable 10 CFR section for conditions that may provide for alternative actions). The licensee then:

- Terminates the use of the licensed material,
- Removes radioactive contamination from the facility to the extent practicable,
- Properly disposes of any radioactive material removed,

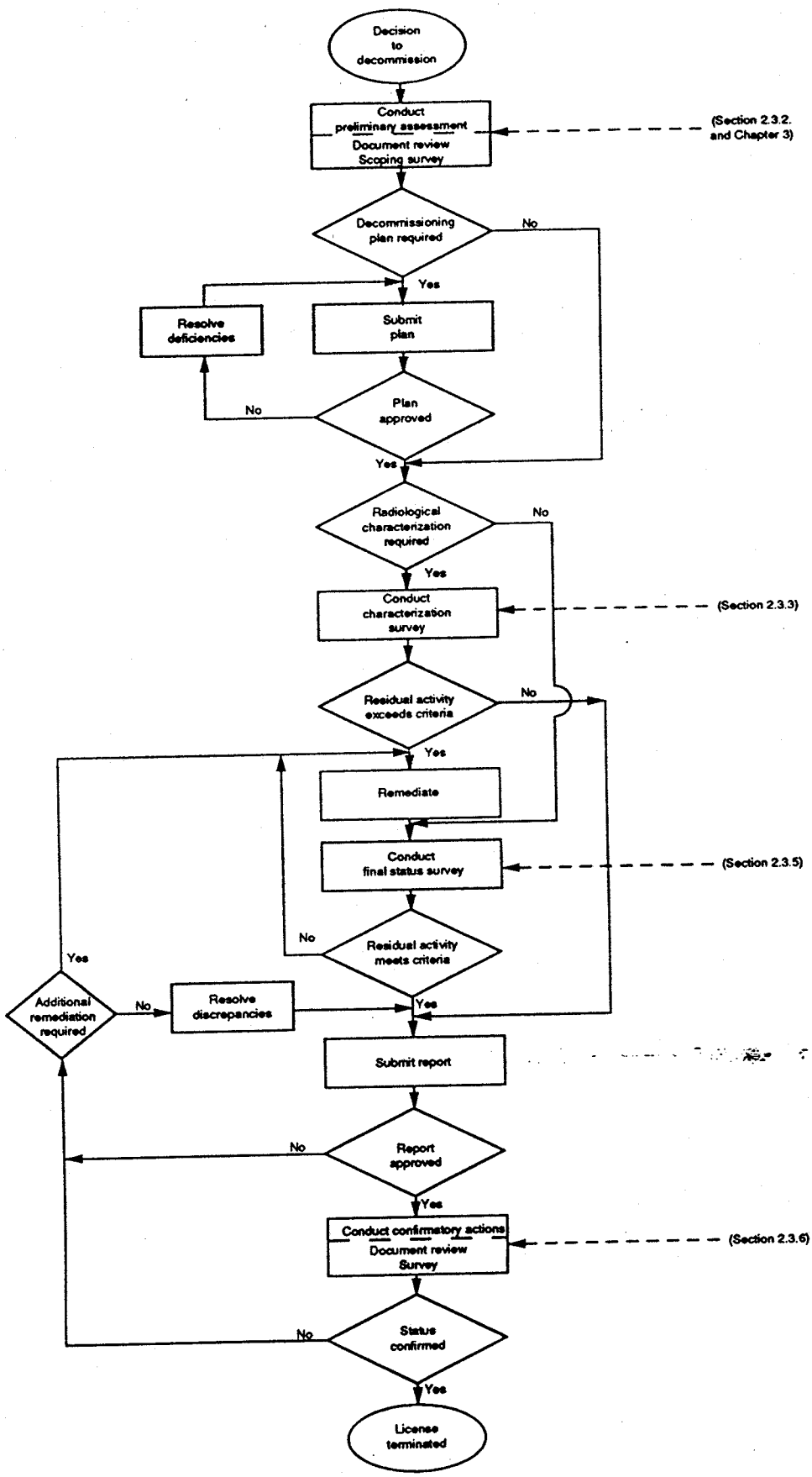

FIGURE 2-1: Flow Diagram Illustrating General Decommissioning Process

- Submits a report form NRC-314, which certifies information concerning the disposition of licensed materials,

- Conducts a radiation survey and/or evaluation of the premises where licensed activities were carried out, and

- Submits to the NRC a report of the final survey or other information to sufficiently demonstrate that the premises are suitable for release for unrestricted use.

The NRC reviews and evaluates the information provided by the licensee; performs independent confirmation of site conditions, as appropriate; and makes a determination on termination of the license.

2.2 Decommissioning Criteria and Guidelines

The ultimate goal of the decommissioning process is to assure that future uses of any licensed facility will not result in individuals being exposed to unacceptable levels of radiation and/or radioactive materials. The NRC establishes the acceptable radiation dose to a potentially exposed individual, based on considerations of risk and scientific data relating dose to risk. (For the purpose of this Manual, the terms dose and radiation dose refer to total effective dose equivalent.) Residual levels of radioactive material that could be present and still assure that an individual would not exceed that acceptable radiation dose are then calculated by the analyses of various pathways and scenarios (direct radiation, inhalation, ingestion, etc.) through which exposure could occur. These derived levels, known as guideline values, **release guidelines**, or simply, **guidelines**, are presented in terms of direct radiation levels, surface activity levels, volume concentrations of radioactive material in soil and building materials, and site inventory limits. These guideline values refer to radiation and radioactivity above normal background levels. Guidelines for direct radiation levels are expressed in units of exposure rate, i.e. microroentgens per hour (μR/h). Surface activity guideline values, applicable to building or equipment surfaces, are expressed in units of activity per surface area [typically disintegrations per minute per 100 cm^2 (dpm/100 cm^2)]. Volume concentration guideline values, which apply to soil, induced activity, and debris, are expressed in terms of activity per unit mass [typically, picocuries per gram (pCi/g)]. Site inventory limit refers to the total quantity of residual radioactive material from formerly licensed operations, permitted to remain on the site following decommissioning; this value is expressed in units of activity, i.e. microcuries (μCi) or millicuries (mCi). The guideline value for direct radiation is not a function of the source of the radiation, i.e., it is independent of the specific radionuclide or its chemical/physical form. However, because of differences in environmental behavior and associated radiation doses through other exposure pathways, the guideline values for surface activity, volume concentration, and site inventory will depend upon the specific radionuclide or radionuclides present. If more than one radionuclide is present, the individual contributions from each

radionuclide are limited, such that the sum of the radiation doses from all sources does not, over time, exceed the established acceptable dose.

This Manual assumes the following conditions for application of guideline values to decommissioning.

Surface Activity

Average surface activity levels (total of fixed and removable activity) are at or below guideline values established as acceptable by NRC.

- Reasonable efforts have been made to identify, evaluate, and remove, if necessary, areas of residual activity exceeding the guideline values. Small areas of residual activity exceeding the guideline value, known as **elevated areas**, may be acceptable to the NRC. This Manual assumes that activity levels of elevated areas, less than three times the guideline values when averaged over a surface region of 100 cm^2, are acceptable, provided the average level within a 1 m^2 area containing the elevated area is within the guideline value.

- Reasonable efforts have been made to clean up removable activity and removable activity in any 100 cm^2 area does not exceed 20% of the average surface activity guideline values.

Soil Activity

- Average radionuclide concentrations are at or below guideline values, established as acceptable by the NRC. For your land areas, averaging is based on a 100 m^2 (10 m x 10 m) grid area.

- Reasonable efforts have been made to identify, evaluate, and remove, if necessary, areas of residual activity exceeding the guideline values. This Manual assumes that areas of residual activity exceeding the guideline value, known as elevated areas, are acceptable, provided they do not exceed the guideline value by greater than a factor of $(100/A)^{1/2}$, where A is the area of residual activity in m^2, and provided the activity level at any location does not exceed three times the guideline value.

Exposure Rate

- Exposure rates do not exceed background levels by greater than the exposure rate limit, at 1 m from the surface. In occupiable building locations, exposure rates are measured at 1 m from floor/lower wall surfaces and may be averaged over floor areas, not to exceed the size of a small office (i.e., about 10 m^2.) For open land areas, exposure rates are measured at 1 m above the surface and may be averaged over 100 m^2 grid areas. This Manual assumes that maximum exposure rates over any discrete area may not exceed two times the limit, above background.

The objective of the survey, as presented in this Manual, is to demonstrate at a 95% (minimum) level of confidence, that the above conditions have been met. For the purpose of this demonstration, each survey unit (Section 4.2.2) is independently evaluated.

Finally, the total inventory of residual radioactive material from licensed operations may require calculation. It is assumed that this calculation will include surface activity, activity in surface and subsurface soil, activity induced in building materials and components, and activity that may remain from previous onsite disposals.

2.3 Radiological Surveys Supporting Decommissioning

Several different surveys may be required as part of the decommissioning process. Since each is intended to provide radiological data for different primary applications or objectives, the survey techniques, thoroughness, data accuracy, and documentation requirements may vary. This section identifies and briefly describes the types of radiological surveys. Additional details on conducting surveys are provided in Section 6.0.

The major steps in the decommissioning process are sequential and each step builds on information gathered from earlier activities. Although the various surveys may appear to be independent, survey results may, in practice, serve multiple purposes. For example, survey measurements obtained during the scoping phase or the characterization phase, may be useable in describing the final site conditions, if the location where those measurements were performed has not experienced subsequent activities which may have altered the radiological status. Conversely, data obtained following remedial action may, if they indicate residual contamination, serve as characterization information to guide further cleanup. Survey activities should be planned to enable optimum use of the data, thereby reducing the level of survey effort associated with a decommissioning project. Such planning should consider the accuracy and specificity of measurements, relative to time constraints and cost, at each stage of the survey.

2.3.1 Background Survey

Because guidelines for residual radioactivity at decommissioned sites are presented in terms of radiation levels or activity levels above normal background for the area or facility, it will also be necessary to perform a **background survey**. This survey will require measuring both direct radiation levels (usually gamma exposure rates) and concentrations of the potential radionuclide contaminants in construction materials and in soil (and sometimes in groundwater) in the vicinity of the site. Where only gamma emitting contaminants are present and soils are not affected, it may be adequate to perform only background exposure rate determinations. It is useful to perform such a survey prior to commencing licensed operations; such surveys may be part of the environmental

baseline surveys required at some of the more complex types of facilities. If such information is already available, it may be used. Otherwise, a survey to establish background will have to be conducted.

Background is determined by measurements and/or sampling at locations on site or in the immediate vicinity of the site (out to several kilometers from the site boundary), which are unaffected by site operations. Preferable locations for interior background determinations are within on-site buildings of similar construction, but having no history of licensed operations. Background direct radiation levels within buildings may differ from those in open land areas, because of the presence of naturally occurring radioactive materials in construction materials and the shielding effect that construction materials may also provide. Background samples and measurements for land areas should be collected at locations which are unaffected by effluent releases (upwind and upstream) and other site operations (upgradient from disposal areas). Locations of potential runoff from areas of surface contamination should also be avoided. Other locations which may have been affected or disturbed by non-site activities and should be avoided include waste management areas and their drainage pathways; roads, parking lots, and other large paved surfaces; storm drains and ditches, receiving industrial or agricultural runoff; railroad tracks; material handling areas such as truck and rail loading facilities; and fill areas.

Because the background levels will be subtracted from total radiation or radioactivity levels to determine the net residual activity from licensed operations, it is necessary that backgrounds be determined with a detection sensitivity and accuracy at least equivalent to data from which it will be subtracted. This can be achieved by using the same instruments and techniques for background surveys as are used in assessing final site conditions.

The degree to which the average background of a particular radiological parameter, determined for a specific site, is representative of the true background level is a factor in determining the number of background measurements required for that determination. Many radionuclides are not present in the environment at levels which are sufficient to be either quantifiable using reasonable, standard measurement techniques or which are significant, relative to the guideline values for unrestricted release. On the other hand, levels of direct radiation (exposure rates) and some naturally occurring (uranium and thorium decay series) or man-made (Cs-137) radionuclides are typically present in the environment at levels which are easily quantifiable and may have background levels which are significant, relative to guideline values. Experience has indicated the variance in the average background value from a set of 6 to 10 measurements will usually not exceed $\pm$ 40% to 60% of the average at the 95% confidence level. However, localized geologic formations, different types of soil, and construction materials at the background measurement locations may result in individual background values which have greater variability. Consequently, additional measurements and samples may be required to assure a representative average value.

For practical purposes, it is recommended that 6 to 10 measurements for each parameter of concern be initially performed and the average and 95% confidence level be determined. If the upper 95% level bound on the background average is less than 10% of the guideline value for that parameter, variations in background may be considered insignificant and no further determination are necessary. However, if the upper 95% level bound on the background average is greater than 10% of the guideline value, the background data should be tested to assure that the average represents the true mean to within $\pm$ 20% at the 95% confidence level. If necessary, additional background determinations should be performed to satisfy this level of representativeness. The procedure for testing the data and determining the number of additional samples needed is described in Section 8.7.

2.3.2 Scoping Survey

Early in the decommissioning process, it will be necessary to identify the potential radionuclide contaminants at the site; the relative ratios of these nuclides; and the general extent of contamination (if any) — both in activity levels and affected area or volume. Although the license and operational history documentation will assist to varying degrees in providing this information, it will usually be necessary to supplement that information with actual survey data. A scoping survey is therefore performed. The scoping survey typically consists of limited direct measurements (exposure rates and surface activity levels) and samples (smears, soil, water, and material with induced activity), obtained from site locations considered to be the most likely to contain residual activity, and from other site locations both immediately adjacent to the radioactive materials use areas and in areas not expected to have been affected by the site operations. This survey provides a preliminary assessment of site conditions, relative to guideline values, and enables initial guidance in classification of the site into "affected" and "unaffected" areas (see Section 4.2.1 for further information on classification of areas by contamination potential). The scoping survey provides the basis for initial estimates of the level of effort required for decommissioning and for planning the characterization survey.

Measurements and sampling in known areas of residual contamination need not be as comprehensive or be performed to the same sensitivity level as will be required for the characterization or final status surveys. However, when planning and conducting this scoping survey, the licensee should remember that some of the data, particularly that from locations not affected by site operations, may be used as final status results or to supplement the characterization and/or final survey results. Similar measuring and sampling techniques as used for those categories of surveys may, therefore, be warranted.

2.3.3 Characterization Survey

After locations which may require decontamination have been identified, a **characterization survey** is performed to more precisely define the extent and magnitude of contamination. The characterization survey should be in sufficient detail to provide data for planning the decontamination effort, including the decontamination techniques, schedules, costs, and waste volumes and necessary health and safety considerations during decontamination. Characterization is typically concentrated on those portions of the site which are known to have been or are suspected of having been affected by site operations involving radioactive materials. The type of information obtained from a characterization survey is often limited to that necessary to differentiate a surface or area as contaminated or non-contaminated. A high degree of accuracy may not be required for such a decision, when the data indicate levels well above the guidelines. On the other hand, when data are near the guideline values, a higher degree of accuracy is usually necessary to assure the appropriate decision regarding the true radiological conditions. Also, one category of radiological data, such as soil radionuclide concentration or total surface activity, may be sufficient to determine the status as contaminated, and other measurements, e.g. exposure rates or removable contamination levels, may therefore not be performed during characterization.

As was the situation with the scoping survey, the choice of survey technique should be commensurate with the intended use of the data, including considerations for possible future use of the results to supplement the final status survey data.

2.3.4 Remediation Control Survey

The effectiveness of decontamination efforts in reducing residual radioactivity to acceptable levels is monitored as the decontamination is in progress by a **remediation control survey**. This type of survey activity guides the cleanup in a real-time mode; it also assures that remediation workers, the public, and the environment are adequately protected against exposures to radiation and radioactive materials arising from the decontamination activities. The remediation control survey typically provides a simple radiological parameter, such as direct radiation near the surface being decontaminated. The level of radiation, below which there is reasonable assurance that the guideline values have been attained, is determined and used for immediate, in-field decisions. Such a survey is intended for expediency and does not provide thorough or accurate data describing the final radiological status of the site. The remediation control survey is applicable to monitoring of surfaces and soils or other bulk materials only if the radionuclides of concern are detectable by field survey techniques. For radionuclides and media which cannot be evaluated at guideline values by field procedures, samples are be collected and analyzed to evaluate effectiveness of decontamination efforts. For large projects, use of mobile field laboratories can

provide more timely decisions regarding the effectiveness of remedial actions. Examples of situations for which remediations control surveys would not be practicable are soil contaminated with pure alpha or beta emitting radionuclides and surfaces with very low energy beta contamination such as H-3.

2.3.5 Final Status Survey

A survey to determine the final condition of the site is performed after decontamination activities (if any were required), are complete. This survey is known by several titles, including **termination survey, post remedial-action survey, final status survey** and **final survey**. The term final status survey is used in this Manual. It is this survey which provides data to demonstrate that all radiological parameters (total surface activity, removable surface activity, exposure rate, and radionuclide concentrations in soil and other bulk materials) satisfy the established guideline values and conditions. Results of the survey are documented in a detailed report, which becomes part of the licensee's application to terminate a license and thereby release the facility for unrestricted use. This type of survey is the principal focus of this Manual.

Although the final status survey is discussed here as if it were an activity performed at a single specified stage of the documenting process, this may not be the case. Data from surveys conducted at other stages of the decommissioning, such as the scoping survey and characterization survey, can, under proper conditions, be incorporated into the final status survey.

2.3.6 Confirmatory Survey

After acceptance of the licensee's termination survey report, the NRC may perform (or arrange for its agent to perform) a confirmatory survey. As the name implies, a **confirmatory survey** is performed to confirm the adequacy and accuracy of the licensee's final status survey. The confirmatory survey develops radiological data of the same type as that presented by the licensee, but is usually limited in scope to spot-checking conditions at selected site locations, comparing findings with those of the licensee, and performing independent statistical evaluations of the data developed by the confirmatory survey and the licensee's final status survey. Although the scope may vary, a confirmatory survey typically addresses from 1 to 10% of the site, but may be extended, if questions or anomalies develop or are identified. The NRC uses the report of this survey in supporting a decision on the licensee's application to terminate a license and release the facility for unrestricted use.