Draft Guidance to Implement Survey and Monitoring Requirements Pursuant to Proposed Rule Text in 10 CFR 20.1406(c) and 10 CFR 20.1501(a)

Draft Guidance for Comment

January 2008

**Division of Waste Management
and Environmental Protection
Office of Federal and State Materials
and Environmental Management Programs
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001**

HOW TO SUBMIT COMMENTS ON THIS DRAFT GUIDANCE

This document is draft guidance to implement, in part, the Decommissioning Planning proposed rule. Any interested party may submit comments on this draft guidance and on the proposed rule, for consideration by the U.S. Nuclear Regulatory Commission (NRC) staff.

To submit comments on this draft guidance document, please send comments by e-mail or by regular mail, to Teresa Mixon, with a copy to James Shepherd, at the following addresses:

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Please include, "Draft Guidance **to Implement Survey and Monitoring Requirements**," in the subject of your email or written comments. Comments on the draft guidance document should be submitted by March 31, 2008, to ensure consideration by the NRC staff. Comments submitted after this comment period may be considered by staff, if practical. The NRC staff is soliciting comments only on aspects of the guidance document related to the Decommissioning Planning proposed rule, and comments on other aspects may not be considered by the staff.

Please direct any questions about the specific material in this guidance document to:

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You should note that procedures for submitting comments on the proposed rule differ from those for submitting comments on this draft guidance. Methods for submitting comments on the Decommissioning Planning proposed rule (RIN 3150-AH45) are described in the proposed rule, which may be viewed and downloaded electronically via the Federal Rulemaking Portal http://www.regulations.gov, or may be obtained electronically at the NRC's Electronic Reading Room at http://www.nrc.gov/reading-rm/adams.html, using the ADAMS accession number ML073470819 for publicly available documents released with the proposed rule.

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FOREWORD

This Draft Guidance Document is Not for Use
The guidance in the following document is published for public comment only, and this guidance is not intended for use until it is published as final guidance. Until the time that this guidance is finalized, U.S. Nuclear Regulatory Commission (NRC) and Agreement State staff, licensees, and the public should continue to use NUREG-1757, Volume 3 (published in September 2003) for guidance on financial assurance, recordkeeping, and timeliness for decommissioning of materials facilities.

The Decommissioning Planning Proposed Rule and this Draft Guidance Document

The NRC staff conducted an analysis of decommissioning issues and presented results and recommendations to the Commission in 2003 (SECY-03-0069, dated May 2, 2003). The recommendations included changes to financial assurance requirements to address the need for more detailed reporting of licensee financial assurance mechanisms to fund site decommissioning activities and protection of the committed funds in cases of financial distress. The Commission approved the staff's recommendations, and in 2007, the Commission approved publication of a proposed rule for public comment that would implement those recommendations. The proposed rule is entitled "Decommissioning Planning," and at the time of this writing, the proposed rule was expected to be published in the Federal Register in January 2008 for a 75-day public comment period. Please refer to the "How to Submit Comments on Draft Guidance" section of this document (see page i) for details on submitting comments on this draft guidance document. Through the rulemaking process, the NRC seeks to improve decommissioning planning and reduce the number of funding shortfalls caused, in the past, by: (1) overly optimistic decommissioning assumptions; (2) lack of adequate updating of cost estimates during operation; and (3) licensees falling into financial distress with financial assurance funds unavailable for decommissioning.

This draft guidance document is compatible with the proposed changes to minimization of contamination requirements in the Decommissioning Planning proposed rule, and it is being released for public comment concurrently with the proposed rule.
This document reflects the proposed amendments to the Code of Federal Regulations (CFR), Title 10, Part 20 that would require licensees to monitor subsurface residual radioactivity and to either clean up leaks and spills when they occur or reflect the cost of such cleanup in their decommissioning cost estimates.

1. INTRODUCTION

1.1 PURPOSE

This document provides guidance to all NRC licensees on how to meet the requirements of proposed revisions to 10 CFR 20.1406 and 10 CFR 20.1501(a). The proposed revisions to §20.1406 require that licensees operate the facility to reduce the amount of radioactive waste at the facility in order to facilitate remediating the site for unrestricted use at the time of license termination.

The proposed revisions to §20.1501(a) require licensees to identify and minimize subsurface residual radioactivity at their site. A significant amount of subsurface residual radioactivity is an amount that would later require remediation during decommissioning to meet the unrestricted use criteria of 10 CFR 20.1402.

Significant subsurface residual radioactivity is a contributing factor to operating sites becoming legacy sites. A legacy site is a facility that is in decommissioning status with complex issues and an owner who cannot complete the decommissioning work for technical or financial reasons. Legacy sites are potential radiological hazards, and the delay in cleanup introduces additional risk to occupational and public health and safety during later decommissioning.

1.2 CHANGES TO 10 CFR 20.1406

The proposed rule adds a new § 20.1406(c) that would require licensees, to the extent practical, to conduct their operations to identify the occurrence of residual radioactivity at their sites, particularly in the subsurface soil and ground water, and minimize the introduction of additional residual radioactivity. Licensees also would be required to keep records of surveys of any residual radioactivity identified at the site with records important for decommissioning.

The phrase "to the extent practical" is used to limit the scope of the regulation to actions that are already manifested in nuclear industry practice or action.

1.3 CHANGES TO 10 CFR 20.1501(A)

The proposed rule revises 10 CFR 20.1501(a) to retain previous survey requirements and specifically includes subsurface contamination within its scope. The term "subsurface" is defined in NUREG-1575 "Multi-Agency Radiation Survey and Site Investigation Manual" and generally means soil-like material approximately 15 centimeters or more below the surface of open areas. The phrase "are reasonable under the circumstances" is retained in § 20.1501(a) and is intended to provide flexibility to licensees to gauge the extent of their survey requirements by taking into consideration the nature of their facility operations.

The proposed rule requires licensees to document in records important for decommissioning, under §§ 30.35(g), 40.36(f), 50.75(g), 70.25(g), and 72.30(d), the survey results identifying residual radioactivity within the site boundary. The current requirements for entering information into "records important to decommissioning" have been widely interpreted by licensees. In response to a recommendation by the Liquid Radioactive Release Lessons Learned Task Force, the staff suggests that entries into §50.75(g) use the definition of significant in ¶1.1 above. The NRC staff recommends that any identified recurring leaks or spills within the facilities or those greater than 100 gallons be entered in the decommissioning records. For those events that are recorded elsewhere, e.g., operational logs, the decommissioning record can be a simple reference to the other records.

When any subsurface contamination above background is identified, the staff recommends that it be noted in decommissioning records, even if it is not otherwise reportable. This is because such information can be very useful for conducting site characterization for purposes of license termination, and to support decisions on the extent of site remediation necessary to meet unrestricted use criteria. It is also useful when planning modifications to a facility. This stems from the logic that if subsurface contamination exists, it came from some plant system that handles that material, so any physical activity on or near those systems should include provisions for dealing with the source of contamination.

1.4 WHAT NEW SURVEY INFORMATION IS REQUIRED

To contaminate the subsurface to the extent that a costly remediation would be needed to meet the unrestricted use license termination requirements, a facility generally must use large volumes of water or other fluids during plant operations and deal with radionuclides of half lives greater than 5 years.

NRC is proposing subsurface contamination surveys at certain facilities that have potential subsurface contamination and the retention of these survey records until license termination, to facilitate later decommissioning of the facility. The existence of subsurface contamination, sometimes undetected by the licensee until after decommissioning actions begin, is one of the prime causes of legacy sites. To determine if any changes are needed to the existing monitoring program, licensees should follow the scheme illustrated in Figure 1-1.

First, licensees should answer three basic questions: is financial assurance currently required, are there fluid processes at the facility, and has there been any unplanned contaminant release from the facility. If the answer to any of these questions is yes, a licensee should evaluate its existing monitoring plan and program for sufficiency, as described below. More information about each item in the figure is contained in Table 1-1. Licensees should propose a comprehensive, site-specific monitoring program, and reach agreement on it with the NRC.

When a license determines that the existing monitoring program needs reevaluation, Figure 1-2a provides an outline of the areas it should review. More information about each item in the figure is contained in Table 1-2a. Additional monitoring may be required at these facilities if significant residual radioactivity is detected. The monitoring techniques are discussed in Sections 2 through 4.

Figure 1-1. Determining If Monitoring Changes are Required

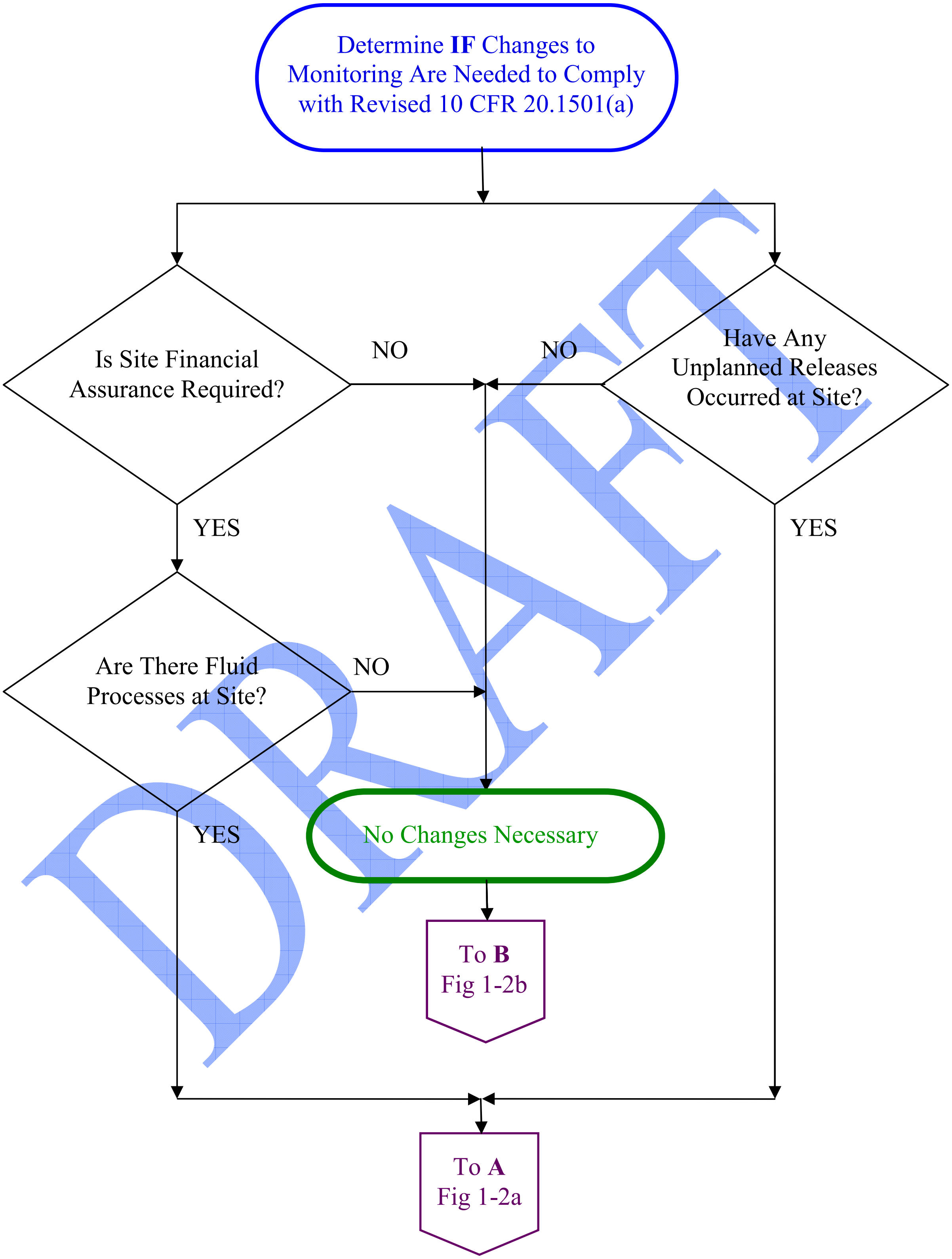


Table 1-1. Description of Figure 1-1.

Financial Assurance	FA is an indication of the volume of radioactive materials on site and thus closely related to the potential cost to remediate the site.
Fluid Processes	Fluids (liquids and gases) disperse much more readily than do solids. However, particulate dispersion should also be considered.
Unplanned Releases	If unplanned releases have occurred in the past at a facility, that demonstrates that failures of systems or procedures can occur there. Detection in an existing well does not necessarily provide enough information to identify the location of the source of the release.

Figure 1-2a. Determining Appropriate Monitoring Requirements

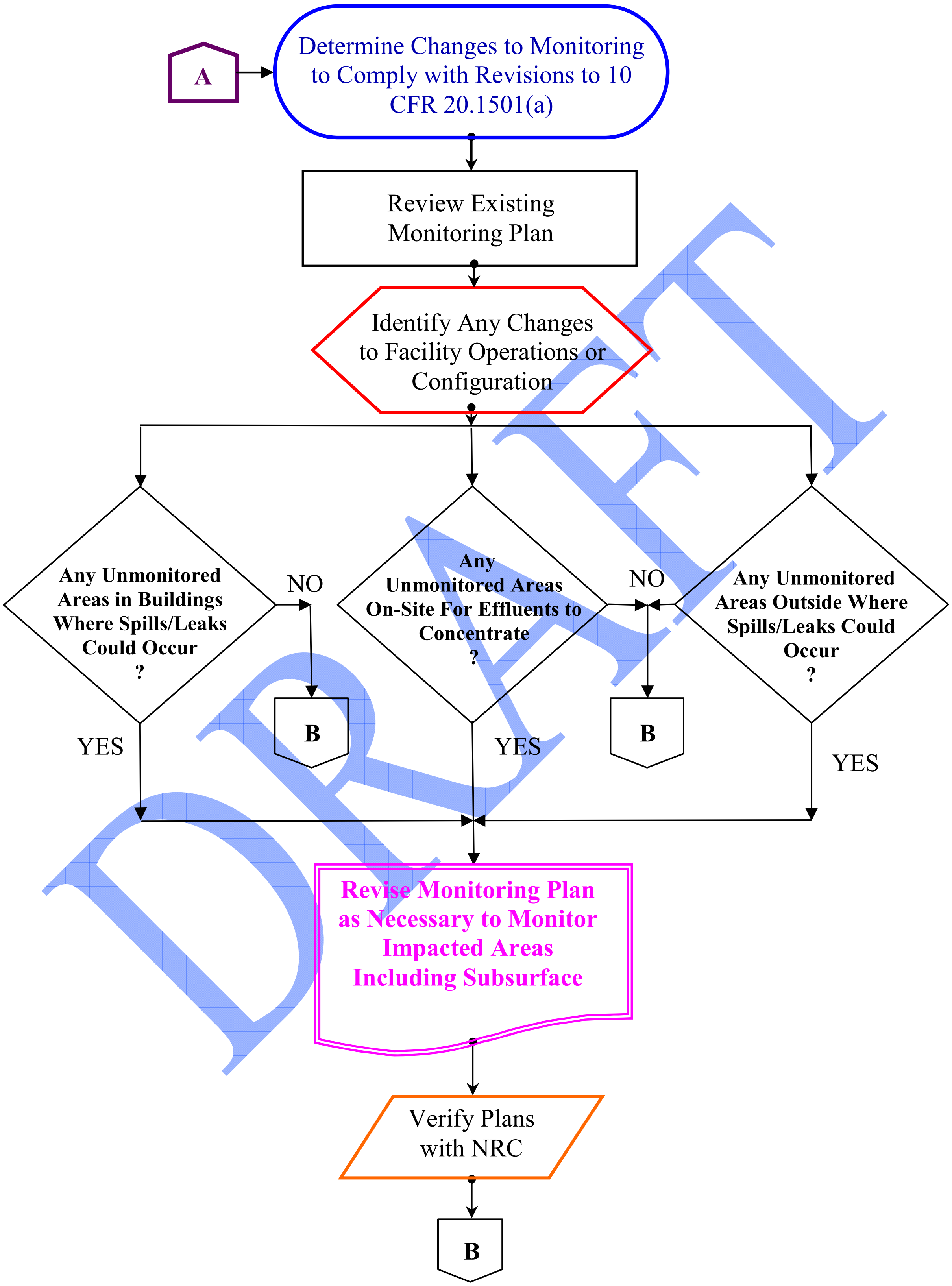
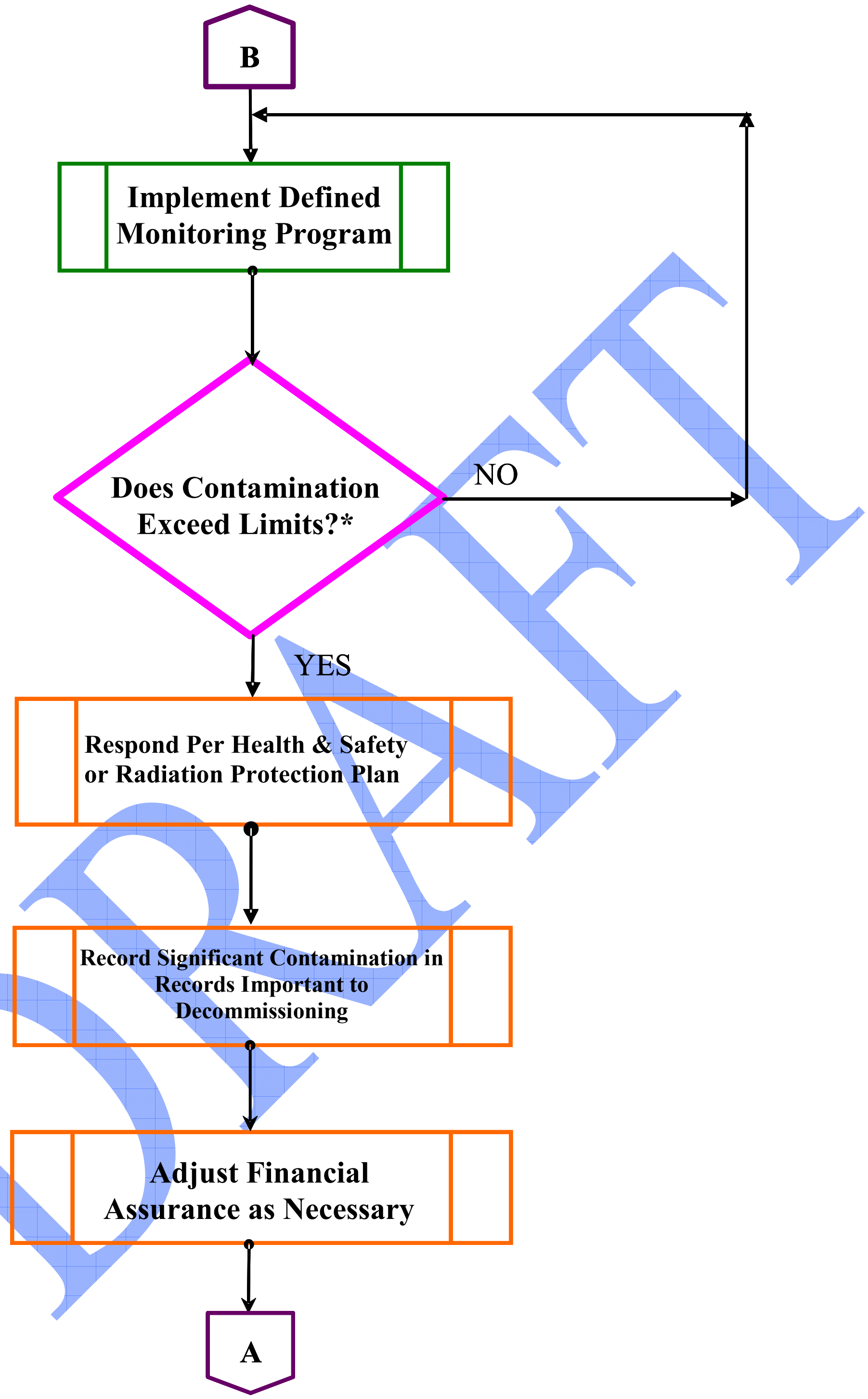


Table 1-2a. Description of Figure 1-2a.

Changes to Facility or Operations	The primary focus of the review of the existing monitoring is to identify any changes to the physical facility or to the operating procedures since the last revision to the plan. These changes may require associated change(s) to the plan to ensure full coverage.
Unmonitored Areas in Buildings	Review the plans against the physical facility to identify any areas within each site building that may not be properly monitored.
Unmonitored Areas Outside Where Spills/Leaks Could Occur	Review the plans against the physical facility to identify any areas outside of the facility building that may not be properly monitored, including subsurface transfer lines, §20.2002s, and waste storage areas.
Unmonitored Areas On-Site For Effluents To Concentrate	Evaluate the entire site to determine if there are areas where planned or unplanned releases could accumulate and concentrate. These include natural low spots in the terrain and areas where there are hydraulic barriers such as footers and highly compacted regions.
Verify Plans with NRC	While NRC does not formally approve such plans, it strongly recommends that licensee verify the revised monitoring plans with the staff to ensure they meet NRC expectations for operating facilities AND meet regulatory requirements to demonstrate the condition of the site at the time of decommissioning.

Figure 1-2b. Determining Appropriate Monitoring Requirements



* Contamination exceeds limits if it is above a License Action Level, or if it exceeds a regulatory limit, or if it would exceed the 10 CFR 20.1402 unrestricted use criteria of 25 millirem/year TEDE at the time of decommissioning.

Table 1-2b. Description of Figure 1-2b.

Is Contamination Detected at Levels Greater Than Action or Regulatory Limits	Do the results of sample analyses show that current concentrations at the sample points exceed licensee-specified action levels, or exceed regulatory limits?
Respond per H&S Plan; Increase Monitoring	Existing plans should define licensee responses to all identified exceedences; the actions may range from reporting to NRC to conducting prompt remediation of the area. The plans should include criteria by which the actions are selected.
Record Significant Contamination in Records Important to Decommissioning	Each license type has requirements for maintaining records, including occurrences of spills and leaks, that are important to decommissioning the facility (e.g. §40.36(f), §50.75(g)). As discussed in this guidance, "significant contamination" is that which would require remediation to meet unrestricted release limits at license termination. Releases ≥ 100 g are defined in this category. Repeat events should also be recorded. Licensees may measure actual concentrations and account for decay, or they may do a calculation using RESRAD or other code to determine dose at the time of license termination (See ¶4 of this Guide).
Adjust Financial Assurance	If the above analyses indicate remedial activities in excess of that currently planned, the results must be factored into the periodic review of financial assurance, and the increased cost reflected in the value of the financial instrument(s). If a licensee elects to conduct prompt remediation using operational funds, the resultant decrease in decommissioning costs may also be incorporated.

2. COMPLIANCE WITH NEW §20.1406(c)

Although facilities are designed to maintain system integrity under expected operation and upset conditions, facilities with fluid processes occasionally have unplanned and uncontrolled leaks or spills. Generally, these spills are of limited volume, confined or captured by design features of the facilities, and the residue is promptly cleaned up. Occasionally there may be a spill that either exceeds the confinement capability of the facility or occurs in an unconfined area and migrates into the environment. Examples include leaks from below-grade storage vessels or particulate filter systems, and on-site disposals (e.g., §20.2002). In other cases, radioactive fluids may be reintroduced onto the site and concentrate in the subsurface after discharge through a monitored effluent pathway, either by anthropomorphic or natural processes. Once in the environment, the contaminants may migrate or be transported (by air, ground water, mechanically, etc.) resulting in a potentially large volume of residual radioactivity in the subsurface that requires remediation before license termination. The cost of this remediation can be significant, perhaps millions of dollars, so it is important to identify the contamination early and include the cost in decommissioning planning [See Section 4 for a discussion of prompt vs. delayed remediation].

Because of potential for such releases, licensees should evaluate facility design and operations, using a risk-informed approach, to identify events leading to them. Licensees should establish a program to monitor facility performance and provide early identification of unplanned releases. Lessons learned from staff experience in nuclear power plants have been compiled in DG-4012 "Minimization of Contamination and Radioactive Waste Generation - Life Cycle Planning." While the focus of this guide is on new nuclear reactor design, many of the ideas are useful for all types of facilities with radioactive fluid processes. They can also be implemented when a licensee decides to modify its plant.

2.1 EVALUATING PROCESS CONFIGURATION

In the experience of the staff at decommissioning facilities, processes that handle large volumes of fluids leak during the operational lifetime. These leaks emanate primarily from storage tanks and ponds and transfer lines. Design for the facility should include a variety of confinement measures, such as curbs and sumps, to contain these events. It should also have appropriate instrumentation to alert facility operators when an event occurs. This instrumentation should include process level and pressure measurements, area moisture detectors and sump level indication. This is especially important for the portions of systems that are not available for visual inspection. One of the principles of system design should be to reduce, to the extent practicable, opportunities for undetected leaks and spills to occur.

If items for improvement are identified during the evaluation of the areas discussed below, they should be recorded and, if appropriate, added to the facility's corrective action plan.

2.1.1 Process Vessels and Connections

Process vessels should be of size and materials to contain all foreseeable process upsets without uncontrolled releases throughout the design life of the facility. The potential upsets should include changes in pressure, temperature, rate of change of process, volume, pH, etc.

Overpressure relief systems should drain to a sump, or similar facility, that is sufficiently large to contain all discharges. Occurrence of fluids in these areas should trigger some notification to facility operators, such as a local or remote alarm.

For piping that connects processes, licensees should be aware that irregular fittings (elbows, tees, etc.) are more likely to leak than straight runs of piping, and establish monitoring accordingly. As with vessels, the materials should be designed to perform and maintain integrity for the expected plant life and range of upset conditions. The piping routes should be amenable to inspections, consistent with occupational exposure and other operational considerations. Where visual or other inspection is not practical, multi-wall pipes or other leak detection mechanisms should be utilized.

2.1.2 Instrumentation

Process instrumentation (pressure, level, etc.) should be sufficiently sensitive to detect small system losses, and such loss should trigger notification (e.g., alarm) to the operators. Such process parameters should be recorded in a way that facilitates identification of cumulative system change over time. These alarms may be local for areas on the facility that are routinely occupied or inspected; otherwise, they should go to a central, monitored station.

Moisture monitors and alarms should be used in areas not readily available for visual inspection, such as subsurface pipe chases. Facility construction could include a french drain arrangement, e.g., around all building footers, and have collection sumps with detection and alarm capability and automatic pumping to a liquid waste management system.

Level or moisture detection instrumentation in sumps and bermed areas should promptly identify the presence of liquids and issue a notification to operators. The operators should respond according to existing Health and Safety, and Radiation Protection Plans.

Licensees and applicants may choose to incorporate leak detection devices directly on components that have the potential to release radioactive material to the outside environment within the site boundary. These devices may be used in place of subsurface sampling until releases are detected, at which time sampling may be necessary to determine the extent of migrations.

2.1.3 Sumps and Berms

Sumps and berms should be installed throughout the facility and provide sufficient confinement capacity for all potential leaks. Each should be equipped with moisture or level detection and notification instrumentation; automatic recording is desirable.

2.2 OPERATING PROCEDURES

Licensees should develop procedures that include periodic inspections or walk downs of the facility to identify potential system leaks and process spills. Areas not routinely observed, but having potential to accumulate liquids, should be especially noted. The procedures should also specify criteria for conducting prompt (e.g., < 4 hours) cleanup, and the site-specific criteria by which the occurrence should be entered into the decommissioning files (§30.35g, §40.36f, §50.75g, etc.). These criteria should be based on limits for total volume released; total activity; residual contamination after remediation; potential for unobserved seepage into joints, cracks, or other openings in floors or other surfaces; potential for migration through the subsurface; and approximate cost to remediate the potentially contaminated volume at the time of license termination.

2.3 CRITERIA FOR SUBSURFACE CONTAMINATION RECORD KEEPING

For subsurface contamination purposes, only those nuclides that have properties that cause them to contribute to biosphere contamination and may cause increases in decommissioning costs need to be considered. These properties include, but are not limited to, high specific activity and high solubility. To be included in records important to decommissioning, the nuclides must be in quantities sufficient that they either:

a) create a potential to increase exposure of workers, or
b) remain in place in concentrations above the values in Table 2 of Appendix B to 10 CFR 20 or Appendix I to 10 CFR 50, or
c) migrate to the site boundary in concentrations that could exceed facility-specified action levels, or regulatory limits.

In the case where remediation is indicated in order to terminate the license, these licensees, except those under 10 CFR 50.75(c), should promptly revise the decommissioning cost estimate to account for the revised remediation effort to reach unrestricted use criteria at license termination.

Also, licensees must act to ensure compliance with worker and public exposure limits in NRC and EPA regulations. These actions could include interim remediation of contaminated areas, or interdiction of contaminant migration (e.g., extraction wells or interceptor trenches).

Considerations for this evaluation include total volume of material that could be released without an alarm, the half life of each isotope that could be released, and the physical and chemical characteristics of each isotope that affects mobility in the subsurface. In considering courses of action, licensees may evaluate the effects of occurrences of events, and the magnitude of the consequences of these events.

3. COMPLIANCE WITH REVISED §20.1501 (a)

The previous section addresses monitoring and detection methods to identify leaks and spills that could occur within a facility. However, there are situations in which leaks or spills may migrate to or occur outside of the process buildings. For example, there have been leaks identified in nuclear plant transfer lines, and from subsurface burials. Storage ponds or burials may leak, other spills or leaks may exceed the confinement capacity or they may occur in unconfined areas, and contaminants are released to the subsurface. This section describes how to determine where a release of contaminants may be transported. To do this, licensees must have a method of identifying the location of the source(s) and a model of the transport mechanisms and paths. This knowledge is also necessary to identify sampling locations and appropriate mitigation actions.

3.1 WHAT MAY CHANGE FOR LICENSEE SURVEY AND MONITORING REQUIREMENTS?

All licensees are currently required by Subpart F of Part 20 to conduct surveys that are reasonable under the circumstances to evaluate potential radiological hazards. In the case of subsurface contamination, site conditions and the results of the surveys may compel the licensee to conduct a more comprehensive site characterization to better define the hydro-geologic units beneath the site, and to implement an enhanced monitoring program to identify the occurrence of leaks or spills and define the extent of any release to the subsurface.

Within existing Health and Safety or Radiation Protection Plans, licensees specify their monitoring and sampling requirements. To start, they measure background, which is deducted from sample results. Licensees currently have instrumentation of sufficient sensitivity to do this type of sampling. Some licensees also have site-specific criteria applied to the release of radioactive material from the site. These licensees currently have specified instrumentation, minimum detectable concentrations, and procedures required for this type of surface sampling. Nothing in this Decommissioning Planning proposed rule would alter any of that.

Many licensees have environmental monitoring programs, including the subsurface, which specify sampling and analyses protocols. Again, nothing in the proposed rule would change those protocols.

To reiterate the definition of residual radioactivity, it includes that from all activities under the licensee's control. Therefore, what may change in monitoring programs to add the objective of identifying unplanned releases includes the following, depending on site-specific conditions:

- number of sampling locations
- frequency of subsurface sampling
- number and type of nuclides for analyses
- sensitivity of measurements
- in-plant system and component monitoring for leakage

Section 4 of this Guidance has additional details for these topics. Also, some record keeping practices may need revisions to ensure the results of these surveys are retained with records important to decommissioning. Together, the amended §§ 20.1501(a) and 20.1406(c) specify that compliance with 10 CFR Part 20 survey and recordkeeping requirements is a necessary part of effectively planning for decommissioning.

3.2 SITE PHYSICAL CHARACTERIZATION

The first step in this process is to adequately characterize the subsurface of the site.

The goal of site physical characterization is to develop an understanding of the structure and properties of the subsurface environment in the vicinity of the site. The preferred time for complete site characterization is prior to construction of the facility. This must be done for large facilities to determine where and how to construct major components of the facility. The characterization documents should be updated after each event at the site that can affect the subsurface. These include on-site construction, nearby off-site construction, changes in ground water use such as increased (or decreased) agriculture or residential development, and seismic events. This is a predecessor to the radiological characterization that should occur during plant operations, and is a requirement for decommissioning. This may be accomplished by one of two types of subsurface investigation.

3.2.1 Steps in Characterization

First, there is a conceptual subsurface investigation. This is normally limited to geologic reconnaissance and some sampling, and field identification of subsurface conditions to achieve generalized site characterization. There are also general observations such as the depth to rock, competent soils, or ground water units; presence of sinkholes and/or solution cavities; organic deposits in low lying swampy areas; and evidence of any fill, debris, or contamination. Conceptual investigations require limited laboratory testing and largely depend on the description of subsurface conditions from boring logs prepared by an experienced field engineer or geologist.

Second, and the more common type of subsurface investigation, is the detailed investigation performed for the purpose of defining site characteristics to be used for facility final design. The initial stage is performed early in the design process prior to specifying the proposed structure elements or the specific locations of foundations. This investigation typically includes a limited number of borings, and testing sufficient for defining the general stratigraphy, soil and rock characteristics, groundwater conditions, and other existing features of importance to foundation design.

A third phase of investigation is performed to obtain specific subsurface information at the final substructure locations for design purposes and to reduce the risk of unanticipated ground conditions during construction after the locations of facility structure foundations and other design elements have been determined. Additional stages can be considered if local subsurface anomalies, such as backfill around buildings, buried pipes, subsurface storage (e.g., rad waste), warrant further study, or when there are significant design changes. When properly planned, this type of multi-phase investigation provides sufficient and timely subsurface information for each stage of design while limiting the cost.

Accurate characterization of site conditions is essential to demonstrate compliance with release criteria for license termination. Subsurface data collected during facility siting may not be sufficient for contaminant transport calculations, which require a comprehensive definition of the subsurface hydro-geology. Specific information on thickness and areal extent of all of hydro-geologic units and possible connections among them is also required. The vertical depth to which detailled characterization is required will be determined on a site-specific basis, but generally, it should be to an impermeable lower aquaclude.

3.2.2 Site Characterization Methods

Each soil unit has characteristics such as density, pore space, fracture pattern, and chemical state that affect contaminant transport. These must be identified for all units underlying the site for use in defining contaminant transport paths and rates, and sampling schemes.

Because ground water is the most common medium for dispersing radiological contamination through the subsurface, it is the primary focus of the following sections. Because each aquifer has its own characteristics, including flow rate and direction, it typically takes four to six wells to characterize each aquifer. Table 3-1 below identifies the types of data required for characterization, the uses of that data, and potential sources for this information.

Table 3-1. Hydro-Geologic Site Characterization

FUNCTIONS	INFORMATION NEEDS	SOURCES
Define GW regimes Define drilling method(s) Define well completion type	Type(s) of geologic materials throughout site	USGS regional geology State GS
Define monitoring zones: well location & depth screen length, depth need for multi-level sampling	Location, depth, thickness of preferential flow paths (high-Kd zones), incl. vertical; Level and fluctuation of water table(s)	State, US GS Site characterization activities
Define well construction and operation materials (casing, pumps, screens, seals, etc.)	Ambient GW quality (pH, Cl, O2, TDS, etc.) Existing contaminants & concentrations	Site characterization activities

Drilling wells serves two purposes: 1) provide site specific hydro-geologic characterization, and 2) provide a means to monitor changes in ground water characteristics. Some of the geophysical tests such as surface resistivity, ground penetrating radar, and electromagnetic conductivity are commonly used because they are effective in establishing ground stratigraphy, detecting sudden changes in subsurface formations, and locating cavities in karst formations. Mechanical waves include the compression (P-wave) and shear (S-wave) wave types that are measured by the methods of seismic refraction, crosshole, and downhole seismic tests. These can provide information on the dynamic elastic properties of the soil and rock for a variety of purposes. In particular, the profiles of shear wave velocity are required for seismic site amplification studies of ground shaking, as well as useful for soil liquefaction evaluations. Disturbed samples are obtained to determine the soil type, gradation, classification, consistency, density, presence of contaminants, stratification, etc. Samples are considered "disturbed" when the sampling process modifies their natural structure. Disturbed samples may be obtained by hand excavating methods by picks and shovels, or by truck-mounted augers and other rotary drilling techniques.

Undisturbed samples are those whose structure is not altered during sample collection. Examples include cores from sonic or direct push drilling. They are used to determine the in-place strength, compressibility (settlement), natural moisture content, unit weight, permeability, discontinuities, fractures and fissures of subsurface formations. Serious inaccuracies may be introduced into the characterization if proper protocol and care is not exercised during recovery, transporting or storing of the samples.

In-situ methods can be particularly effective when they are used in conjunction with conventional sampling to reduce the cost and the time for field work. Certain tests, such as the electronic cone penetrometer (CPT), provide information on subsurface soils without the effects of sampling disturbance, and data are collected in real time. Stratigraphy and strength characteristics are obtained as the CPT progresses in the field. Because all measurements are taken during field operations and there are no laboratory samples to be tested, there may be considerable time and cost savings.

The frequency and spacing of borings will depend on the variability of subsurface conditions, type of facility, and the investigative phase being performed. For conceptual design studies in areas of generally uniform or simple subsurface conditions, very wide boring spacing, perhaps several hundred meters, may be acceptable. For preliminary design purposes, a closer spacing is generally necessary, but the number of borings would be limited to that necessary for making basic design decisions. For final design, however, relatively close spacing of borings may be required. This data should be readily available for purposes of evaluating extent of contamination at the site. If it is not, additional subsurface characterization may be necessary.

Drilling and logging techniques should be selected to optimize data collection at the site. There are discussions of these in the references.

Once a licensee has defined the facility subsurface, it can establish a monitoring plan to identify and manage subsurface contamination.

3.3 SUBSURFACE MONITORING

The subsurface is considered to be soil type material greater than about 15 centimeters below the surface. Once the subsurface has been fully characterized, it should be monitored to identify any changes. Monitoring of variables such as moisture content, porosity, density, etc. should occur on a routine basis throughout the plant life, ideally from preconstructing to license termination. This routine monitoring should be supplemented for occurrences such as any on-site construction, seismic events that could disturb the regional hydro-geology, unusually heavy rainfall, extended periods of no rainfall, etc. Because subsurface monitoring has typically been more limited than other types of at nuclear facilities, more detail is included in this part of the guidance.

3.3.1 Subsurface Soil Monitoring Plan

There are two essential elements to subsurface soil monitoring plans: locations of sample taking, and methods of sample taking.

3.3.1.1 Determine Locations of Sampling

The first step in developing a subsurface soil monitoring program is to determine the areal extent of the contamination. For purposes of this guidance, it is assumed that the isotopes of interest are insoluble, therefore the initial distribution occurs from airborne dispersion, physical transport (e.g., truck), stockpiling (dumping), or subsurface disposal. Subsurface lateral migration occurs by mechanical means such as excavation, erosion, adherence to vehicle tires, etc. To determine the areal extent of such contamination, the guidance in Chapter 5 of NUREG-1575 (MARSSIM), especially § 5.2, is useful. If there is no surface contamination identified, no on-site subsurface disposals, and no contaminant or waste transport across the site, licensees should document that there is no basis for additional soil sampling for subsurface contamination at the site.

Next is to determine the vertical extent of contamination. The depth to which the insoluble contamination exists depends strongly on the method of disposition, soil characteristics, and surrounding activities. For purposes of estimating remediation requirements to meet unrestricted use criteria and the associated cost during facility operation, reasonable assumptions about the depth are appropriate. For example, migration of insoluble contaminants would not be expected much below the bottom of a planned disposal area. If there is soil-type deposition on a bedrock formation, insoluble contaminant migration below the interface is also unlikely. However, long term erosion, even on slopes of a few degrees, can further disperse insoluble contamination both laterally and vertically.

Finally, the location and frequency of sampling must be defined. Because the purpose of sampling during operations is to obtain a reasonable estimate of the type, extent, and concentration of contamination, high density sampling is not necessary. Biased sampling in areas expected to have the highest concentrations is acceptable. Additional samples in adjoining areas are also recommended. Concentration averaging is also acceptable for these estimates. The mechanics of soil sampling are strongly dependent on the soil characteristics. For example, in a clay or silt soil, a direct push approach may be adequate. For a rocky matrix, a form of rotary drilling may be necessary. Access to the area by such drilling rigs is an important consideration in planning the program. Further, the existence of subsurface utilities (power, water, communications) also constrains the location of drilling. Because there are few things that contribute to subsurface migration of insoluble isotopes, this sampling can occur infrequently. The schedule should include consideration of events such as new disposals, identified but unplanned releases, and physical events affecting the subsurface (seismic, erosion, etc.).

3.3.1.2 Soil Sampling Procedures

The most important consideration in subsurface soil sampling is that the sample is representative of the subsurface conditions. Also, the measurement uncertainty is strongly dependent on the sampling technique, including collection, preservation, and transportation to the analysis laboratory. The collection technique must correlate with the analysis technique. The U.S. Department of Energy Environmental Measurements Laboratory provides sampling guidance in HASL-300, "EML Procedures Manual." Analysis guidance is provided in NUREG-1576 "Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP)."

3.3.2 Ground Water Monitoring Plan

Monitoring of variables such as water level, pH, total dissolved solids, etc. should occur on a routine basis throughout the plant life, from preconstructing to license termination. This routine monitoring should be supplemented for occurrences such as unusually heavy rainfall, extended periods of no rainfall, any seismic events that could disturb the regional hydro-geology, etc. Supplemental monitoring should also be implemented when there is a change in use of ground water or surface water in the area. Examples include dam construction (or destruction), new or expanded agriculture water uses, and housing or industrial construction in the area.

3.3.2.1 Objectives of the Plan

Because ground water (GW) is the agent for dispersion of subsurface contamination, it is monitored as an indicator of site conditions. Other media, soil or sediments for example, may be monitored or sampled for specific purposes, such as installation of new below-grade facilities, or estimating volumes that must be removed to meet site release criteria. The first step in developing a ground water monitoring plan (GWMP) is to define the specific objectives of the plan. Typical objectives of such a plan include the following:

a. Establish Site Baseline Environmental Conditions
   i. Lateral and vertical extent of all "aquifer(s)" beneath the site
   ii. Water levels of each "aquifer"
   iii. Water chemistry of each "aquifer"
   iv. Matrix (soil, rock) chemistry for each "aquifer"

b. Define Variations in Environmental Conditions
   i. Natural (seasonal, tidal, phenomenal — fire, flood, etc.)
   ii. Man-induced (land development, change in GW use, etc.)

c. Define Direction and Rate of Flow (x, y, z) in each "aquifer"

d. Identify Existence and Extent of Contamination Before Facility Construction
   i. Types
   ii. Concentrations
   iii. Potential sources

e. Evaluate Extent of Contamination from the Facility Throughout Life
   i. Concentrations
   ii. Volumetric extent
   iii. Rate and direction of movement (x, y, z)

f. Determine the Source(s)/Location(s) of Facility-generated Contamination
   i. Internal (Process Components)
   ii. External (Storage Ponds, §20.2002, etc.)

g. Define Long-Term Trends of Contaminant Distribution in 3-D

h. Demonstrate Compliance with Applicable Regulations
   i. NRC
   ii. Environmental (EPA, State)

i. Develop and Validate Site Conceptual Model for Performance Assessment

Important parameters of a site conceptualization model include the following:

- Solubility of the radionuclides in the site-specific media, which includes accounting for effects on nuclide-specific rates of migration from interaction with other contaminants, especially organics, in the area of the spill and downstream.

- Three dimensional modeling of ground water movement. Vertical migration is often more difficult to determine than is lateral migration, but it is important, especially if there are additional ground water aquifers around the spill.

- The rate at which contaminants are introduced into the subsurface. In the case of a spill, the volume is fixed, but in the case of a process leak, there is essentially an infinite supply, until it is isolated. These conditions have a strong influence on the total volume that must be considered for remediation.

- The effects of radioactive decay. This includes the introduction of daughter products into the environment, where the daughter products may have different migration characteristics than the original nuclides.

Additional guidance on developing ground water monitoring plans is available from the EPA. Criterion 7 of Appendix A to 10 CFR 40 provides additional information on staff considerations when evaluating a ground water monitoring plan. A flow chart for developing a ground water monitoring system is shown in Figure 5-1 below.

The GW monitoring plan should include a definition of the events to be detected, the contaminants of interest, and the concentrations at which action is required. The events should be those that have potential to cause migration of nuclides away from the spill or leak area, either migrating to the site boundary or causing an increase in volume of areas requiring remediation to meet unrestricted use criteria. For example, radionuclides like tritium move with the speed of the ground water while others, like Cesium-137 move much more slowly. Therefore, the frequency of sampling may need adjustment to account for these differences. These parameters help define well number and location, and sampling frequency.

The contaminants of interest are those used within the facility with half lives long enough that a) if they remain on site will be in concentrations in excess of unrestricted use criteria; or b) if they migrate beyond the site boundary, may do so in concentrations that could cause a dose exceeding regulatory limits to a member of the public. This requires a computation of decay and transport as well as a definition of potential land use(s) and users and the dose pathways beyond the site boundary. Contaminants may also include both chemicals and radionuclides in the ground water from sources upstream of the site because of the potential for interaction with site releases.

3.3.2.2 Implementing a Ground Water Monitoring Plan

To be effective, a Ground Water Monitoring Plan (GWMP) must have wells accurately placed (in all three dimensions) and properly installed. It must also have an effective sampling and analysis scheme (frequency, isotopes for analyses, counting times, etc.). In addition to background wells to measure ambient conditions, there must be wells downstream of all potential release points; these include locations in the nominal ground water flow direction and in preferential flow paths for each "aquifer." The wells should be close enough to the release points that, in conjunction with the planned sampling and analyses program and transport calculations, contamination can be identified and the need for remediation evaluated and implemented, if necessary, before the contamination could migrate beyond licensee control. The locations and number of wells, sampling frequency, or range of analyses may need to be increased following a release event. Additional guidance on developing ground water sampling is provided by the EPA.

3.3.2.3 Well Location

Without knowing the characteristics of each aquifer first, the exact placement of these wells is not known. A reasonably conservative approach is five wells, one at each "corner" of the site, and one in the middle. If the aquifers are not fully characterized using data from these wells, additional wells would be needed. The locations of these are a function of the results from the first five. Locations are site-specific and depend on knowledge of regional hydrogeology and the topography of the site. Licensees should keep in mind that there may be more than one water-bearing zone beneath the site, and the characteristics of each, including flow direction, may be very different. Therefore, care should be used not to introduce flow or migration paths among them by the drilling program. Initial placement of characterization wells to be used for establishing background conditions should be up gradient of the planned facility, based on regional geology. Additional wells are located from the interpretation of the well logs and sampling information from the "background" wells. Final well placement is based on a thorough understanding of the subsurface and the location of potential contaminant sources. These sources include process and storage tanks, transfer lines, process and waste ponds, and any potential subsurface disposals (e.g., §20.2002).

Figure 3-1a. Developing a Ground Water Monitoring System.

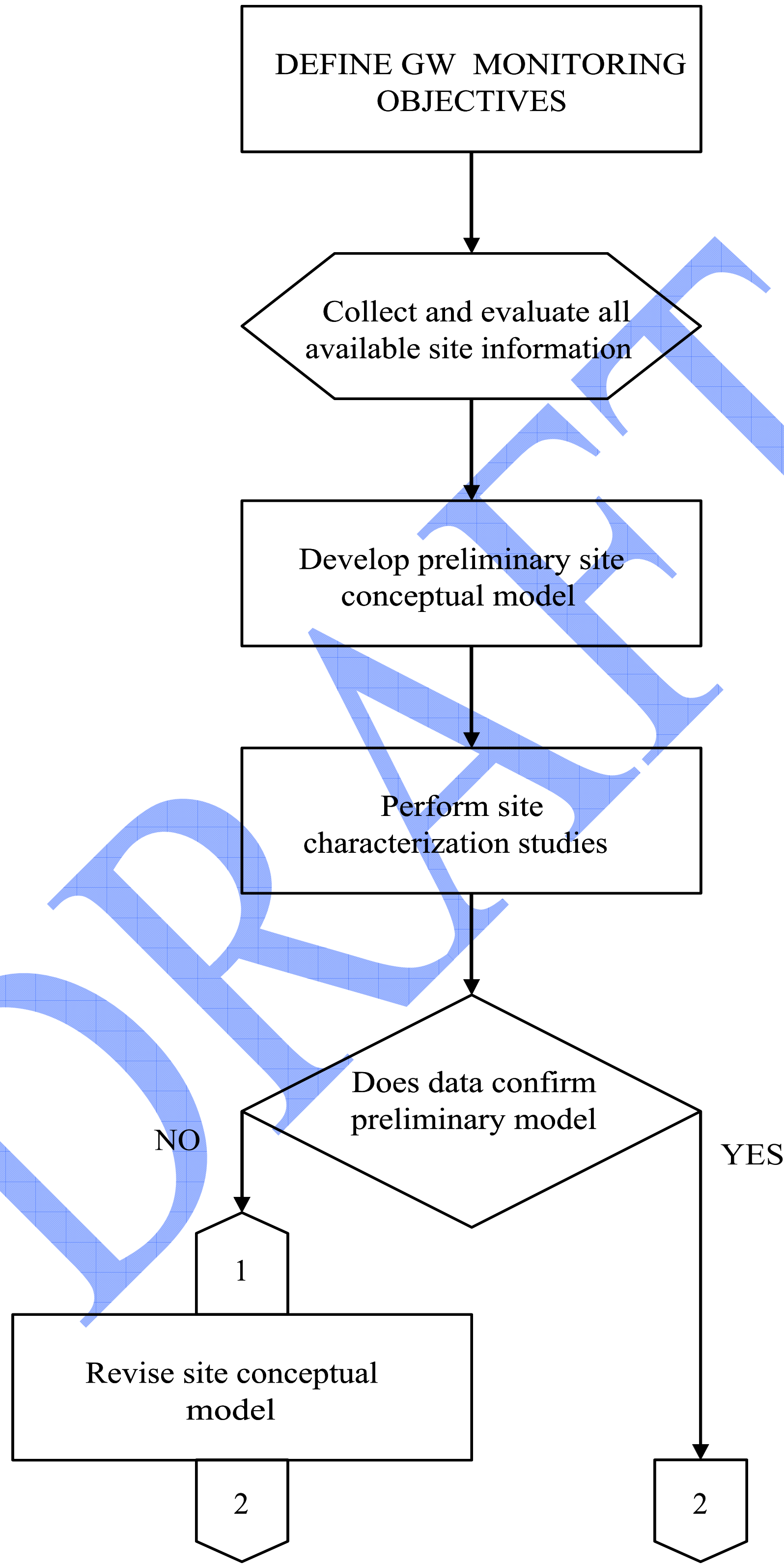


Figure 3-1b. Ground water Monitoring

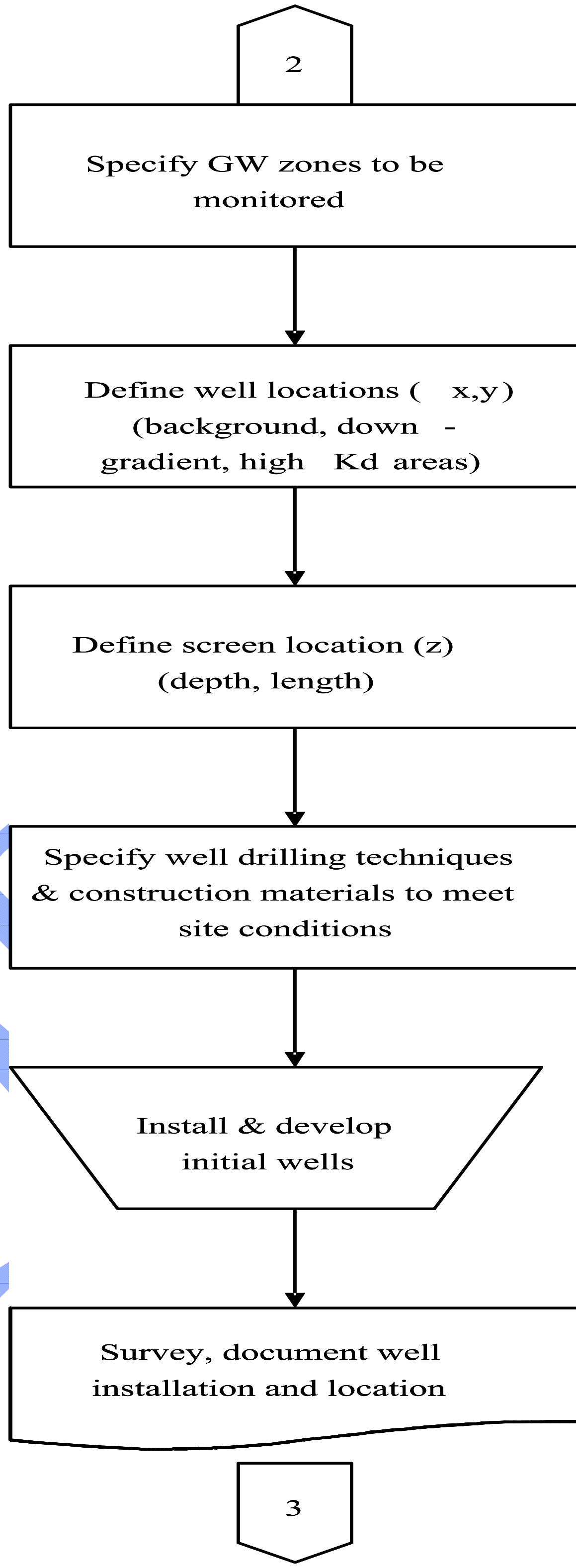
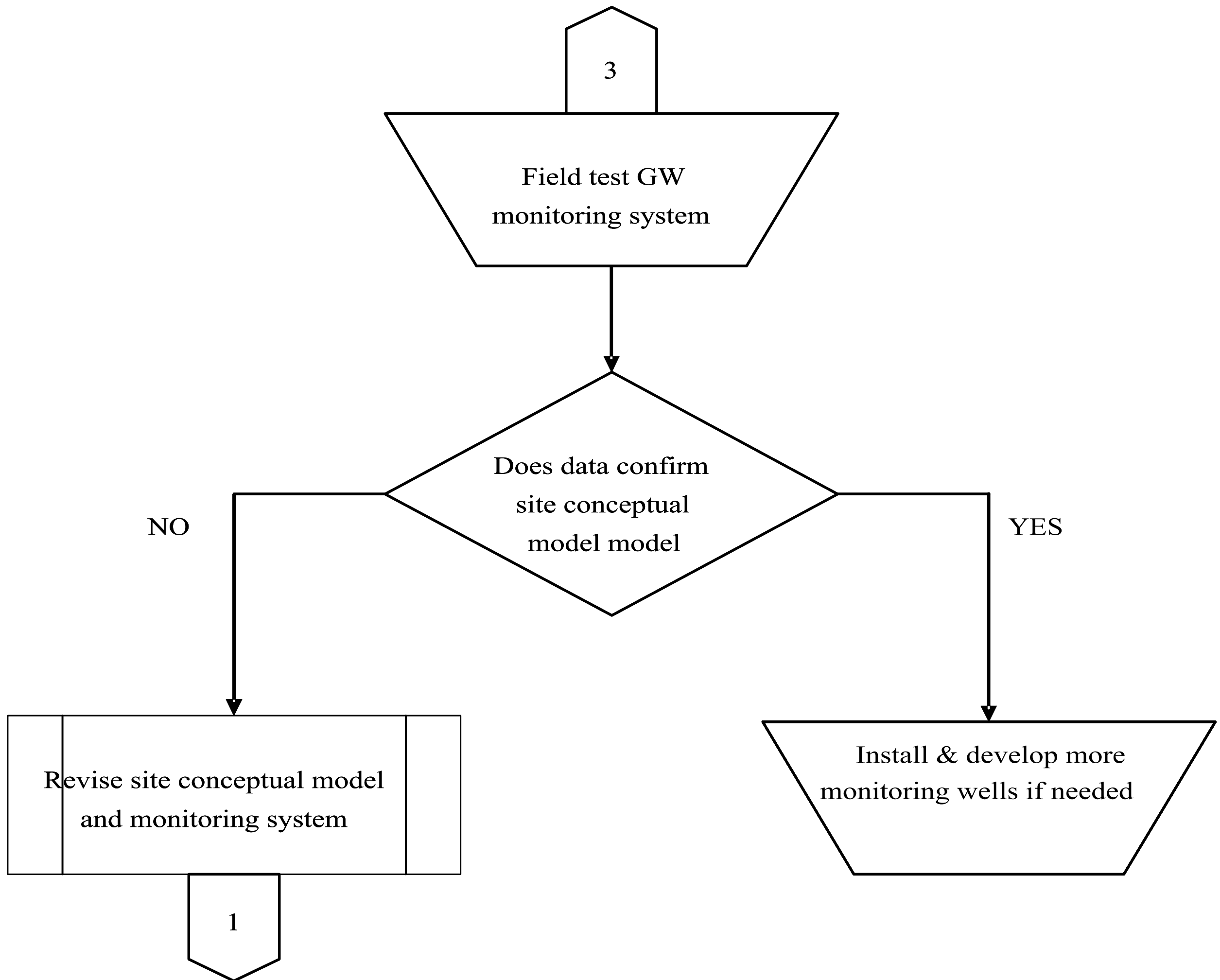


Figure 3-1c. Ground Water Monitoring



3.3.2.4 Sampling Frequency

Once the hydro-geologic regime has been adequately characterized, it must be monitored to identify changes. The most obvious change of interest is any increase in concentration of any radionuclides from the facility. However, there are other changes there are equally important. These include changes in water chemistry that may affect the solubility and transport of radionuclides; seasonal changes in water levels, flow rates and flow direction, including vertical, that effect dispersion; and the effects of natural and man-made events such as flood, drought, and additional construction on the site, or in the nearby off-site.

Thus, there are two parts to a monitoring program: the specification of how often each well is sampled, and the specification of the suite of contaminants for which each sample is analyzed. Once a baseline, including predictable changes such as seasonal changes, is established the program is structured to identify changes. Those wells that reflect known changes can be sampled on a routine basis, at times when such changes are expected. If there are radionuclides or chemicals in the process that are representative and relatively simple to identify, they should be used as indicators of potential releases to the subsurface. If unexpected changes are identified, in either frequency or range, the program should specify additional sampling to define the changes and the sources of change.

The monitoring program should define the sampling frequency for each well based on geological and meteorological conditions. A monitoring program might sample water level, temperature, and pH in a few wells (4-6, including upstream of the facility) on a quarterly basis. Additional routine samples in locations where releases could occur might be analyzed for representative process materials and gross radioactivity semiannually. If no facility-related isotopes are identified in the routine sampling, the license should document this absence. Sampling frequency may be adjusted accordingly.

If an identified event occurs, either natural or man-made, the appropriate samples should be taken and analyzed promptly. Additional sampling and analyses should be done at an increased frequency, e.g., weekly to monthly, until the effects of the event are defined.

3.3.2.5 Analyses

A facility may release several isotopes with very different characteristics (e.g., transport attributes and the type and energy of the radioactive decay mechanism). While it may not be necessary to analyze for each isotope in each sample, the analysis plan should specify what analyses should be done on each sample, and at what frequency. Often, there may be simpler, less costly analyses that provide information on the rate and direction of flow of all soluble isotopes. These may be used as effective indicators of the average condition of the site, and should be performed regularly. Broader, isotope-specific analyses should be conducted on a periodic, though less frequent, basis to define actual conditions.

3.4 QUALITY ASSURANCE

Quality assurance of all subsurface samples should be maintained in accordance with existing QA/QC plans and procedures. Guidance is available in NUREG-1575 (MARSSIM) Sections 7.2, 8.2, and 9, and in Regulatory Guide 4.15 "Quality Assurance for Radiological Monitoring Programs (Inception Through Normal Operations to License Termination) — Effluent Streams and the Environment."

4. RESPONSES TO A CONTAMINATION EVENT

Licensees should develop a plan and implementing procedures to respond to events that result in an unplanned release of radioactive material. This plan should encompass all credible events identified in the event analysis, from small contained spills or leaks to major releases on or off the site, and specify the response actions. Sections 4.1 and 4.2 discuss assessment and response activities. Section 4.3 describes methods to determine if the contaminating event meets regulatory criteria that would require the licensee to submit a revised decommissioning funding plan and adjust decommissioning financial assurance for the licensed facility. A cost-benefit analysis, with examples, is presented as an approach that can be used in the decision-making regarding the value of prompt cleanup compared to delayed cleanup.

4.1 CHARACTERIZATION OF EVENTS

In the event of an unplanned or uncontrolled release, it is important to identify the source and "fix" it promptly. For spills, this basically means understanding the hazards associated with the spill, and cleaning them up, or containing the migration. Responses can range from an immediate cleanup of occupied areas to waiting for the next scheduled maintenance to clean out a sump.

Leaks and unplanned releases are more complicated than spills. Ideally, the licensee is able to identify the location of the leak or release, the area can be surveyed, and the contamination remediated with follow-up surveys to demonstrate the absence of a radiological hazard. In cases when the location of a leak is in an inaccessible area that does not allow radiation survey and repair activities, licensees should consider reducing the use of the line, or changing operational parameters, such as flow rate and pressure, to minimize the rate of leakage until it is reasonable to access the area for repairs. The licensee should balance the decision to perform survey and repair activities against the potential to compromise safe operation of the facility. For example, an area within the footprint of the building, during licensed operations, is most likely not a suitable area for survey and repair activities if the process of performing this work would have an adverse affect on facility operations.

4.2 DEFINING AND IMPLEMENTING A RESPONSE

Contaminated soils near the surface can generally be removed using standard excavation techniques. The remediation of deeper contamination can be done using standard techniques, but the licensee should consider subsurface facility components, such as buried fluid lines, electrical conduits, and communications channels, during the clean up planning process. Damage to these could affect facility operations or provide additional migration pathways, through either the backfill or the conduit itself.

It may be appropriate for the licensee to take no immediate remedial action. For example, if the contamination is limited and it does not pose a worker or public exposure hazard, either immediately or by calculated migration, the preferred option may be to postpone active remediation until a scheduled outage or another specific date in the future.

If the licensee identifies migration of radioactive materials into the ground water, prompt assessment and plans for remedial action need to be evaluated as soon as practical. This should include a review of the existing monitoring program to determine if it is sufficient to define the migrations. It should also identify criteria for initiating supplemental subsurface monitoring, including determining if such measures are warranted by potential dose or environmental impact. The possible actions include reviewing the existing ground water monitoring plan for effectiveness, increasing the frequency and locations of monitoring, and active interdiction. Potential actions to mitigate migration of contaminants through the ground water could include extracting contaminated ground water through existing, or possibly new, wells; construction of interceptor trenches or sumps, or dewatering the area to change the hydraulic heads; and use of chemicals to bind the contaminants.

The response may call for the licensee to fully characterize the resultant contamination at the site. Site characterization is discussed in sections 3.2 – 3.3 of this document. The characterization data collected during facility operation should be used to determine radiological hazards and as a source of data that may be used as input in a site conceptualization model of the area hydrogeology, if this modeling effort is later determined to be necessary. If the chemical mass, toxicity and specific activity levels of the contamination are very low, there is little reason for detailed modeling of flow and transport. If any of these are considered a high level, then the licensee should consider use of a site conceptual model to assess the potential risk of chemical transport in the ground water. The licensee should consider the following parameters to determine an appropriate level of effort to model ground water in response to a contamination event: i) rate of release or leak; ii) total volume of release, and for each radionuclide; iii) specific activity of each radionuclide released; iv) transport characteristics of each radionuclide; and v) location and characteristics of receptors (i.e. definition of the critical group for the potential exposure).

4.3 COST-EFFECTIVENESS ANALYSIS FOR CONTAMINATION CLEANUP

For purposes of remediation of radiological contamination from unplanned or uncontrolled releases, the measurable benefit of interest is a cost savings between prompt action and postponed action. The major contributors to cost of remediation are labour, shipping (packaging and transport) of the contaminated media, change of contaminated volume, and disposal. Future cost is related to present cost by inflation factors for each of these. The factor most readily controlled by the licensee is the volume to be remediated. Left untouched, the contaminated volume will increase through migration. The effects of dilution vary with the “size” of the source term and rate of migration. These can only be determined by some model.

Following a release to the environment, unremediated, soluble contaminants will migrate and increase the volume that may need excavation to meet site release criteria at the time of license termination. Historically, all of the other factors have also increased over time. In most cases it is likely to cost more to wait for remediation than to do it promptly.

The NRC staff encourages licensees to perform cost-effectiveness analysis of prompt versus delayed clean up of residual radioactivity at the site. It is recommending that licensees perform relatively simple cost-effectiveness analysis of specific spills, leaks and unplanned releases.

Cost-effectiveness analysis supports decision making by evaluating the economic costs and benefits of different courses of action, in this case primarily due to the timing of cleanup activities. Licensees first should determine the nature and extent of a significant unplanned release of residual radioactivity. If the release is not cleaned up promptly, the action of wind, precipitation, runoff, groundwater flow, and other factors may cause the contamination to spread to a larger area or other environmental media. Because the time between release of residual radioactivity and decommissioning can be years or decades, the spread of contamination can be significant, resulting in a larger amount of material requiring cleanup and higher cleanup costs.

Factors other than the spread of contamination will affect cleanup costs over time. For example, labor, transportation and disposal costs will most likely change over time. Because these are specialized services in a unique and relatively small market, their rate of increase will likely be higher than the increase attributed to general price inflation. The cost to the licensee of borrowing funds likely will change over time, which may affect the carrying cost of additional decommissioning financial assurance. An expectation of improved technology may make it easier to remediate an unplanned release at a later date. Qualitative factors also should be considered, including the risks posed to employee health and safety, and public relations with the community. All of these should be considered by the licensee in the decision making to evaluate the cost-effectiveness of contamination cleanup at different points in time.

With due weight given to the factors identified in Section 4.2 above, the recommended approach to evaluate cost-effectiveness is for the licensee to compare the net present worth of a future cleanup to the cost of an immediate cleanup, with the lower value deemed to be more cost-effective. Licensees will need to determine the cost of prompt cleanup, the cost of the future cleanup, an interest rate to represent the weighted average cost of borrowing for the licensee, and the number of years in the future when the cleanup will occur. The net present worth is determined by the following formula:

$$P = F / (1+i) n$$

where:
P = present worth of a future cleanup activity
F = cost of the cleanup activity at time n, in Year n dollars
i = annual discount rate (expressed as a decimal)
n = number of years for which the cleanup is delayed compared to prompt cleanup

An example follows to demonstrate the use of the net present worth formula to determine the cost-effectiveness of prompt compared to delayed cleanup. This example demonstrates how a licensee might compare the costs of immediate cleanup to future cleanup costs. It is not intended to demonstrate how those cleanup costs are estimated. In this example, a special nuclear material facility has an unplanned release of technetium-99 (Tc-99) to groundwater through leaching of contaminants from disposal pits. The release is quickly identified, and the cost of repairing the disposal pits to ensure no additional leaching occurs and to cleanup the limited amount of contaminated soil and groundwater is determined to be $500,000 in current year dollars. It is also independently determined that if the licensee waits over a period of 5 years to conduct a cleanup activity, then the contamination will have spread to create a groundwater plume with a maximum concentration of Tc-99 of 4,000 pCi/L. This cleanup would require constructing and operating a groundwater pump-and-treat system to remove contaminated groundwater. After assessing the spread of the contamination, the reduction in the activity of the Tc-99, separate cost escalation factors for labor, transport, and disposal of the residual radioactivity, the estimated cleanup cost is determined to be $3.6 million (in future year dollars). The increase in costs is due primarily to the spread of the contamination over time and the resulting increase in the amount of environmental media that must be cleaned up or disposed. The annual discount rate for the licensee is assumed to be 3%.

With the cost of an immediate cleanup equal to $500,000, the present worth of cleanup considering a 5 year delay is calculated from the equation to be $3,100,000.

$$P = F / (1+i)\ n$$

where:
F = $3.6 million, in year n dollars
i = 0.03
n = 5

Because the cost of immediate cleanup is less than the cost to delay cleanup activities, all other things being equal, the licensee should perform cleanup activities sooner rather than later. Other value judgments will influence the cleanup decision, including an estimate of the threat posed by the contamination, averted dose and the requirement to keep occupational exposure as low as is reasonably achievable (ALARA), the risk that cleanup activities will affect operations, availability and cost of personnel and monitoring equipment to perform cleanup work, and other considerations. The documentation by a licensee of value judgments that influenced a decision of prompt versus delayed cleanup of a significant unplanned release should be included in records important for decommissioning.

The NRC staff believes the factor in cost-effectiveness analysis that is most readily controlled by the licensee is the volume of contamination that needs to be remediated. The NRC staff encourages licensees to assess the cost-effectiveness of prompt versus delayed remediation. In most cases, the real cost of prompt cleanup will be less than the real cost of deferral. Prompt cleanup also will remove the need to use a site conceptualization model to determine migration by ground water if the contamination has soluble or dispersible contaminants.

4.4 REVISE DECOMMISSIONING FUNDING PLAN AND ADJUST FINANCIAL ASSURANCE

The Decommissioning Planning proposed rule (RIN: 3150-AH45) contains amended regulations in 10 CFR 30.35(c)(6), 40.36(c)(5), 70.25(c)(5), and 72.30(d) that would require materials licensees to submit a decommissioning funding plan within one year of completing a survey that indicates contamination at the site is detected at levels that would, if left uncorrected, prevent the site from meeting the 10 CFR 20.1402 release criteria for unrestricted use. The release criteria in 10 CFR 20.1402 are that the surveyed contamination at the site does not exceed 25 mrem (0.25 mSv) per year Total Effective Dose Estimate (TEDE) to an average member of the critical group, and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). Any contaminating event should be surveyed and analyzed using one of the methods discussed below. Results above 25 mrem per year TEDE will be sufficient to trigger the need for the licensee to submit an updated decommissioning funding plan (DFP) to the NRC within one year of completing the survey, if the dose estimate is not believed to be ALARA.

Other amended regulations in §§ 30.35(e)(1), 40.36(d)(1), 70.25(e)(1), and 72.30(b)(2) would require licensees to identify, in their DFP, a detailed decommissioning cost estimate, including the volume of onsite subsurface material that will require remediation to meet unrestricted use criteria, and the effect of spills and unplanned releases to the environment. The licensee would also be required to provide a certification that decommissioning financial assurance has been provided in the amount of the detailed cost estimate.

A licensee may adjust up or down its decommissioning cost estimate based on actual contamination at the site. A new leak or unplanned release of a significant amount would increase the decommissioning cost estimate. If the licensee conducts remediation activities during facility operations, these can result in a lower decommissioning cost estimate and reduce decommissioning financial assurance. Any reduction in the decommissioning cost estimate by the licensee should include the possibility of recontamination of the areas that have been remediated unless engineering controls and procedures have been implemented to preclude their reoccurrence. The methods to prepare a decommissioning cost estimate are well understood by licensees and by the NRC staff.

This section of guidance identifies two methods that licensees may use to determine whether a contaminating event exceeds the 25 mrem per year TEDE to an average member of the critical group, at time of decommissioning. Whether or not the contaminating event exceeds 25 mrem per year TEDE will depend on a variety of factors, including the concentration and extent of radionuclide contamination, the type of media contaminated, the potential use of the land following release, and the proximity and density of those occupying the site and nearby populations. Two methods are provided below to determine if the contaminating event exceeds the regulatory limit. These two methods are the use of screening values, and the use of modeling. In either case, the determination should be based on the projected site conditions at the time of planned decommissioning. If a licensee does not have a specific date for decommissioning, then the determination should be based on projected conditions when the license is due to expire or when the license requires renewal.

The determination should take into account the potential spread of contamination that would occur prior to decommissioning, including the potential for contamination to spread off-site, and the potential to contaminate environmental media not already contaminated. For example, a release to soil may spread over time to a larger contaminated area, off-site areas, and groundwater. The risks associated with this spread should be taken into account when determining whether the site risks exceed the 25 mrem per year TEDE threshold.

In general, fixed and determinate contamination that is currently below the 25 mrem per year TEDE is not likely to meet or exceed that threshold in the future. Over time, the radionuclides will decay, so the risks associated with the decay chain must be evaluated. If the leak or spill has been stopped, the influence of spreading contamination will decrease the concentration over time. The effects on public confidence, environmental stewardship, and public relations also should be considered.

<u>Screening Values</u>

Screening values are concentration levels in contaminated media that have been determined to generally meet certain risk criteria, such as less than 25 mrem per year TEDE. Use of screening values is typically less complicated than using modeling because the determination is made simply based on the concentrations of radionuclides measured in the contaminated media. If the concentrations of radionuclides are below the screening values, the cleanup of the release will not be required at decommissioning, and no additional financial assurance is needed. If the concentrations are likely is determined to exceed the screening value at time of decommissioning, site-specific modelling is necessary to determine if cleanup will is likely to be required. Financial assurance should be adjusted may need adjustment to account for the costs of that any identified cleanup.

The concentration values are different for different environmental media, such as soil and groundwater, because the exposure pathways and other factors differ. Screening values are typically based on conservative assumptions that may results in values lower than those identified through modeling. Screening values may NOT be used as DCGLs at the time of decommissioning if there is subsurface contamination (see §5.1 of Vol. 2 of NUREG-1757). The numbers are useful during operations as an **indicator** of the potential for additional remediation at the time of decommissioning.

The NRC has published screening values for surfaces and soil in NUREG-5512 and NUREG-1757, Volumes 1 and 2. The acceptable screening values for surface contamination are in units of dpm/100 cm^2. The surface soil screening values are in units of pCi/gram.

The NRC does not use screening values for groundwater contamination. However, EPA has identified concentrations of radionuclides in groundwater used for drinking water that result in an exposure of 4 mrem per year from groundwater consumption (for beta and photon emitters). This value may be added to the contribution from other sources to determine if the total dose meets the 25 mrem per year limit. The levels identified by EPA can be found in the document Radionuclides Notice of Data Availability Technical Support Document, March 2000. http://www.epa.gov/safewater/radionuclides/pdfs/regulation_radionuclides_rulemaking_techsupportdoc.pdf

<u>Modeling</u>

The use of modeling is a second approach to determine whether an unplanned release exceeds the 25 mrem per year TEDE. Models depend on site-specific factors, and may result in higher allowable concentration values for contaminated media than screening values. However, modeling requires more detailed information to be collected about the contamination and potential receptors, and also requires additional effort to set up and run the model.

Licensees that choose to use modeling to determine whether they need to adjust their financial assurance should use the RESRAD model, which has been designed to help determine the risks associated with radionuclide contamination. The RESRAD model is available free of charge at http://web.ead.anl.gov/resrad/home2/. This website also contains guidance on how to set up and use the model.