CHAPTER 5

RADIOLOGICAL HAZARD AND SAFETY

ENVIRONMENTAL MONITORING

5-1 GENERAL

A nuclear weapon accident *is different from other accidents due to the possibility of radioactive contamination at the immediate accident site and extending "beyond the accident vicinity. The complexities of a nuclear weapon accident are compounded further by general lack of public understanding regarding radiological hazards. The On-Scene Commander* (OSC) *must therefore, quickly establish a vigorous and comprehensive health physics program to manage the health safety aspects of a nuclear weapons accident. A good health physics program provides for civil authority/ official involvement in the cooperative development of response efforts and a site restoration plan,*

5-2 PURPOSE AND SCOPE

This chapter provides information on health physics and guidance concerning the radiological safety and other hazards associated with a nuclear weapon accident. Also included is information on the radiological control resources available, *the hazards and characteristics of radioactive materials present, and suggested methods for detecting these hazards and protecting personnel from them. This information assists the OSC in the operations under his control. The Joint Hazard Evaluation Center* (JHEC) *is the* OSC's *organizational means to task* on-*site hazard and radiological data collection and analyze data collected for the most accurate and complete hazard/ radiological assessment. The chapter furnishes recommendations, advice, sample forms, and assistance to civil authorities with jurisdiction over areas affected by the accident. Also, weapon systems contain non-radioactive toxic materials, such as beryllium, lithium, lead, propellants, high explosives, oxidizers and plastics. These hazards are discussed in Chapter 9. The JHEC coordinates closely with the FRMAC. The FRMAC supports the OSC with off-site monitoring and assessment.*

5-3 SPECIFIC REQUIREMENTS

Department of Defense (DoD) has an obligation to protect response force personnel and the public from on-site hazards associated with a nuclear weapon accident and to *mitigate potential health and safety problems. To accomplish this, the DoD establishes a JHEC with the following objectives:*

a. Determine if radioactive contamination has been released.

b. Advise the OSC of precautionary measures for residents and other persons in potentially contaminated areas.

c. Identify and monitor potentially contaminated personnel on-site, including decontamination efforts, and establish a bioassay program.

d. Determine levels *of contamination present and* on-*site boundaries of the contaminated areas through ground and air surveys.*

e. Establish dosimetry *and documentation procedures during personnel decontamination and restoration operations.*

f. Recommend methods and procedures to prevent spread of radioactive contamination.

g. Assist the Federal Radiological Monitoring and Assessment Center (FRMAC) *in coordinating and planning the site restoration plan.*

5-4 RESOURCES

a. Response Force Resources. Response forces should have a full complement of operable and calibrated radiological monitoring equipment. Sufficient quantities of materials should also be available for replacement or *repair of critical or high failure rate components such as mylar probe faces. Replacement plans are necessary because radiation detection equipment* **(RADIACs)** *available to initial response forces will not meet initial operational needs after a large release of contamination. Though response forces are equipped and trained to conduct radiation surveys for low levels of radioactive contamination, it is difficult to do over rough surfaces like rocks, plants, and wet surfaces. Specialized DoD and Department of Energy (DoE) teams are better equipped to conduct low level contamination monitoring, and monitoring should wait until the teams arrive. Appendix 5-A contains a list of radiological monitoring equipment used by the Services with a summary of their capabilities and limitations. Additionally, personnel should be cognizant of the various units in which contamination levels might be measured or reported, and of the method of converting from one unit to another. A conversion table for various measurements is provided in Chapter 11.*

b. Specialized Teams. Several specialized teams are available within the DoD and DoE with substantial radiological monitoring, hazard assessment, and instrument repair capabilities. Moreover, they can provide field laboratories and analytical facilities. Specialized teams when integrated into the Service Response Force **(SRF)**, *provide adequate technical resources to make a complete assessment of the radiological hazards. Additionally, specialized DoE teams, which have off-site responsibilities, should be integrated into the SRF. Integration of specialized team operations is accomplished best through establishment of a JHEC as discussed in paragraph 5-5. When not required* **on**-*site, DoD specialized teams should assist in the off-site radiological response-efforts. Specialized teams are:*

(1) The U.S. Army Radiological Advisory Medical Team **(RAMT)** *is discussed in Chapter 14.*

(2) The following specialized teams or resources are discussed in detail in Chapter 20:

(a) U.S. Army Radiological Control **(RADCON)** *Team.*

(b) U.S. Navy Radiological Control **(RADCON)** *Team.*

(c) U.S. Air Force Radiation Assessment Team **(AFRAT).**

(d) U.S. Air "Force Air Transportable **RADIAC** *Package (ATRAP).*

(e) Department of Energy Aerial Measurement System **(AMS).**

(f) Department of Energy Atmospheric Release Advisory Capability **(ARAC).**

(g) Department of Energy Mobile Accident Response Group Unit (HOT SPOT).

(h) Department of Energy RANGER Environmental Monitoring Capability.

(i) Department of Energy Radiological Air Sampling Counting and Analysis Lab (RASCAL).

(j) *Department of Energy Mobile Decontamination Station.*

(k) Defense Nuclear Agency Advisory Team.

(1) DoD EOD Teams.

5-5 CONCEPT **OF OPERATIONS**

This concept of.operations assumes that an accident has resulted in release of contamination to areas beyond the immediate vicinity of the accident site. The distinction between on-site and off-site is significant for security and legal purposes; however, for effective collection and meaningful correlation of radiological data, the entire region of contamination must be treated as an entity. The on-site and off-site distinction should be considered **only** *when assigning areas to monitoring teams. Possible response force actions are addressed first in this concept of operations. Only limited equipment and expertise may be available to the initial response force.*

a. Initial Response Force **(IRF)** *Actions. Within the constraints of available resources, IRF action should determine the absence or presence of any radiological problem and its nature; minimize possible radiation hazards to the public and response force personnel; identify* **all** *persons who may have been contaminated and decontaminate them as* **necessary;** *provide appropriate news releases; and notify officials/ personnel of potential hazards. If responding by air, radiation detection instrumentation should be carried to ensure that personnel and aircraft are not contaminated. Efforts should be made, during the flight,* **to** *avoid contamination; appropriate ground support should be provided upon landing if personnel and aircraft become contaminated.*

(1) **Pre-Deployment** *Actions.*

(a) Prior to departing for the accident site, delivery arrangements should be made for an Atmospheric Release Advisory Capability **(ARAC)** *plot, if available, to assist in determining possible areas of contamination.* **ARAC** *plots will provide theoretical estimates of the radiation dose to personnel downwind at the time of the accident. Also, plots will provide the* **expected** *location and level of contamination deposition on the ground. A detailed discussion of ARAC is in*

Appendix 5-C. As it becomes known, specific accident data described in the appendices should be provided to the ARAC facility at Lawrence Livermore National Laboratory.

(b) If an advance party is deployed, at least one trained person should have radiation detection instruments to determine if alpha emitting contamination was dispersed and to confirm that no beta and/or gamma hazard exists. The earlier that confirmation of released contamination is established, the easier it will be to develop a plan of action and communicate with involved civil authorities.

(2) *Initial Actions.*

(a) If the OSC, or an advance party, deploys by helicopter to the accident site, an overflight of the accident scene and the downwind area can provide a rapid assessment of streets or roads in the area and the types and uses of potentially effected property. During helicopter operations, flights should remain above or clear of any smoke, and at a sufficient altitude to prevent resuspension from the downdraft when flying over potentially contaminated areas. The landing zone should be upwind, or crosswind, from the accident site.

(b) After arrival at the site, a reconnaissance team should enter the accident site to inspect the area for hazards; determine the type(s) of contamination present; measure levels of contamination; and assess weapon status. The approach to the scene should be from an upwind direction if at all possible. The accident situation indicates whether anti-contamination or respiratory protection is required for the initial entry team. Every consideration should be given to protecting the initial entry team, and to preventing undue public alarm. Until the hazards "'are identified, only essential personnel should enter the possible contamination or fragmentation area of the specific weapon(s). The generally accepted explosive safety distance for nuclear weapons is 610 meters (2000 feet); however, the contamination may extend beyond this distance. Additional explosive safety distances may be found in classified EOD publications. At this point, a temporary contamination control line should be considered. Later, when the boundary of the contaminated area is defined and explosive hazards are known, the control line may be moved for better access to the area. Contamination, or the lack of it, "should be reported immediately to the OSC. Anti-contamination clothing and respiratory protection should always be donned before entering a suspect area.

(c) If *radiation detection instruments are not yet on-scene, observations from firefighters and witnesses and the condition of the wreckage or debris may indicate contamination. Anticipated questions that may be asked to evaluate the release of contamination are:*

1. *Was there a high explosives detonation?*
2. *Has a weapon undergone sustained burning?*
3. *How many intact weapons or containers have been observed?*
4. *Do broken or damaged weapons or containers appear to have been involved in an explosion or fire?*

(d) If no contamination was released by the accident, the remaining radiological response becomes preparations for response in the event of a release during weapon recovery operations.

(3) Actions to be taken if contamination is detected. "Authorities should be notified and the assistance of specialized radiological teams and the DoE Aerial Measurement System requested. The highest priority should be actions to initiate general public hazard abatement. Do not delay or omit any life-saving measures because of radiation contamination. If precautionary measures have not been implemented to reduce the hazard to the public, civil authorities/ officials should be advised of the situation and consider possible actions. Actions which should be initiated include:

(a) Dispatch monitor teams, with radios if possible, to conduct an initial survey of the security area.

(b) Prepare appropriate news release.

(c) Determine if medical treatment facilities with casualties have a suitable radiation monitoring capability. If not, dispatch a monitor to determine if the casualties were contaminated. Also assist in ensuring that contamination has not spread in the facility. Procedures a medical treatment facility may use to minimize the spread of contamination are described in. Chapter 14.

(d) Initiate air sampling.

(e) Identify, in conjunction with civil authorities/ officials, witnesses, bystanders, and others present at the accident scene.

(f) *Establish a contamination control station and a personnel monitoring program. If available, civil authorities/ officials should have monitoring assistance provided at established personnel processing points.*

(g) Implement procedures to protect response personnel. Protective coveralls (anti-contamination clothing), hoods, gloves, and boots are necessary to 'protect response personnel from contamination and to prevent its spread to uncontaminated areas. If airborne

contamination exists, respiratory protection is required. Respiratory protection can be provided in most instances by using Service approved protective masks. If extremely high contamination levels of tritium *are suspected in a confined area,* firefighting *and other special actions require a positive pressure self-contained breathing apparatus. Unless an accident is contained within an enclosed space, such as a magazine, only those personnel working directly with the weapon need take precautions against* tritium.

(h) Develop and implement plans for controlling the spread of contamination. Administrative controls must stop contamination from being spread by personnel or equipment, and protect response force personnel and the general public. This control is usually established by determining a control area and limiting access and exit through a Contamination Control Station (CCS). *The perimeter of the contamination control area will be in the vicinity of the line defined by the perimeter survey; however, early in the response before a full perimeter survey is completed, a buffer zone may be considered. If the control area extends beyond the National Defense Area* (NDA) *or Security Area the assistance of civil authorities/officials will be required to establish and maintain the control area perimeter. Personnel and equipment should not leave the control area until monitored and decontaminated. Injured personnel should be monitored and decontaminated to the extent their condition permits. A case-by-case exception to this policy is necessary in life threatening situations.*

(i) Establishing the location and initial operation of the Command Post, Operations Area, JHEC, *and Base Camp is discussed in Chapter 4.*

b. Service Response *Force* (SRF) *Actions. Upon arrival on-scene, the SRF personnel review the initial response force actions. Actions include: the status of identification and care of potentially contaminated people, casualties, and fatalities; the results of radiation surveys and air sampling; radiological response assets on-scene or expected; logs and records; and the location for the* JHEC. *Representatives from the DoE, Federal Emergency Management Agency* (FEMA) *and Environmental Protection Agency (EPA) will be on-scene within a few hours after the response force. They and civil officials, are the primary off-site health and safety interface with the public. However, the SRF should continue to provide assistance and radiation monitoring support, as necessary. During those periods early in the response when Explosive Ordnance Disposal* (EOD) *operations* limit *access to the accident site, radiological survey teams should only support the weapon recovery efforts. Off-site radiological surveys require coordination with civil authorities. This arrangement can be understood by explaining the role of the* JHEC *and FRMAC, and by inviting the civil government/approved radiological response organization to participate in FRMAC operation. DoD specialized teams and the Department of Energy Accident Response Group (DoE ARG) are integral parts of the SRF. The OSC should integrate DoE ARG radiological assets into* the *JHEC organization.*

(1) Joint Hazard Evaluation Center. The JHEC is the organization that oversees the on-site hazard and radiological data collection and assessment efforts. By analyzing data, it provides accurate and complete on-*site hazard/ radiological recommendations. The JHEC Director should be knowledgeable about data on-site and how to best employ the technical resources available. The recommended functional* organization *is shown at Figure 5-1.*

(a) On-site collected data is processed through and further distributed by the JHEC to the FRMAC.

(b) JHEC is the single control point for all hazard/ radiological on-site data and will *provide the most rapid, accurate, and complete radiological information to both military and civil users. Data provided to the JHEC for analysis, correlation, and validation includes all hazard data on-site. After the initial response, the JHEC establishes a radiation and dosimetry program which meets Service needs and requirements for personnel working in or entering the on-site contamination control area. The JHEC should:*

1. *Collect radiological and hazard data required* by *the OSC on-site. Refer all unofficial requests for contamination information to the Joint Information Center* (JIC).
2. *Analyze and correlate all contamination data collected to identify inconsistencies which require further investigation.*
3. *Provide contamination plots and other required data to the OSC.*
4. *Review and correlate records from contamination control stations and other personnel processing points to ensure* bioassays *or other appropriate* follow-*up actions are taken.*
5. *Implement OSC'S health and safety standards and monitor the safety procedures of all participating in weapon recovery operations.*
6. *Brief and train people not designated previously as radiation workers who will be working in" the contaminated area on personal protective equipment, hazards, and safety measures.*

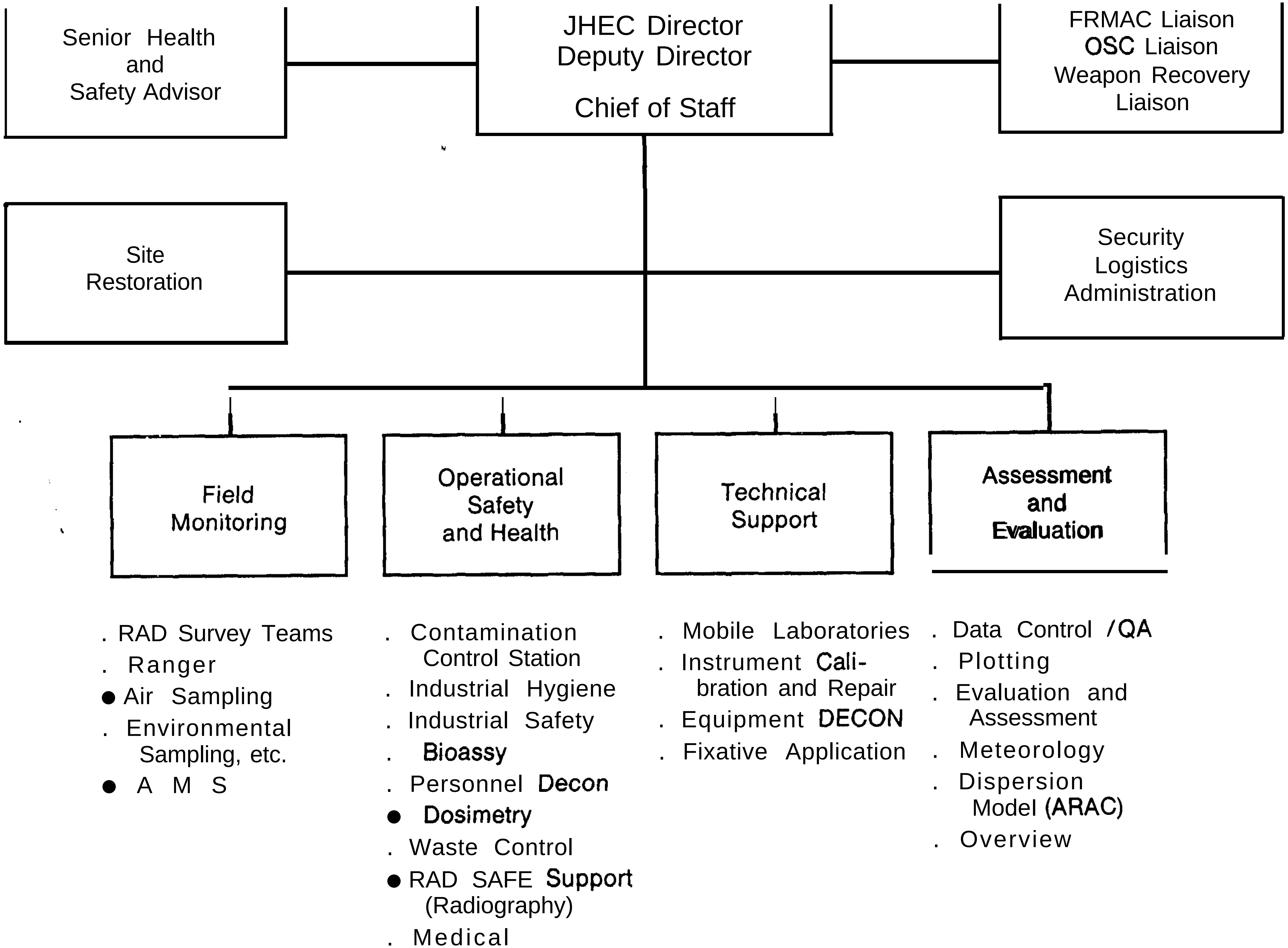


Figure 5-1. *Joint Harard Evaluation Center (JHEC) Functional Organization*

(c) Consolidate all radiological assessment information for on-site recovery operations and provide it to the OSC.

(d) When the National Defense Area (NDA) is dissolved, JHEC personnel and resources may be integrated into FRMAC operations.

(2) *Materials Sampling.*

(a) Environmental Sampling.

1. *Air sampling is conducted to determine if airborne contamination is present. Also it provides a basis for estimating the radiation dose/exposure which people without respiratory protection may have received. The reaction time to an accident combined with the time required to initiate air sampling will result in little or no data being obtained during the initial release of contamination. It is at this period that the highest levels of contamination are expected. Later placement of a sampler downwind the accident, per Appendix 5-B, will result in a sample of airborne contamination. Air sampling will verify the resuspension hazard during response and recovery operations. To achieve this, samplers should be placed downwind of the accident, dependent on wind velocity approximately 500 meters upwind, and at the contamination control station.*

2. *Soil, water, vegetation and swipe sampling of surfaces are required. Sampling should be initiated in the contaminated area soon after the accident. Samples must be taken also at locations remote from the contaminated area to verify background readings. After this, samples are required periodically during the recovery process to determine radioactive material migration and dispersion and to substantiate decontamination/ recovery completion. The JHEC will determine on-site sampling parameters, for example, sample location(s), method, frequency, volume of sample, and size.*

(b) Bioassay Program,

1. Bioassays *methods estimate the amount of radioactive material deposited in the body. The methods use either direct measurement, sensitive x-ray detectors placed over the chest (lung counting) and/ or other organs, or detection of radioactivity y in the excreta (nasal mucous, feces or urine).*

2. *A bioassay program for all individuals is recommended to determine if any internal dose was received, and to assure those who did not receive a dose that their health was not impaired. Implementation of a bioassay program and the documented results will be important in the equitable settlement of any legal actions that may occur in the years following a nuclear weapon accident. Personnel monitoring and bioassay programs are discussed in this paragraph and bioassay techniques in Chapter 8.*

(3) Work Force Protection. Standard radiation accident and incident response procedures provide guidance for personnel protection during the first few days. As conditions stabilize, regulations governing work in radiation areas should be implemented. Consideration must be given to participating organizations or Services dosage calculation methods and previous dosages as long as their procedures do not jeopardize health and safety, or unduly impair operations. The JHEC is responsible for implementing the OSC's health and safety standards and monitoring closely the safety procedures of all participating organizations. Personnel entering the contaminated areas, if not trained to work in a radiation environment,' should be given specific guidance.

(4) Radiological Surveys. Radiological surveys and other radiological data are required by the OSC and civil authorities/ officials to identify actions to minimize hazards to the response force and the public. Site characterization and decontamination, and restoration planning will also need this information. Radiological survey and data requirements must be given to the FRMAC for implementation to meet this requirement in an expeditious manner. Prior to extensive survey initiation, the following must be completed: select appropriate detection equipment, calibrate instruments, and determine the background readings. Surveys include NDA perimeter, area, and resource/facility surveys. The survey results are complicated by sensitivity y/ fragilit y of equipment, background readings, and the age of the fissile materials. The survey process can require days to weeks to complete. Survey procedures are located in Appendix 5-D and forms are at Appendix 5-E.

(5) Radiological Advisory to the JIC. All public release of information will be processed by DoD Directive 5230.16, reference (b), and made through the JIC. Public interest in the actual or perceived radiological hazard resulting from a nuclear weapon accident will produce intense media concern and public scrutiny of response operations. The JIC requires assistance from the JHEC and FRMAC in preparing press releases to minimize and allay these concerns. Any portion of the public which may have been advised to take precautionary measures will seek clear, understandable explanations of methods to protect their health and property. The public must be provided information through the JIC and the Community Emergency Action Team (CEAT) explaining all real hazards, in terms which

recognize the populace's knowledge level and understanding of radiation and its effects.

(6) Fixing of Contaminants. Fixatives maybe used to reduce resuspension and the spread of contamination. If water is readily available, it may be used as a temporary fixative to reduce resuspension. Other more permanent fixatives may be used to reduce the spread of contamination by resuspension and run-off from highly contaminated areas. The use of fixatives in areas of low level contamination is usually inappropriate. Fixatives may enhance or hinder decontamination and restoration operations, and affect radiation survey procedures. The DoE ARG can provide information on the advantages and disadvantages of different types of fixatives and methods of application. They should be consulted prior to application of permanent fixatives.

(7) Recovery/ Restoration,

(a) Recovery. This activity includes the initial reconnaissance, the render safe procedures, hazard removal, and disposition of the weapons and components. The two-person rule must be enforced strictly when working with nuclear weapons. In the early stages of accident response, following all of the required security measures may be difficult. However, the OSC should implement necessary security procedures as soon as possible. The initial entry will determine the preliminary weapon(s) status and hazards in the area. In the process of determining the weapon condition, search may be required to find the weapon(s). The OSC directs the initiation of the render safe procedures. The EOD team advises the OSC of the safest and most reliable means for neutralizing weapon hazards.

(b) Site Restoration. Procedures/methods to return the accident scene to a technically achievable and financially acceptable condition begins early in the response effort. Site restoration becomes a major issue after classified information, weapons, weapon debris, and other hazards are removed. Several factors have significant influence on site restoration decisions and procedures, such as size of the contaminated area, topographical, geological, hydrological, meteorological and demographic information. Other important aspects are utilization of the area and civil authorities/officials prerogatives for the area. Restoration will include those measures to remove or neutralize the contamination.

(8) Disposal of Contaminated Waste. Contamination control station operations and JHEC field laboratory operations creates considerable quantities of contaminated waste. Provisions, are required therefore, to store this waste temporarily in the contaminated area until it can be moved to a disposal site. Procedures for the disposal of contaminated waste are addressed as part of site restoration in Chapter 19.

(9) Logistics Support for Recovery/ Radiological Operations. Radiological response assets arrive with sufficient supplies to last a few days. High use items which soon require resupply include hundreds of sets of anti-contamination clothing each day, two-inch masking or duct tape, varied sizes of polyethylene bags, marking tape for contaminated materials, and respirator filters. Anti-contamination clothing may be laundered in special laundry facilities (discussed in Appendix 17-A) and reused. The turnaround time, when established, determines the approximate amount of anti-contamination clothing required. Close liaison will be required between the JHEC and the SRF supply officer.

c. Radiological Hazards. The primary radiological hazard associated with a nuclear weapon accident is from the fissile material, particularly the alpha emitters. Sufficient quantities of beta/gamma emitters to pose a significant health problem will not normally be present at a nuclear weapon accident.

(1) Radiological Hazard Assessment. From the outset, concern exists about the potential health hazard to the general public, particularly by those residing near the accident site. Consideration of possible radiation exposures is the primary method of estimating the potential health hazard. If no beta/ gamma radiation is present, the primary risk is inhalation of alpha emitters which may cause a long term increase in the probability of radiation related diseases. Initial hazard assessments will, of necessity, be based on limited information, assumptions, and worst case projections of possible radiation doses received. Atmospheric Release Advisory Capability (ARAC), described in Appendix 5-C, provides a theoretical projection of the maximum internal radiation dose people may have received if outdoors without respiratory protection from the time of release to the effective time of the ARAC plot. Exposure to resuspended contaminants normally results in doses which are a small fraction of that dose which would be received from exposure to the initial release for the same time period. Contamination released by the accident should not normally affect the safety of public water systems with adequate water treatment capability.

(2) Reduction of Public Exposure. The hazard assessment must be followed quickly by recommended precautionary and safety measures to protect the public from exposure. To control and minimize exposure, radioactive contaminants must be prevented from

entering the body and confined to specific geographic areas so that the contamination can be removed systematically. Methods for reducing the exposure to the public should be implemented by, or through, civil authorities/ officials. Although political and possibly international issues are likely to be involved, the ultimate decisions on measures to be taken should be made based on health and safety considerations.

(a) The initial response force may need to advise civil authorities/ officials of recommended actions and provide technical assistance until appropriate civilian assets arrive. When contamination has been released, or when probable cause exists to believe that contamination was released, the implementation of precautionary measures to reduce exposure to radiation or contamination are appropriate, even though the service response force personnel may not arrive for some time.

(b) Protective measures include:

1. *Establishing a contamination control area. This operation requires identifying people in the area at the time of the accident/incident or and restricting access to the area. Any vehicles or people exiting the area should be identified and directed to go to a monitoring point immediately.*

2. *Sheltering. Sheltering is used to minimize exposure to the initial release of contamination as it moves downwind, and to minimize exposure to resuspended contamination prior to an evacuation. Sheltering is implemented by advising the people to seek shelter and the procedures to follow. The effectiveness of sheltering depends on following the procedures provided.*

3. *Evacuation. Contaminated areas must be defined and an evacuation procedure developed and implemented by civil authorities. Civil authorities will be responsible for the evacuation but may require radiological advice and assistance. Immediate evacuation of downwind personnel should be discouraged since the probability of inhalation of contaminants may increase. Explosive or toxic materials may present an immediate hazard to people near the accident site and immediate evacuation would then be required.*

4. *Fixing Areas of High Contamination. Areas of high contamination must be controlled to prevent spread by resuspension, water run-off, or movement of personnel. Although fixing of contamination is part of the site restoration process, some fixing procedures may be necessary long before site restoration plans are implemented.*

d. Respiratory and Whole Body Protection. Protection of the general public, response force members, and workers in the accident area from exposure through inhalation is extremely important. Refer to Appendix 5-D for additional guidance.

e. Radiation Surveys. Extensive radiation surveys will be required to identify and characterize the area so that decontamination and restoration plans may be developed and the results evaluated. Determining that contamination was released by the accident is very important, if release occurred, priority must be given to the actions to identify and minimize the hazards to people. These actions are included in Appendix 5-E.

f. Site Restoration. Site restoration involves negotiating cleanup levels and fixing or removing contamination. The removal is most time consuming and requires an extensive workload to collect, remove, decontaminate, if appropriate, and replace the top soil. Monitoring is required during the removal process to verify that cleanup has been achieved.

g. Verification. The decontamination effectiveness will be verified by remonitoring/ resurveying the accident scene to determine that the cleanup levels are achieved.

h. Protective Action Recommendations (PARs) and re-entry recommendations (RERs) provide appropriate protective action and re-entry recommendations to the public. The PARs and RERs will have been coordinated/ reviewed by the cognizant federal authority (DoD) and responsible civilian authorities/ officials. The PARs and RERs will consider Protective Action Guides issued by EPA and state agencies. In an accident, PARs for initial notification or evacuation would likely not be prepared formally. The notification in the accident area would occur via visual means or word-of-mouth. Evacuation of approximately a 600 meter disaster cordon might occur automatically or at the direction of civilian law enforcement personnel. A PAR for a controlled evacuation could be formalized in anticipation of a subsequent release of hazardous materials or radioactive contamination. The PAR/ RER format may include, as a minimum; problem, discussion, action, coordination and approval sections (the format should be site and situation specific). A sample PAR for controlled evacuation is found on the next page.

5-6 ACCIDENT RESPONSE PLAN ANNEX

Procedures and information appropriate for inclusion in the' Radiological Hazard Safety annex to the accident response plan include

Protective Action Recommendation

for

Major Accident ____________________________ at (location

Issued by:

Problem: An accident involving ___________________ missile system re-entry vehicle occurred at (Time, date and location). Maintenance technicians have experienced complications in removing the missile second stage from the missile launch facility.

. Discussion: It is possible, though highly improbable, that the second stage could explode. In the unlikely event of an explosion, debris could be thrown __________ yards/ meters. As a result, an evacuation of (outline the specific area) has been ordered by Civilian Authority Office,

Action: With the possibility of the explosion of the missile second stage during removal operations, the following area will be evacuated. (Indicate the specific area to be vacated and a schedule indicating evacuation start, completion, verification of evacuation, maintenance work start, work completion and return to the area). Note: All personnel are required to sign in at a specific location(s) during evacuation to help local law enforcement/ SRF personnel verify that all personnel are out of the area prior to maintenance start. A holding area, for example, YMCA, gymnasium, or school may be a temporary holding area for evacuees. Also, the evacuees could be released for shopping or other activities outside the area. Upon successful completion of maintenance, the personnel would return to their houses/businesses.

Note: Release of this "Protective Action Recommendation" cannot precede confirmation of the presence of a nuclear weapon by the OSC and should be coordinated with local officials and PAO prior to release.

a. A description of the JHEC organization and responsibilities.

b. Procedures for operation of the JHEC.

c. Procedures for establishing and maintaining the contamination control line.

d. Procedures for ensuring that all indigenous personnel possibly exposed to contamination are identified, screened, and treated. This function will become DoE and/ or civilian responsibility as time progresses.

e. Guidelines for determining radiation survey and decontamination priorities.

f. Procedures for ensuring that response force personnel working in the contaminated area are properly protected.

g. Procedures for recording and maintaining pertinent data for the radiological safety of response force personnel.

h. Procedures for recording, correlating, and plotting the results of radiological surveys and data collection instrumentation (for example, air samplers).

i. Procedures for JHEC and FRMAC interfacing.

j. Procedures for JHEC incorporation into the FRMAC.

APPENDIX 5-A

RADIOLOGICAL MONITORING EQUIPMENT

DOSIMETERS

Instrument	Capability/Limitations
Self Reading Ionization Chamber Dosimeter	*Reusable device for measuring exposure to X- and/or gamma radiation. Limitations: False positive readings due to charge leakage and sensitivity to mechanical shock.*
Non-Self Reading Ionization Chamber Dosimeter	*Same capabilities, limitations, and use* as *Self-Reading Ionization Chamber* Dosimeter. *Additional Limitations: Requires reading device.*
Film Badge	*Provides measurement and permanent record of beta and gamma radiation doses over wide dosage range. Special neutron films are available. Ten (10) percent dose accuracy depending on quality control during development. Limitations: Sensitive to light, humidity, aging, and exposure to x-radiation. Delay between exposure and dose reading due to processing time.*
Thermoluminescent Dosimeter (TLD)	*The TLD (thermoluminescent* dosimeter) *provides measurement of gamma radiation dose equivalents up to 10000 rem. Accurate to within a factor of two when the energy of the neutrons is unknown. Limitations: after long periods of exposure* (± mrem), *damaged or bent cards delay processing, static electric discharge causes spurious readings, and temperatures >115° degrees F reduce sensitivity. Delay between exposure and dose reading due to central processing of TLDs.*

TRITIUM DETECTION INSTRUMENTS

Instrument	Capability	Scale	Indicator
T-446	Tritium	0 *to* 10	μCi/m^3

Portable, tritium *detector; automatic scale switching; and trickle charger for nickel cadmium F cells. With adapter kit, has urinalysis capability for* tritium *with 5-minute response. Weighs 22 pounds. Has particulate filter with filters down to 0.3 microns (eliminates sensitivity to smoke and paint fumes).*

Instrument	Capability	Scale	Indicator
T-290A	Tritium	0 *to 1,000* *3 ranges*	μCi/m3 *Concentration of gas in chamber*

Portable, air sampler; and detects presence of radioactive gas. Weighs 17 pounds Must be rezeroed *after 15 minutes of operation and once an hour thereafter. Sensitive to smoke and paint fumes. External battery pack is available for cold weather operations.*

TRITIUM DETECTION INSTRUMENTS (CONTINUED)

Instrument	Capability	Scale	Indicator
IC-T2/PAB(M)	Tritium	0 to 100,000 3 ranges	μCi/m^3

Portable air monitor designed to detect gaseous radioactivity in ambient air. Alarm sounds at preset meter readings.

AN/ PDR-74	Tritium	O to lOOK 3 ranges	μCi/ m^3

The portable RADIAC set contains an IM-246 light weight tritium air monitor to detect airborne radioactive gases. Also, the instrument is calibrated directly in terms of tritium activity but may also be used to detect other radiogases or to monitor gamma radiation if appropriate calibration factors are applied to the meter reading. The instrument is battery operated (D cells) and has an audible alarm when radioactivity exceeds a preset level.

ALPHA SURVEY INSTRUMENTS

Instrument	Capability	Type	Scale	Indicator
AN/ PDR-56	Alpha	Scintillation	O to 1,000K 4 ranges	CPM/ 17 cm^2

A small auxiliary probe provided for monitoring irregular objects. Mylar probe face is extremely fragile and a puncture disables the instrument until repaired. Accompanying x-ray probe is calibrated for 17 KeV with associated meter scale from O-10 mg/ m^2 in four ranges.

AN/ PDR-60 (PAC-ISAGA)	Alpha Gamma	Scintillation G-M tube	O to 2,000K . 4 ranges	CPM/ 60 cm^2 R/ hr

Capable of measuring gamma utilizing the 2R range. Intermediate and high-range alpha survey; intermediate gamma range; weighs eight pounds. May use plutonium gamma detector (pG-l) for inclement weather. Mylar probe face is delicate and puncture disables alpha monitor capability until repaired; gamma detector will continue to function. AN/ PDR-60 or PAC-IS has identical alpha capabilities but does not have the gamma detection capability.

PRM-5	Alpha	Scintillation	O to 500K 4 ranges	CPM

Portable, high and low-range instrument, for detecting alpha contamination through measurement of the associated X-rays and low energy gamma radiation. This exercise is done with probes with separate ranges. PG-2 probe, 10 to 100 KeV and FIDLER probe O to 100 Kev. Weighs 5.4 pounds. The FIDLER probe has significantly greater sensitivity than other probes. Very few units other than specialized Service and DoE teams possess the FIDLER. PRM-5 probes are effective in inclement weather and are much less subject to damage during field use than other alpha meter probes.

ALPHA SURVEY INSTRUMENTS (CONTINUED)

Instrument	Capability	Type	Scale	Indicator
Ludlum Model 3	Alpha/ Beta/ Gamma	Scintillation G-M Tube	O to 400K O to 200mR/h	cpm mR/ h

Portable, high and low range analyzer for detecting alpha, beta and gamma emissions. The Model 3 is an electronic package similar in operation and function to the PDR-60 analyzer. Probe 43-5 detects alpha via scintillation, the probe surface area is 50 cm^2. Probe 44-6 (Hot Dog) uses a G-M tube to detect beta and gamma. Probe 44-9 (Pancake Probe) detects low energy gamma, O to 200 mR/h.

Instrument	Capability	Type	Scale	Indicator
Ludlum Model 2220	Alpha	Scintillation	O to 500K 4 ranges	cpm

The Model 2220 is an alpha detector electronics package that has a liquid crystal display and integral digital readout. The unit weighs 3.5 pounds and has an adjustable high voltage and adjustable lower level discrimination feature.

VIOLINIST II - HIVOLT-PREAMP FIDLER INSTRUMENT SET. *This instrument set includes the FIDLER, high voltage power supply and preamplifier and the Violinist H. The Violinist 11 consists of a battery operated 256 multi-channel analyzer and a preprogrammed microprocessor. This instrument set, when calibrated appropriately, measures and determines surface contamination levels of plutonium and americum-241 in $\mu Ci/m^2$.*

RANGER. *The instrument set includes the FIDLER/ Violinist 11 and a position determining system. The microwave ranging system uses a base station, fixed repeaters and mobile units. The mobile units transmit FIDLER radiation data to the repeaters and base station. The microprocessor develops in near real time radiation readings, contamination density, and isopleths. The microwave ranging system is limited to near line-of-sight. Dense vegetation, building, and hilly terrain may effect the ranging signal.*

BETA/GAMMA SURVEY INSTRUMENTS

Instrument	Capability	Type	Scale	Indicator
AN/ PDR-27	Measures gamma on all scales. Detects beta two lower scales.	Geiger-Muller	0 to 500 4 ranges	mR/h

Low range; weighs eight pounds; beta window on probe to detect beta, and suitable for personnel monitoring. May saturate and read zero in high-radiation fields (over 1,000 r/ hr).

Instrument	Capability	Type	Scale	Indicator
AN/ PDR-43	Measures gamma. Detects beta on all scales.	Geiger-Muller	0 to 500 3 ranges	R/h

High range; weighs 4.5 pounds, and will not saturate in high-radiation area. Readings in gamma fields other than CO-60 may have inaccuracies greater than 20 percent.

Instrument	Capability	Type	Scale	Indicator
IM-174/PD	Gamma	Integrating ion chamber	0.1 to 10 0 to 500	R/h

High range; weighs 3 pounds; logarithmic scale, and temperature sensitive.

Instrument	Capability	Type	Scale	Indicator
Ludlum Model 19	Gamma	Scintillation	O to 5 mr/hr	uR/h

APPENDIX 5-A.1

RADIATION DETECTION AND MEASUREMENT

(The Inference of Plutonium Contamination using the FIDLER)

5-A.1-1 OVERVIEW

a. Quantitative *measurements of radioactive contamination in the field are extremely difficult. Particles having short ranges, such as alpha and low energy beta radiation, are significantly and incalculably affected by minute amounts* of *overburden, for example, dust or precipitation. Therefore, detection rather than measurement is a more realistic goal for alpha-beta surveys. More penetrating radiations, such as gamma and higher energy x-rays, are effected less by such overburden; however, these elements require special attention to field calibration techniques in order to convert meter readings to contamination estimates.*

b. Field survey of uranium is best accomplished through measurement of x-rays in the 60-80 thousand electron volt (keV) *range emitted by uranium isotopes and daughters. For plutonium, the best technique is to detect the accompanying contaminant Am-24 1, which emits a strong 60* keV *gamma-ray. Knowing the original assay and the age of the weapon, the ratio of plutonium to americium can be calculated accurately and thus the total plutonium contamination determined.*

c. Many of the factors which cannot be controlled in a field environment can be managed in a mobile laboratory which can be brought to an accident/ incident site. Typically, the capabilities include gamma spectroscopy, low background counting for very thin alpha- and beta-emitting samples and liquid scintillation counters for extremely low energy beta emitters such as tritium.

5-A.1-2 GENERAL

a. Scope. This appendix provides detailed information from LLNL Report M-161 and Steven G. Hamann, references (o) and (p) on the instrumentation and associated techniques used to perform radiological monitoring at an incident/accident involving the release of radioactive material. This appendix is not intended to serve as a "user's manual" for the various instruments. However, it includes sufficient detail to provide an understanding of the limitations of field measurement techniques and thus provides for proper application and the use of techniques in case of *an emergency. For completeness, some elementary characteristics of different kinds of radiation are included. Throughout this appendix the word "radiation" will refer only to nuclear radiations found at a nuclear incident/accident.*

b. Detection versus Measurement.

(1) Nuclear radiation cannot be detected easily. Thus, radiation detection is always a multi-step, highly indirect process. For example, in a scintillation detector, incident radiation excites a florescent *material that* de-*excites by emitting photons of light. The light is focused onto the photocathode of a* photomultiplier *tube that triggers an electron avalanche. The electron shower produces an electrical pulse which activates a meter read by the operator. Not surprisingly, the quantitative relationship between the amount of radiation actually emitted and the reading on the meter is a complex function of many factors. Since control of those factors can only be accomplished well within a laboratory, only in a laboratory setting can true measurements be made.*

(2) On the other hand, detection is the qualitative determination that radioactivity is or is not present. Although the evaluation of minimum levels of detectability is a considerable quantitative challenge for instrumentation engineers, the task of determining whether a meter records anything is considered much easier than the quantitative interpretation of that reading.

(3) *The above discussion suggests that the same equipment can be used for either detection or measurement. In fact generally, detectors have meters from which numbers can be extracted. However, to the extent that the user is unable to control factors which influence the readings, those readings must be recognized as indications of the presents of activity (detection) only and not measurements.*

(4) In the discussions that follow, personnel must be aware of the limitations imposed by field conditions and their implications on the meaning of readings taken. Therefore, instructions are careful to indicate the extent to which various instruments may be used as measurement devices or can be used only as detectors.

5-A.1-3 TYPES OF RADIATION

a. General. Four major forms of radiation are commonly found emanating from radioactive matter: alpha, beta, gamma and x-radiation. The marked differences in the characteristics of these radiations strongly influence their difficulty in detection and consequently the detection methods used.

b. Alpha. An alpha particle is the heaviest and most highly charged of the common nuclear radiations. As a result, alpha particles very quickly give up their energy to any medium through which they pass, rapidly coming to equilibrium with and disappearing in the medium. Since nearly all common alpha radioactive contaminants emit particles of approximately the same energy, 5 million electron volt (MeV), some general statements can be made about the penetration length of alpha radiation. Generally speaking, a sheet of paper, a thin layer (a few hundredths of a millimeter) of dust, any coating of water or less than four (4) centimeters of air are sufficient to stop alpha radiation. As a result, alpha radiation is the most difficult to detect. Moreover, since even traces of such materials are sufficient to stop some of the alpha particles and thus change detector readings, quantitative measurement of alpha radiation is impossible outside of a laboratory environment where special care can be given to sample preparation and detector efficiency.

c. Beta. Beta particles are energetic electrons emitted from the nuclei of many natural and man-made materials. Being much lighter than alpha particles, beta particles are much more penetrating. For example, a 500 keV beta particle has a range in air that is orders of magnitude longer than that of the alpha particle from plutonium, even though the latter has ten times more energy. However, many beta-active elements emit particles with very low energies. For example, tritium emits a (maximum energy) 18.6 keV beta particle. At this low an energy, beta particles are less penetrating than common alpha particles, requiring very special techniques for detection. (See Chapter 7).

d. Gamma and x-radiation. Gamma rays are a form of electromagnetic radiation and as such, are the most penetrating of the four radiations and easiest to detect. Once emitted, gamma rays differ from x-rays only in their energies, with x-rays generally lying below a few 100 keV. As a result, x-rays are less penetrating and harder to detect. However, even a 60 keV gamma-ray has a typical range of a hundred meters in air, and might penetrate a centimeter of aluminum. In situations in which several kinds of radiations are present, these penetration properties make x-ray/gamma ray detection the technique of choice.

e. Radiations from the Common Contaminants. The following table lists some of the commonly considered radioactive contaminants and their primary associated radiations.

TABLE 5-A.1-1. Commonly Considered Radioactive Contaminants and Their Primary Associated Radioactive Emissions

	Alpha	Beta	Gamma	X-rays
Ac-227		x		x
Am-241	x		x	x
Cd-109			x	
C-14		x		
co-57			x	
CO-60		x	x	
H-3		x		
I- 125			x	
I- 129		x	x	
1-131		x	x	
K-40		x	x	
Pa-23 1	x			
Pm-147		x		
PO-210	x			
Pu-239	x			
Ra-224	x			
Ra-226	x			
Ra-228		x	x	
Sr-90		x		
Th-228	x			
Th-230	x			
Th-232	x			
U (nat.)	x	x		
U-235	x			
U-228	x	x		
Y-90		x		

5-A.1-4 ALPHA DETECTION

a. Because of the extremely low penetration of alpha particles, special techniques must be employed to allow the particles to enter the active region of a detector. In the most common field instruments (AN/ PDR-56 and -60), an extremely thin piece of aluminized mylar film is used on the face of the detector probe to cover a thin layer of fluorescent material. Energy attenuation of the incident alpha radiation by the mylar is estimated to be less than ten (10) percent. However, use of this film makes the detector extremely fragile. Thus, contact with literally any hard object, such as a blade of hard grass, can puncture the film allowing ambient light to enter the detection region and overwhelm the photo-multiplier and meter. (Even sudden temperature changes have been shown to introduce stresses that can destroy a film). In addition, contact with a contaminated item could transfer contamination onto the detector. Thus, monitoring techniques must be used which keep the detector from contacting any surface. However, recall that the range of the alpha radiation is less than four (4) centimeters in air. This requirement to be within a few centimeters of monitored locations without ever touching one makes use of such detectors impractical except for special, controlled situations (for example, monitoring of individuals at the hotline or air sampler filters).

b. As discussed above, the sensitivity (minimum detectability) of an alpha detector is not dictated by the ability of the active region of the detector to respond to the passage of an alpha particle; counting efficiency for alpha detectors is 25-60 percent of the alpha particles from a distributed source that reach the detector probe. Fortunately, -alpha detectors" in good repair normally have a fairly low background: there are few counts from cosmic and other spurious radiation sources and the elimination of most electronic noise is easy with current state-of-the-art instruments. As a result, count rates in the order of a few hundred counts per minute are easily detectable on instruments such as the AN/ PDR-60. However, the detectability is dominated by the ability of the alpha particles to get into the active region of the detector, which depends upon such factors as overburden (amount of dust and/or moisture lying between the alpha emitters and the detector), and the proximity of the detector to the emitters.

c. In demonstrations conducted in the laboratory, a sealed alpha source (Am-24 1) was monitored with a well maintained AN/ PDR-60 alpha probe and meter. Dust and water were sprinkled onto the source and changes noted. It was found that a drop of water, a heavy piece of lint or a single thickness of tissue paper totally eliminated all readings. A light spray of water, comparable to a light dew, reduced readings by 40-50 percent. A layer of dust that was just visible on the shiny source had minimal effect on the count rate; however, a dust level that was only thick enough to show finger tracks reduced readings by 25 percent. These simple demonstrations reinforced the knowledge that detection of alpha particles in any but the most ideal situations is most problematical. The leaching or settling of contaminants into a grassy area or the dust stirred up by vehicular traffic on paved areas will significantly decrease or eliminate alpha detection.

5-A.1-5 BETA/GAMMA DETECTION

a. Gamma rays and high energy (>1 MeV) beta particles are highly penetrating radiations. As a result, the major problems listed for alpha detection do not apply. Furthermore, at the energies of concern in nuclear weapon accidents/ incidents, detection efficiency for most detectors is relatively high. Thus, beta/gamma detection is relatively easy.

b. From a detection standpoint, unfortunately, high energy beta and gamma radiation are not produced in the most likely radioactive contaminants (for example, Plutonium, Uranium or Tritium). Rather, the major potential source of beta/gamma emitters is from fission product radioelements which could be produced in the extremely unlikely event of a partial nuclear yield. Beta/ gamma detection, therefore, has no quantitative use in determining the extent of plutonium or uranium contamination, but is used as a safety precaution to determine any areas containing hazardous fission products.

c. Common gamma detectors are scintillation detectors (using scintillation media different from that described above for alpha detection) or gas ionization type detectors (ion chambers, proportional counters or Geiger counters). In either case, the high penetrability of the radiation allows the detector to have reasonably heavy aluminum, beryllium or plastic windows and to be carried at a 0.5-1 .0m height. Dimensions of the active region of the detector (for example, the thickness of a scintillation crystal) can be made larger to increase sensitivity. Because the detection efficiencies are reasonably insensitive to energies in the energy regions of interest, the detectors can be calibrated in terms of dosage (rads or rem), rather than in terms of activity:

this practice reflects the common use for beta/ gamma detectors

d. Typical of a beta/gamma detector is the Ludlum Model *3 with a* Ludlum *44-9 "pancake"* (Geiger-Muller) *probe. Minimum detectability for such a detector is a radiation field that produces readings two to three times greater than the background (no-contaminant, natural radiation plus electronic noise) reading. Customarily, this corresponds to a few hundredths of a millirem per hour.*

5-A.1-6 X-RAY DETECTION

a. For low energy (17-100 keV) x-rays, the scintillation detector is again the instrument of choice. Window thickness is again a factor, though not as much as with alpha *particles. For example, the half-thickness for absorption of 17* keV *x-rays in aluminum is 0.4 mm and in air is about four meters. These factors increase rapidly with energy. For 60* keV *x-rays, the distances become 2.5 cm and 190 m respectively. Thus, for* x-*rays above 15 keV, an x-ray detector can be held at a comfortable height (0.5 m) above the contaminated surface.*

b. The size of an electronic pulse produced by an x-ray in a scintillation-type detector is proportional to the energy of the x-ray. This has a most important application, commonly called pulse-height discrimination. Because of the relatively low (10s of keV) energy of the x-rays of interest, an x-ray detector and its electronics must be quite sensitive. Unfortunately, such a detector is sensitive also to the myriad of radiations from natural sources and to common low-level electronic noise. The result is a deluge of signals that overwhelm the pulses from sought-after x-rays. To remove the unwanted signals, circuitry is installed in the meter to ignore all pulses whose size lies below a user-selectable lower level (threshold). In cases of high (natural) background, it is also useful to discard all pulses whose size is greater than a user-selectable upper level. The accepted pulses, therefore, are only those from the desired x-rays and that small amount of background that happens to fall in the same pulse-size region.

c. Unfortunately, pulse-height discrimination is not as "easy" as described above. In fact, the signals from the *detection of identical x-rays will not be identical in size; rather, a large number of such detections will produce a distribution of pulse sizes* which *cluster about a mean pulse size. If one sets the lower-level discriminate or slightly below and the upper level slightly above the mean pulse size,* a *large fraction of the desired pulses will be eliminated, resulting in a significant decrease in detector response. However, setting the discriminator levels far from the mean will admit too much background, thereby masking the true signals. See Figure 5-A. 1-1. Thus, the setting of discriminator levels requires a qualitative judgment which can significantly affect the readings from a given contamination. Furthermore, since the width of the pulse size distribution depends in a most complicated way upon the condition and age of the detector, it is impossible to specify one setting for all similar instruments. Rather, techniques have been developed to establish the sensitivity of a given detector, with its electronics, in a field environment. This technique is described in the following section.*

d. In spite of the above complications, the scintillation detector remains the instrument of choice for detection

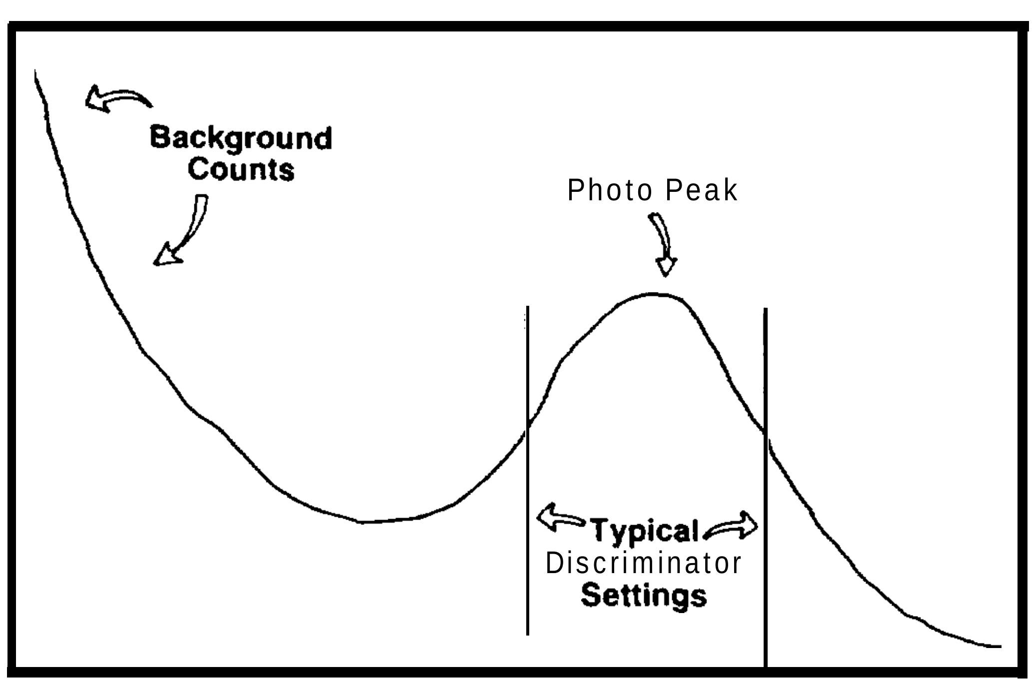


Figure 5-A.1-1: *Spectral* Plot (Showing Normal Spread Of Pulses From A Mono-energetic Source Mixed With A Typical Background Spectrum and Indicating Typical Discriminator Settings).

of x-ray emitting radioactive contamination. One such detector is the Field Instrument for Detection of Low Energy Radiation (FIDLER). *A* FIDLER (4"x1 *mm.* NaI (Tl)) *probe, in good condition, mated to a* Ludlum *2220 electronics package, can detect 60* keV *activity as low as 0.2* microcuries *per meter. In a typical* weapon-*grade mix for a medium-aged weapon, this mix would correspond to about one microcurie of plutonium per square meter. Furthermore, since the x-rays are much less affected by overburden than are alpha particles, the radiation monitor has much better control of the factors which influence his meter readings. As a result, the monitor can make quantitative measurements of the amount of radiation, and infer the actual amount of contamination, with far greater confidence than with* any *other* field *technique.*

5-A.1-7 DETECTION OF URANIUM AND PLUTONIUM

a. Although uranium and plutonium are alpha emitters, they and their daughters also emit x-radiation. Therefore, as discussed above, the instrument of choice for detection of these elements is a scintillation detector.

b. The detection of uranium contamination is fairly straightforward. Among the radiations emitted in the decay of Uranium-235 and its daughters is an 80 keV *x-ray. Set-up and field calibration of the detector as described in this chapter allows measurement of the x-ray activity per square meter and thus evaluation of the uranium contamination. Confidence in the accuracy of these measurements is in the* μ/ *-25 percent range.*

c. The detection of plutonium is somewhat more complicated. Plutonium-239 and its daughters emit a 17 keV *x-ray which can be detected with a* FIDLER *detector. However, absorption of that relatively low energy x-ray by overburden plus interference by background signals in the same range as the desired x-ray make measurement of the 17* keV *a highly uncertain technique. The determination of plutonium contamination can be made more confidently through the following, indirect technique.*

(1) Weapons grade plutonium contains several isotopes: in addition to the dominant Pu-239, *there is always a trace amount of Pu-241. Pu-241 beta decays, with a half-life of 14.35 years,* to *Am-241. Am-241 subsequently decays with the emission of a* 60-keV *x-ray which,* like *the* 80 keV *x-ray of uranium, is relatively easy to detect under field conditions. Thus, a most sensitive technique for the detection of weapons grade plutonium is to detect the contaminant Am-241 and infer the accompanying plutonium.*

(2) Clearly, this technique requires more information than the direct detection of radiation from the most plentiful isotope, such as knowledge of the age and original assay of the weapon material. However, decay times, weapon age and assay-are known or controllable quantities, whereas overburden and its effect on alpha and low energy x-radiation are not. Thus, the safeguards community has standardized upon the detection of plutonium via its americium daughter.

d. To facilitate the calculations and calibration needed to measure plutonium contamination by x-ray detection in the field, the Lawrence Livermore National Laboratory has produced a series of utility codes called the HOT SPOT Codes.[1] *Available for IBM-compatible computers, as well as the HP-41 calculator systems, the HOT SPOT Codes include an interactive, user-friendly utility routine called* FIDLER *which steps a user through the process of calibrating an x-ray detector (the Field Instrument for Detection of Low Energy Radiation), the* FIDLER *code is applicable to any x-ray detector if the full calibration technique, involving a known americium calibration source, is used.*

e. Particularly useful in the FIDLER code is the provision to aid in the measurement of the geometric factor for any specific detector. Measurements made at the Ballistic Research Laboratory and *the Lawrence Livermore National Laboratory have shown that the value of K(h) for h = 30cm can vary from less than 0.4 m2 to over 1.0 m2, apparently depending upon external configuration and subtle internal details of a particular* FIDLER *probe. For this reason, the* FIDLER *code contains both a detailed laboratory procedure and a field-expedient procedure for determining K(h) for a given detector. The code provides also a default value of 0.5 m2.* This *value was chosen to* give *a relatively conservative reading indication of contamination per count rate.*

[1]Steven G. Homann, *HOT SPOT Health Physics Codes,* Lawrence Livermore Laboratory Report M-161 (April 1985).
[2]Steven G. Homann, Hazard Control Department, Lawrence Livermore National Laboratory, private communication.

5-A.1-8 LABORATORY TECHNIQUES

As discussed above, laboratory procedures are necessary to make quantitative measurements of radiation contamination. For this reason, mobile laboratories are available within DoD and DoE for deployment to an accident site. Although specific instrumentation will vary, the types of laboratory analyses fall into three categories: gamma and x-ray spectroscopy, alpha-beta counting, and liquid scintillation.

a. Gamma and X-ray Spectroscopy. The major tools involved in gamma and x-ray spectroscopy are a reasonably high resolution gamma/ x-ray detector (such as a GeLi or selectively high resolution NaI) and a multi-channel analyzer. With this equipment, it is possible to accurately determine the energies of the gamma and x-radiation emitted by a contaminated sample. Generally, spectroscopic techniques are not used for absolute measurements of amount of contamination (for example, microcuries) in a sample. However, by adjusting for the energy dependence of detection efficiencies and using standard spectral unfolding techniques, the relative amounts of various isotopes present in the contaminant may be determined accurately. Recalling the discussions in the preceding sections, immediate application can be seen for such information: For example, spectroscopy allows determination of the relative abundance of Am-241 to Pu-239, resulting in accurate calibration of the most sensitive (FIDLER) survey techniques.

b. Alpha-Beta Counting.

(1) Another laboratory technique, alpha-beta counting, results in a reasonably accurate determination of the absolute amount of contamination in a sample. Two types of counters are common and both are fairly simple in principle. In one, a reasonably sensitive alpha-beta detector, such as a thin layer of ZnS mated to a photomultiplier tube, is mounted in a chamber that is shielded to remove background radiation. A sample, made very thin to minimize self-absorption, is inserted into the chamber under the detector. In some apparatus, air is evacuated from the chamber to eliminate air absorption of the radiation. The count rate is then measured. Knowing the geometry of the experiment permits translating the count rate to an absolute evaluation of sample activity.

(2) Another alpha-beta technique involves gas-flow proportional counters. In these devices, a sample is inserted 'into the chamber of a proportional counter. Any emitted radiation causes ionization of the gas in the counter which is electronically amplified and counted.

(3) In both types of alpha-beta counter, the most difficult, sensitive part of the experiment is the sample preparation. To achieve absolute measurements of activity, absorption of the radiation must be minimized by the overburden caused by the sample itself. Techniques used include dissolution of the sample onto a sample holder; evaporation of the solvent leaves a very thin, negligibly absorbing sample. Clearly, quantitative alpha-beta counting is a difficult, time-consuming process.

c. Liquid Scintillation.

(1) In a few cases, notably in the detection of beta radiation from tritium, the energy of the radiation is so low - and the resultant absorption is so high - that solid samples cannot be used for quantitative analysis. In these cases, dissolving the contaminant in a scintillating liquid may be possible. Glass vials of such liquid can then be placed in a dark chamber and the resulting scintillation light pulses counted using photomultipliers.

(2) Again, the outstanding difficulty with this process is in the sample preparation. Scintillation liquids are extremely sensitive to most impurities which tend to quench the output of light pulses. As a result, the most common technique for liquid scintillation sample gathering is to wipe a fixed area (typically 100 square centimeters) of a hard surface in the contaminated area with a small piece of cloth. The cloth can then be immersed totally in scintillation liquid in such a way that subsequent light emission will be visible to one of the photomultipliers in the analysis chamber. Alternatively, the cloth can be replaced by a special plastic material that dissolves in scintillation liquid without significantly quenching light output. In either case, the technique works best when the contamination can be gathered without large amounts of local dirt, oil, etc.

APPENDIX 5-B

ENVIRONMENTAL SAMPLING

5-B-1 GENERAL

The collection and analysis of samples provides numerical data which describes a particular situation. The JHEC will provide direction for sampling procedures. The sampling criteria will be situation and site dependent. The results then may be used for the formulation of a course of action. This appendix addresses air, soil, vegetation, water, and swipe samples.

a. *Air Sampling. Air sampling is conducted to determine if airborne contamination is present. It provides a basis for estimating the radiation dose which people without respiratory protection may have received. The time required to respond to an accident and initiate an air sampling program will result normally in little or no data being obtained during the initial release of contamination when the highest levels of airborne contamination are expected. Most air sampling data obtained during an accident response will reflect airborne contamination caused by resuspension. Even though this discussion is directed primarily at airborne contamination caused by resuspension, the recommended priorities and procedures will permit as much information as possible to be collected on the initial release if air samplers are positioned soon enough. Priority should, therefore, be given to initiation of an air sampling program as* soon *as possible after arrival on-scene. Whether or not data is obtained on the initial release, air sampling data will be needed immediately to assess the hazard to people still in the area, to identify areas and operations which require respiratory protection and to identify actions required to fix the contaminant to reduce the airborne hazard and spread of contamination. When using filtration to collect particulate samples, the selection of filter medium is extremely important. The filter used must have a high collection efficiency for particle sizes that will deposit readily in the lung (5 microns or less).*

b. *Response plans should include provisions for establishing an air sampling program. This plan would include sufficient air monitors (battery powered or a sufficient number of portable electric generators), air monitor stands, filter paper, personnel to deploy samplers and collect filters, analysis capability and a method to mark and secure the area monitors against tampering. Also important is a means to ensure that air samplers are properly calibrated (see Table 5-B-l).* Staplex *air samplers use the CKHV calibrator for 4" filter and CKHV-81O calibrator for the 8" x 10" filters. Normally, 1000 CFM of air must be sampled for accurate results.*

Table 5-B-1. Air Sample Calibration

Filter Type	Cal.Kit	Flow Rate	Operation Time
4" *TFA #41*	*CKHV*	*18 CFM*	*55* min
4" TFA #21 33	CKHV	36 CFM	28 min
4" TFA "S"	*CKHV*	*70 CFM*	*15* min
8" X 10" TFA-81O	CKHV-81O	50 CFM	20 min

5-B-2 AIR SAMPLING TIME

The period of time over which an air sample is collected determines the volume of air sampled. Variables which affect the accuracy of air sampling results include the type of sampling equipment used, the accuracy with which contaminants on the filter can be measured, and the size of the sample. The sum of the errors can be offset, in part, by increasing the total volume of the sample collected. Increasing sample time presents no real difficulty when the interest is in long-term average concentrations, precision of results, or in detection of very low levels of contamination, as will be the case during decontamination and restoration operations. During the initial response, when the interest is in rapid evaluation of air contamination to identify areas where high concentrations of airborne contamination could pose a hazard to unprotected persons in relatively short periods of time, short sampling times are appropriate. When taking samples for rapid evaluation, samplers should be operated long enough to sample a minimum of 1000 *cubic feet of air. Once that data required for prompt evaluation is obtained, an air sampling program should be established to obtain 24 hour samples (equipment permitting), or high volume samples on a regular basis.*

5-B-3 AIR SAMPLER PLACEMENT

Sampler positioning is directed toward the first 24-48 hours following an accident, or until an air sampling program tailored to the specific situation can be implemented. During this period the number of air samplers available will be limited, and should be placed to obtain the maximum amount of information possible.

a. *The amount of airborne contamination caused by resuspension will vary from location to location as a function of surface type, physical activity, surface wind patterns, and the level of contamination on the ground. Recommendations on the initial placement of samplers assume that the mix of surface t ypes is relatively constant throughout the area, that air samplers will be placed to minimize any localized wind effects, and that the location of physical activity in the area (for example, response actions or evacuation) will be known and controlled. The main variables in determining the amount of airborne contamination will be ground contamination levels and wind speed. To provide the quickest and most accurate estimate of the maximum concentrations of airborne contamination, priority should therefore be given to placing an air sampler at, or near, the most highly contaminated area which is accessible.*

b. Figure 5-B-1 shows the recommended placement of air samplers. The sampler number indicates the priority which should be given to placement. All air sampling locations should "be marked with a unique number or symbol on a stake, so that data may be correlated with other information in the following days. During the initial response, sampler No. 1 is placed downwind from the accident site to determine the hazard in the immediate area of the accident and should operate continuously. The distance should be modified in a downwind direction if necessary to permit access by a clear path for placement and periodic readings and filter changes. The time of readings and/or filter changes should be coordinated with EOD personnel. Air Sampler Placement sampler No. 2 is placed downwind from the accident at a distance dependent upon the wind velocity, see Table 5-B-2. Modifications to this location should be considered based on accessibility, the location of nearby populated areas and microclimatology. Down-wind samplers should be operated until it can be determined that no airborne contamination exists at their locations, and that actions taken upwind of the location

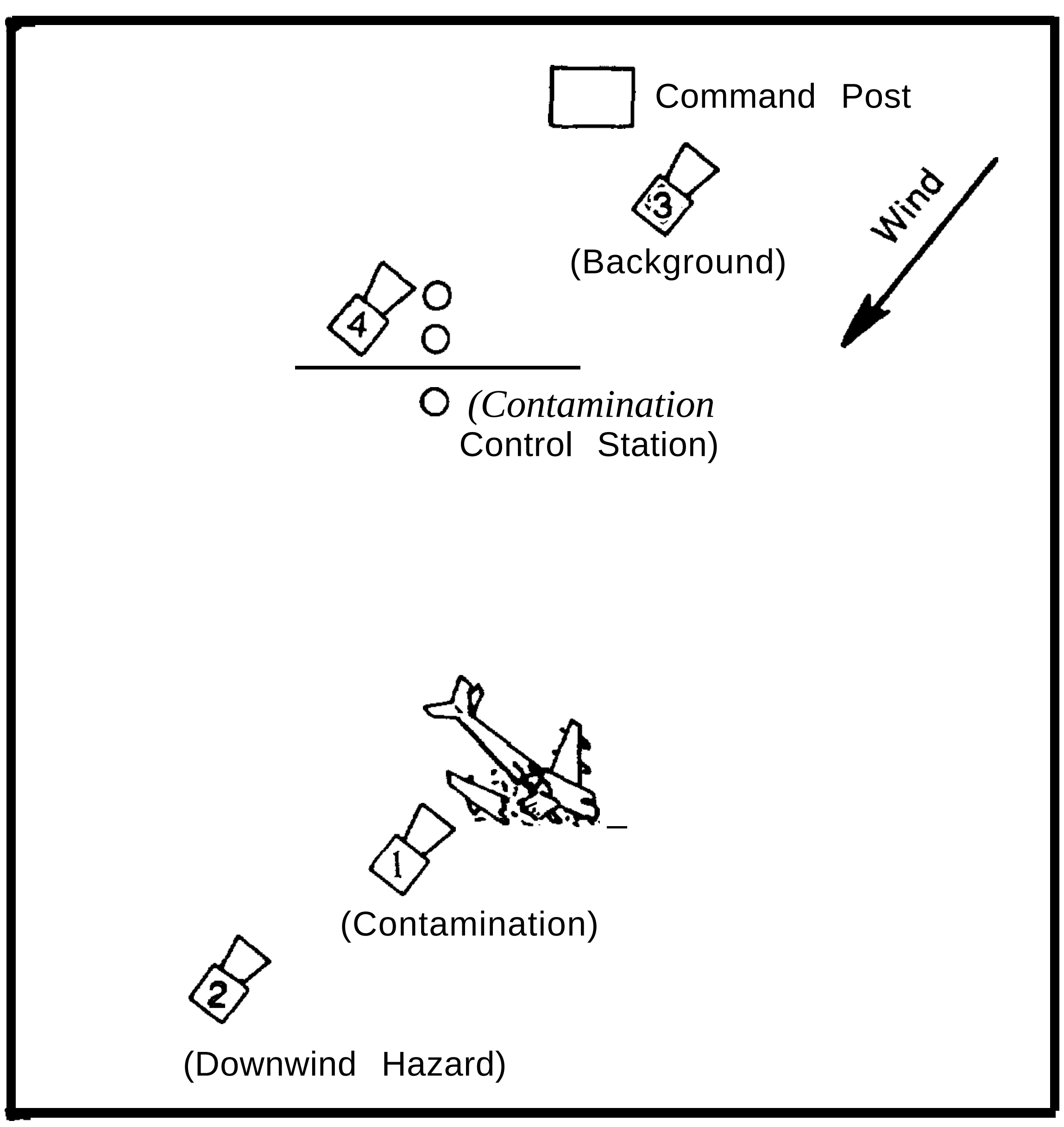


Figure 5-B-1. Air Sampler Placement.

Table 5-B-2. Air Sample Placement (No. 2)

Wind Speed		Approximate Downwind Distance	
(MPH)	**(Knots)**	**(Meters)**	**(Feet)**
6-10	**4-9**	**1,000**	**3,300**
11-IS	**10-13**	**1,500**	**5,100**
16-20	**14-17**	**2,000**	**6,600**
Above 20	**Above 17**	**2,500**	**8,200**

or changes in meteorological conditions will not result in airborne contamination. Sampler No. 3 is placed approximately 610 meters upwind of all contamination and outside the contamination control area to obtain simultaneous background air samples for use in interpretation of other readings. Background samples should be collected concurrently with the sample of interest, if possible, as the amount of naturally occurring airborne radioactive particulate may vary as a function of time due to wind changes. Air sampler No. 4 is placed at the contamination control station and operated continuously during contamination control station operations since personnel leaving the contaminated area may carry and resuspend contaminants. The amount of contamination resuspended in this manner is expected to be small. During the initial phases of response, consideration should be given to using all additional samplers, if available, in downwind locations to supplement sampler No. 2, particularly when populated areas are in, or near, the contaminated area.

5-B-4 AIR SAMPLE DATA RECORDING

For air sampling data used in the overall radiological assessment and confirmation of field calculations, and confirmed or validated later by laboratory analysis, all pertinent data must be recorded. An air sampling log containing all of the following data should be maintained. When falters are changed, they should be placed in a plastic bag for laboratory analysis and annotated with items a - f.

a. Type and serial number of sampler.

b. Location of sampler, including identification of field marking (stake) used to mark location.

c. Average flow rate and/ or volume of air.

d. Date.

e. Start and stop time of sample.

f. Wind direction and weather conditions.

g. Type of filter.

h. Field readings on filter and time made, particularly if readings were taken without changing falter. Including radiation detection instrument type and serial number as well as designation of attached probe used to monitor the filter.

i. Laboratory facility to which the filter was sent for processing..

5-B-5 AIR SAMPLE ANALYSIS

Air sampler filters can be analyzed using radioanalytical techniques by DoE, RADCON, and AFRAT personnel or by using a calculation method. The calculations shown below are for field use in calculating gross activity on the filter. Any background radiation from naturally occurring radionuclides (for example, radon, thoron, and their daughters) should be subtracted when applying the calculated results to protection standards. This calculation is done by subtracting the gross activity of the background sampler (No. 3) from the gross activity of the sampler of interest when making rapid evaluations. Background corrected, results may also be obtained by letting the naturally occurring radon, thoron, and their daughters decay to background. The radon chain may be considered completely decayed after almost four hours, and the thoron chain after almost three days. Re-measurement after these times permits identification of the amount of sample activity caused by these elements. During rapid field calculations early in the response, the check for radon is appropriate if, or when, levels of airborne contamination detected are at or slightly above the established levels. The three-day decay time precludes checking for thoron during the initial response.

a. The following equation may be used for initial field evaluation of air sampling data to obtain rough estimates of airborne contamination utilizing the AN/ PDR-60 or AN/ PDR-56 (with the large probe attached) and 8 x 10 inch or 4-inch (round) Whatman #41 filters.

$$\text{dpm/m}^3 = \frac{\text{cpm x CF}}{\text{AFR x T (rein)}} - \text{Background Reading}$$

where cpm = alpha meter reading on air filter in counts per minute

AFR = Average Flow Rate of the air sampler in cubic feet per minute

T = Time in minutes the air sampler was running

CF = Conversion factor (1000 for AN/ PDR-60, 4000 for AN/ PDR-56) includes unit conversions, area correction factors, and other constants, assuming use of 8 x 10 inch Whatman #41 filter paper. For 4-inch, (round) filter paper, the conversion factors are 200 and 800 for the AN/ PDR-60 and AN/ PDR-56 respectively.

b. If other alpha instruments or filters are being used the following equation should be used for field evaluation of air sampling data.

$$\text{dpm/m}^3 = \frac{\text{cpm x } A_f}{0.5 \text{ x m}^3 \text{ x F x } E_f \text{ x } E_c \text{ x } A_c}$$

where cpm = alpha meter reading on air filter in counts per minute

A_f = Area of filter used (any units)

A_c = Area of filter actually counted by the instrument (same units as Af)

F = Alpha absorption factor for filter used (from manufacturer's specifications)

E_f = Collection efficiency of filter used (from manufacturer's specifications)

m^3 = Total volume of sampled air in cubic meters

E_c = Efficiency of counting instrument

5-B-6 ENVIRONMENTAL SAMPLES

a. Soil. Soil sampling procedures depend on the purpose of the sampling program. In all cases, careful selection of control (background) samples is required to allow interpretation of results. The following minimum quantities are necessary for analysis:

(1) Gamma spectrometry plus gross alpha and/or gross beta—two kilograms of soil (approximately one square foot area three inches deep).

(2) Gross alpha and/ or gross beta only—100 grams.

(3) For a specific alpha and/or beta radionuclide, particularly Pu-239 (plutonium) —consult the appropriate Service laboratory.

b. Water.

(1) Surface and/ or waste discharge sources-two liters.

(2) Drinking water sources—one liter.

c. Vegetation. The minimum sample volume is three liters of densely packed sample and should be double plastic bagged or packed in a one-gallon wide-mouth plastic jar.

d. Swipes. Filter paper discs are used for taking swipe tests. Whatman No. 41 filter paper, 4.25 cm, FSN 6640-00-836-6870, is recommended for swipes. If this is unavailable, other filter paper with a maximum diameter of 1 3/4 inches may be substituted. Place a small "x" IN PENCIL ONLY on the outer edge of the filter paper on the side which is to touch the radioactive source or area being tested for contamination. Each swipe should be taken from an area of about 100 cm^2 by gently rubbing two or three times with the dry filter paper disc. The swipe is then placed, *unfolded*, in a properly completed Service form for a Swipe Container. If forms are unavailable, a plain envelope containing the required collection information may be substituted.

APPENDIX 5-C

SPECIALIZED RADIOLOGICAL MONITORING, RADIAC REPAIR, AND HAZARD ASSESSMENT/CAPABILITIES TEAMS

5-C-1 GENERAL

a. This appendix provides information on service radiation monitoring teams (health physics and bioassay specialists, a radiation equipment repair team) and on DoE and related monitoring and assessment capabilities.

b. The detection/measurement of different types of radiation and the inherent difficulties have been enumerated. However, in the event of an incident/ accident, radiation detection/ measurement must be completed. The need or preliminary data on the absence/ presence of radiation for the OSC is imperative. Many military units and some civilian firms/ agencies possess alpha and gamma detection capabilities. These units/ firms have equipment and individual monitor capabilities that can provide radiation measurements and preliminary survey data. However, a finite definition of the accident area is needed to plan, initiate, and complete site restoration.

c. The radiological characterization of the accident site is an iterative process involving the systematic integration of data produced by several assessment techniques. The following describes those resources available to enable theoretical, preliminary, and definitive site characterization for the OSC.

5-C-2 DEPARTMENT OF DEFENSE

a. U.S. Army Radiological Control (RADCON) Team. The RADCON Team is a specialized team located at Aberdeen Proving Ground, Maryland, and organized to provide technical assistance and advice to the OSC in radiological emergencies.

(1) The RADCON Team is organized to:

(a) Perform detailed radiological surveys for alpha, beta, and gamma radiation.

(b) Control and supervise waste disposal measures.

(c) Provide health physics services.

(d) Control and supervise radiological safety services.

(e) Supervise and provide technical advice for decontamination operations.

(f) Supervise and provide technical advice for the control and containment of the radiological contamination at an accident site.

(2) The RADCON Team will consist as a minimum of a team leader, a qualified health physicist, and eight specialists qualified in air sampling and in monitoring for alpha, beta, and gamma radiation. All team members have a minimum security clearance of Secret and are authorized access to Restricted Data and Critical Nuclear Weapons Design Information.

(3) Requests for additional information should be directed to RADCON personnel. Radiological Control team assistance may be requested through the Army Operations Center or the JNACC.

b. U.S. Air Force Occupational and Environmental Health Laboratory (OEHL). The Occupation and Environmental Health Laboratory, Brooks AFB, Texas, 78235, provides many radiation protection services as follows:

(1) Conducts calibration, traceable to the National Institute of Standards and Technology, and minor repair services for portable instruments used and owned by the USAF Medical Service for. the detection and measurement of electromagnetic and ionizing radiation.

(2) Maintains the USAF stock of low energy photon field survey instruments with trained operators to support disaster operations.

(3) Deploys a field-qualified team of health physicists, health physics technicians, and equipment called the AFRAT. This team is capable of responding worldwide to radiation accidents with air transportable equipment for detecting, identifying, and quantifying any type of radiation hazard; radioisotope analysis of selected environmental, biological, and manufactured materials; and on-site equipment maintenance and calibration.

(4) Conducts special projects dealing with long and short term evaluations of radiation exposures.

(5) Request for additional information should be directed to OEHL personnel. OEHL services may be requested through the Air Force Operations Center or the JNACC.

c. U.S. Air Force Air Transportable RADIAC Package (ATRAP). The Air Transportable RADIAC Package is located at Kelly AFB, Texas. It is a collection of RADIAC equipment, spare parts, and trained instrument repair technicians maintained in an alert status by the Air Force Logistics Command for airlift to the scene of a nuclear accident or radiological incident. The Air Transportable RADIAC Package is able to support forces responding to an accident or incident by providing spare RADIAC sets and an on-scene repair shop for instruments used in radiological surveys. The ATRAP team is prepared to repair, calibrate and issue RADIAC instruments to radiation survey teams at the scene of the accident on a twenty-four hours, seven days a week basis.

(1) The OSC will coordinate support for the ATRAP and accompanying technicians.

(2) The ATRAP will maintain in a ready status for deployment to the scene of a nuclear accident/ radiological emergency within four hours after notification by the Air Force Operations Center. The ATRAP will move over the road to sites within 150 miles of Kelly AFB, Texas. Beyond three hours driving time, the ATRAP will be airlifted by Military Airlift Command. For accident sites on inaccessible terrain or in water, ATRAP units will be moved by helicopter or by water/ sealift means.

(3) Requests for additional information should be directed to ATRAP personnel. ATRAP services may be requested through the Air Force Operations Center or the JNACC. Phone numbers are listed in Appendix 1-G.

d. U.S. Navy RADCON Team. The Navy RADCON Team provides health physics assistance to the OSC or activity commander in the event of a nuclear weapons accident. The Navy RADCON Team is located at the Naval Sea Systems Command Detachment, Radiological Affairs Support Office (NAVSEADET RASO), Yorktown Virginia.

(1) The Navy RADCON Team can provide the following capabilities:"

(a) Field survey and laboratory analysis for " alpha, beta and gamma radiation emitters.

(b) Environmental sample analysis,

(c) Limited bioassay analysis.

(d) RADCON and radiation health expertise to the OSC.

(e) Reference library.

(f) Air deployable assets.

(g) personnel dosimetry support, limited RADIAC repair, and Hot Line management.

(2) Request for additional information should be forwarded to the Director, Radiological Controls Program Office (SEA-06GN), Naval Sea Systems Command.

5-C-3 DEPARTMENT OF ENERGY (DoE)

Services of DoE capabilities will be requested by the DoE Team Leader, but requests may be made also through JNACC if the DoE Team Leader is not on-scene.

a. HOT SPOT Health Physics Codes.

(1) The HOT SPOT Health Physics Codes were developed for the Department of Energy's Accident Response Group (DoE ARG) to provide a quick initial assessment of accidents involving radioactive materials. These codes are run on the Hewlett-Packard HP-41 family of hand-held computers to allow for easy "field" use. Also, the codes are available in an IBM-PC compatible version. At present, 13 separate programs exist, ranging from general programs for downwind assessment following the release of radioactive material to more specific programs dealing with the release of plutonium, uranium, or tritium to programs that estimate the dose commitment from the inhalation of various radionuclides.

(2) The HOT SPOT computer programs were created to provide Health Physics personnel with a fast, field-portable calculational aid for evaluating accidents involving radioactive materials. These codes provide a first-order approximation of the radiation effects associated with the atmospheric release of radionuclides

within minutes of data input. Although significant errors are possible, the HOT SPOT programs will provide a reasonable level of accuracy for a timely initial assessment. More importantly, the HOT SPOT codes will produce a consistent output for the same input assumptions, thus minimizing the potential errors associated with reading a graph incorrectly or scaling a universal nomogram during an emergency situation.

(3) The HOT SPOT Health Physics Codes operating instructions and information are contained in Lawrence Livermore National Laboratory (LLNL) Manual 161, reference (o). The manual is designed for users of the codes and therefore does not contain detailed descriptions of algorithms used in the codes; however, key assumptions (for example, particle-size distribution and release fraction) are noted as appropriate.

(4) Table 5-C-1 is a summary of the programs contained in reference (o). Several programs deal with the release of plutonium, uranium, and tritium, to expedite the initial assessment of accidents involving nuclear weapons. Three general programs: PLUME, EXPLUME, and RESUS—allow for downwind dose assessment following the release of any radioactive material as a result of the continuous or puff release, explosive release, or an area contamination event. These three programs interact with a data-base containing 75 radionuclides selected from ICRP Publication 30. The source term can contain any or all of the radionuclides in the database, each with its independent release fraction, activity, and mitigation factor, if applicable. Should a desired radionuclide not reside in the database, a dose-conversion factor can be input by the user. Other programs estimate the dose commitment from inhalation of any one of the radionuclides listed in the database and estimate the effects of a surface-burst detonation of a nuclear weapon.

(5) The dosimetric methods of ICRP have been used throughout the HOT SPOT programs. Individual organ dose values (unweighed) are produced, along with the committed dose equivalent (weighted, equivalent whole-body dose commitment). Programs involving the atmospheric transport of radionuclides employ a Gaussian plume-dispersal model. Initial radionuclide distribution is modeled using virtual source terms as needed, for example, modeling the initial distribution associated with an explosive release or area.

TABLE 5-C-1. Programs Contained in the HOT SPOT Physics Codes

Program Name	Description
PUEXP	Downwind dose commitment and ground deposition estimates resulting from an explosive release of plutonium.
PUFIRE	Downwind dose commitment estimates resulting from a fire involving plutonium.
PURES	Downwind dose commitment estimates resulting from the resuspension of plutonium.
FIDLER	FIDLER calibration and data reduction. Also contains a subroutine for the determination of radionuclide weight fractions as a function of mix age.
TRIT	Downwind dose commitment estimates resulting from a tritium release.
UFIRE	Downwind dose commitment estimates resulting from a fire involving natural uranium of any enrichment of 235U.
LUNG	Lung screening for plutonium using a FIDLER detector.
BOMB	Effects of a surface-burst fission weapon.
RADWORK	Determination of recommended workplaces for the handling of radioactive materials.
PLUME	General Gaussian plume dispersion model, using ICRP-30 Library.
EXPLUM"E	General explosive release dispersion model, using ICRP-30 Library.
RESUS	General resuspension model, using ICRP-30 Library.
DosE	Inhalation dose commitment, using ICRP-30 Library.

Resuspension Source Term. Owing to the large uncertainties associated with the source terms and diffusion coefficients, additional fine tuning of the model with plume-rise algorithms and similar modifications was deemed unwarranted.

b. Atmospheric Release Advisory Capability (ARAC). ARAC is a DoE and DoD resource, directed by the Lawrence Livermore National Laboratory, that provides support to emergency response teams during accidents involving radioactive materials.

(1) ARAC provides the user with computer model estimates of the contamination distribution resulting from a nuclear weapon accident. ARAC products include computer generated estimates of the location and contamination levels of deposited radiological material and radiation dose to exposed population in the surrounding areas. Until time and equipment permit completion of extensive radiation surveys and bioassays, ARAC projections will assist in assessing the potential impact of an accident and in identifying areas for initial investigation by response force radiological teams.

(2) In the event of a nuclear weapon accident at or near an ARAC-serviced facility, the ARAC Center will be alerted by the facilit y's personnel using the ARAC site system computer located at the installation, immediately after the initial report to the NMCC is completed. If the accident occurred in a CONUS area, remote from an ARAC serviced DoD installation, notification of ARAC will come through the NMCC'S JNAIR Team. However, ARAC should be contacted directly by the installation initiating the OPREP-3 report to NMCC, by calling ARAC'S EMERGENCY number: commercial (41 5) 422-9100, FTS 532-9100, or through AUTOVON by asking the Albuquerque operator for the Livermore tie line extension 2-9100. At this time ARAC can't support OCONUS facilities in the same manner as CONUS facilities.

(3) During normal working hours (currently 0730 to 1615 Pacific Time), initial estimates of the extent of contamination can be ready for transmission from ARAC approximately 30 minutes after ARAC has received notification of the:

(a) Accident location.

(b) Time of accident.

(c) Type and quantity of weapons involved in the accident [weapon information should be transmitted using the line number(s) contained in TP-20-11, General Firefighting Guidance (C)].

(4) Responses outside the hours listed above are subject to an additional 60-90 minutes delay.

(5) Every effort should be made to provide updated or supplementary information to the ARAC Center as soon as it is available. Desired information includes:

(a) Observed wind speed and wind direction at the time of the accident, and subsequent weather changes.

(b) Description of accident particulars, including line numbers for the specific weapon(s) releasing. contamination, type and amount of fuel involved and measured contamination at specific locations with respect to the contamination source, if available.

(c) Specific details of accident fire or explosion, such as mechanism of the release (high explosive detonation or fire), duration of any fire, and height and size of the plume or cloud (if available from reliable observers).

(6) Approximately 30 minutes after the ARAC facility has been notified of the necessary accident information, a computer generated estimate of maximum credible ground-level-contamination spread and projected whole-body effective dose to exposed persons in the downwind area will be available. Conservative assumptions are made in calculating the amount of radiological material released so that these initial projections place an upper bound on levels of resulting contamination and dose. Weapons at risk, excluding insensitive high explosive (IHE) weapons, when exposed to unusual stress during the accident undergo a non-nuclear high-explosive detonation. Also, all the nuclear material at risk (except that of the IHE item[s]), is released in an aerosolized form. Similar conservative assumptions are made where specific accident information is missing or unknown. If the accident location isn't close to an ARAC serviced site, the initial projections will probably not include geographic features (roads, city boundaries, etc.). ARAC projected doses will assist initial response efforts in evaluating the potential hazard to the general public until comprehensive radiation measurements and bioassays can be performed. Projected deposition patterns will assist estimates of site restoration efforts.

(7) Approximately 60 to 90 minutes after notification of ARAC, a more refined projection will be available in somewhat less conservative assumptions are made in estimating the actual amount of material at risk released during the accident. (Estimates are now based on only those known to have undergone a high-explosive detonation). For consequence analyses, ARAC can generate a calculation based on a meteorological forecast to give projected contamination patterns in case of dispersal during a weapon-safing operation. Although the initial projections are shown typically on a 30-by-30' kilometer grid, these refined projections may cover either a larger or smaller area depending on the

downwind extent of the contamination. Note that ARAC can generate projection plots to match a given map scale (for example, 1:50,000) for ease of overlaying the projected deposition pattern.

(8) When available, ARAC may be transmitted to the ARAC site system computer located at most ARAC-serviced sites. If the site does not have a site system computer, the projections can be telefaxed to any CCITT Group 3 telecopier machine. The following paragraphs provide information regarding the ARAC example "initial" projections shown in Figures 5-C- I and 5-C-2.

(a) Geographic Contour Display. Release location is centered in this area (refined projections may have release location offset from center) with a 2000-foot fragmentation circle drawn around the release point. The display is always oriented with north toward the top. A maximum of three contoured areas will be shown emanating from the release point which will, in most cases, overlay a geographic representation, showing road networks and waterways, etc., of the area around the accident site. The words "SEE NOTES" will be printed across the middle of the display directing the viewer to the ARAC Computer Estimation Notes on the right side of the graphics plot. Printed across the top of each graphic display area will be the title of the underlying computer estimation denoting either a "50 Year Whole Body Effective Dose" or "Cumulative Deposition" plot.

(b) Descriptive Notes. To the right of the contour display will be a legend. The first line is a title line for these notes. The second line will denote the date and time that the specific computer model estimation was produced. Lines three through six will be reserved for general amplifying remarks about the computer estimation. Line seven identifies either the dose integration period or total deposition period time as appropriate (NOTE: All times will be shown as "Z" time. "Z" is equivalent to Universal Coordinated Time (UTC) which has replaced the more familiar Greenwich Mean Time (GMT)). Line nine shows the radiological material modeled, and the height above ground level at which the contour levels are calculated and displayed. Lines 10 through 22 will show the specific computer estimation action levels as calculated for that particular plot. The next several lines (down to the scale of the display shown in both kilometers and feet) comprise three separate blocks of information. Within each block is an area showing a particular contour cross hatch pattern used to mark areas in the contour display where the dose or deposition is greater than the stated value; the area covered by this particular pattern in square kilometers; and abbreviated, generalized actions that may be considered within this area. Note that the area given will encompass the area of all higher levels shown (for example, the area given for exceeding 25 rem is the sum of the area covered by the 25 and 150 rem contour patterns). There are a maximum of three cumulative deposition and four dose exposure levels for which projections are made. Only the areas with the three highest projected levels will be shown on any ARAC plot. Projected cumulative depositions are for levels greater than 600,60, and 6 microCuries per square meter ($\mu Ci/m^2$). Dose exposures are projected for levels greater than 150, 25, 5, and 0.5 rem, which refer to a 50 year whole body effective dose via the inhalation pathway.

(9) The wording which accompanies the action levels in the legend follows:

(a) 50-Yr Whole-Body Effective-Dose "Exposure Action Levels." Projected doses apply only to people outdoors without respiratory protection from the time of the accident until the valid time of the plot, and recommended actions are to reduce the projected dose to those people exposed.

1. Greater than 150 rem - Immediate respiratory protection and evacuation recommended.

2. Greater than 25 rem - Prompt action required; respiratory protection required; consider sheltering or evacuation.

3. Greater than 5 rem - Respiratory protection required; recommend sheltering; consider evacuation.

4. Greater than 0.5 rem - Consider sheltering.

(b) Cumulative Deposition "Exposure Action Levels."

1. Greater than 600 $\mu Ci/m^2$ - Immediate action may be required until the contamination is stabilized or removed; issue sheltering instructions; recommend controlled evacuation.

2. Greater than 60 $\mu Ci/m^2$ - Supervised area; issue sheltering instructions; recommend controlled evacuation 2-14 days.

3. Greater than 6 $\mu Ci/m^2$ - Restricted area; access on need only basis; possible controlled evacuation required.

(c) The wording of the preceding deposition action levels was contracted because of space limitations on the ARAC plots. The full wording follows:

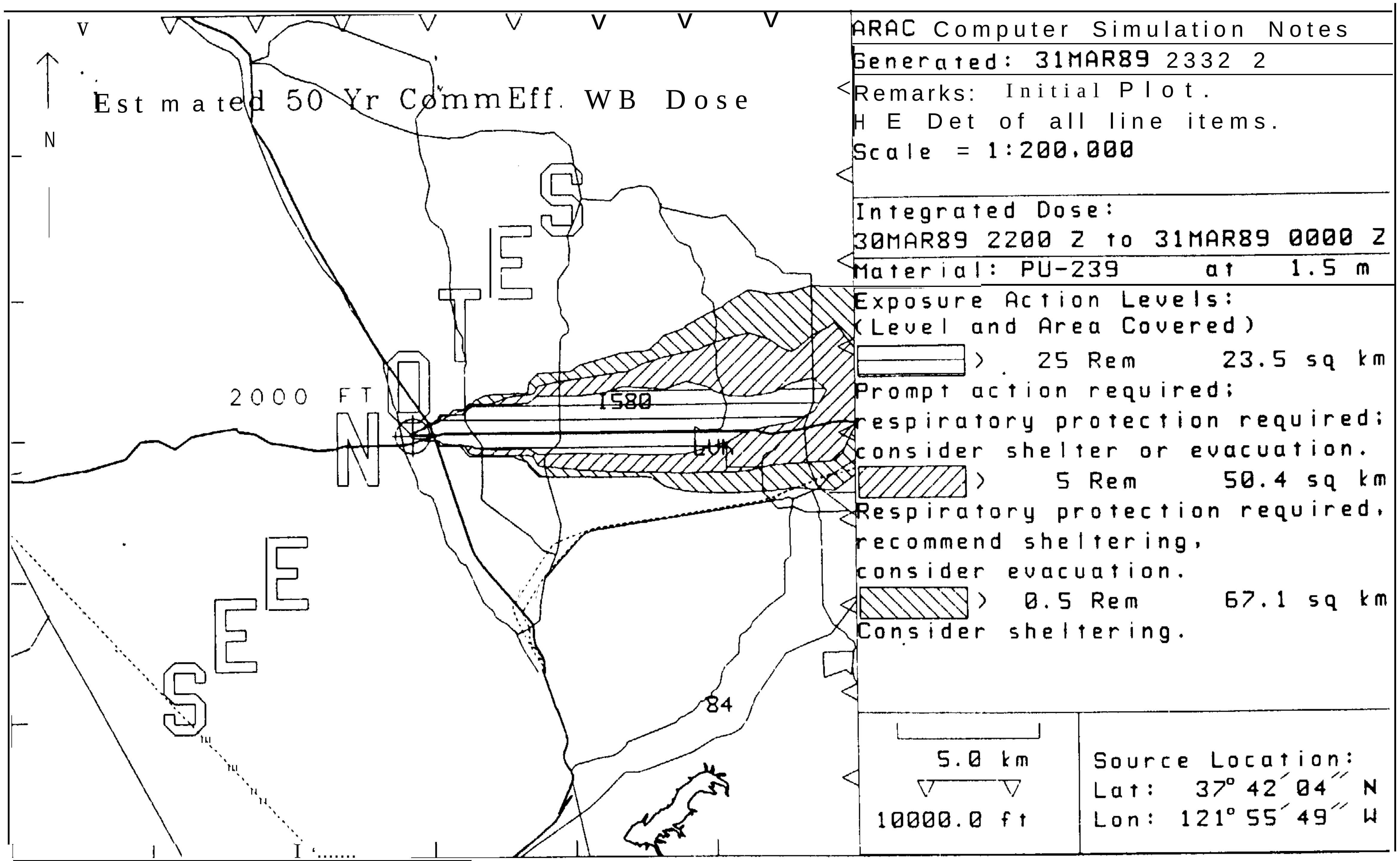


Figure 5-C-1: ARAC PLOT-Lung Dose.

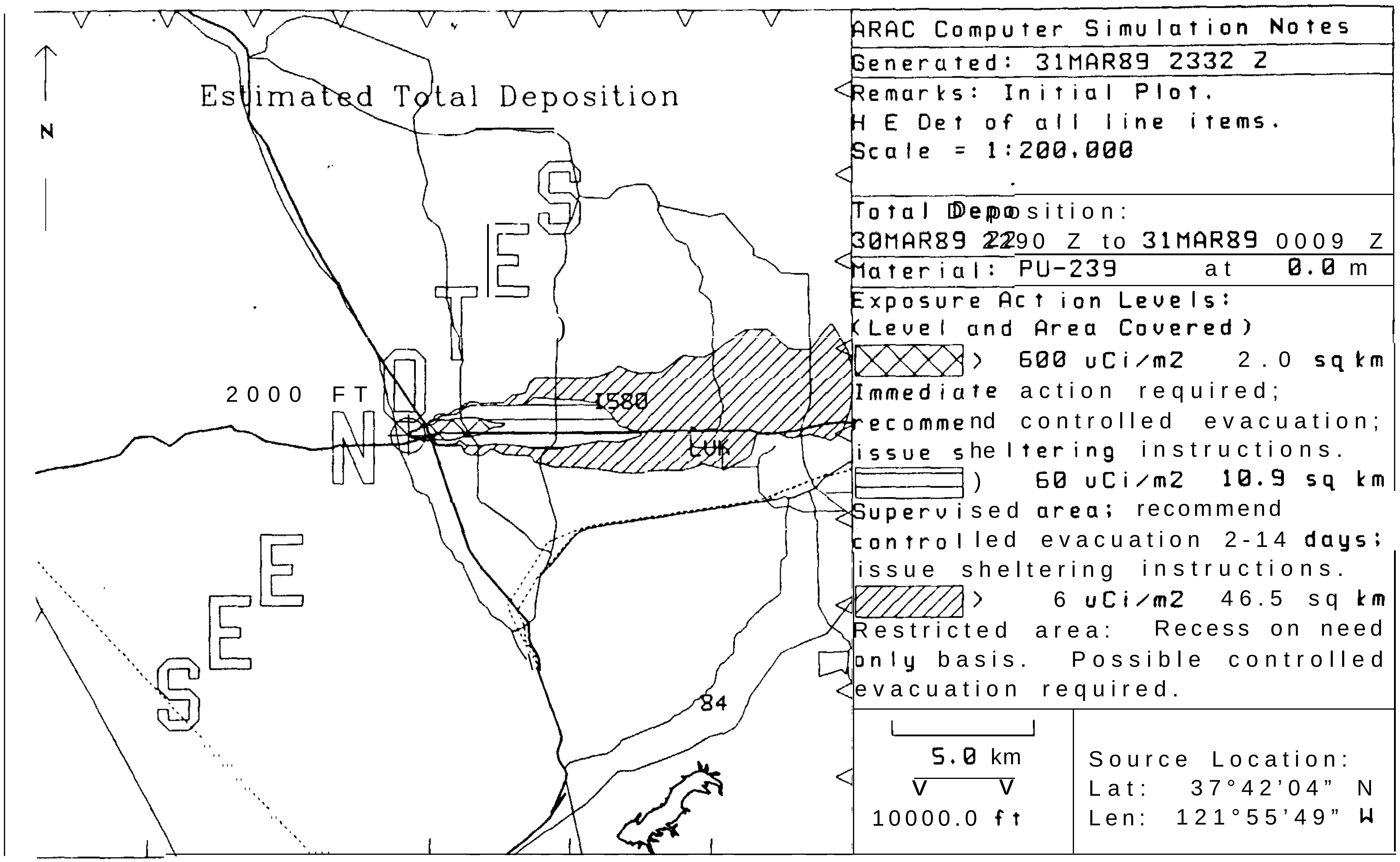


Figure 5-C-2. ARAC PLOT-Deposition.

1. Greater than 600 $\mu Ci/m^2$ - Immediate action required. Urgent remedial action may be needed from within a few hours up to two days. Full anti-contamination clothing and respiratory protection required by all emergency staff in this area. Residents should remain indoors with doors and windows closed. Room air conditioners should be turned off. Controlled evacuation of children and adults should be considered urgent. All work on, or the use of, agricultural products and/ or meat and poultry must be controlled and further action regarding them assessed.

2. Greater than 60 $\mu Ci/m^2$ - Supervised area. Controlled evacuation should be considered and may have to occur between about two days and two weeks or more. All activities should be considered carefully and supervised. Full anti-contamination clothing and respirators required for all personnel engaged in heavy work or dusty, windy operations. Residents should remain indoors with windows closed unless evacuation is in progress or there is no significant airborne hazard and none forecast to occur via resuspension.

3. Greater than 6 $\mu Ci/m^2$ - Restricted area. Entry restricted to those who live, work, and/or have a need to be there. Decontamination personnel and public health and safety staff should wear limited anti-contamination protective clothing. Controlled evacuation of residents, especially children, is possible during decontamination if there is a possibility of airborne contamination via resuspension.

c. Aerial Measurement System (AMS).

(1) General. The EG&G AMS has three capabilities available to support a weapon accident: aerial radiological mapping, aerial search for weapons and/ or weapon components, and aerial photography.

(2) Aerial Radiological Mapping. Aerial radiological surveys provide rapid assessment and thorough coverage of large areas and yield average ground concentrations of the contaminant. The system can also be used to quickly prepare crude, but appropriately scaled, incident site maps. Instrumentation includes large-volume, sodium-iodide gamma-ray detectors, data formatting and recording" equipment, positioning equipment, meteorological instruments, direct readout hardware, and data 'analysis equipment. A variety of DoE owned aerial platforms (fixed-wing and helicopter) are dedicated to supporting this mission. Also, equipment capable of being mounted on a variety of DoD helicopters is available to perform survey missions as needed.

(a) In, a nuclear weapon accident, a preliminary radiological survey would establish whether radioactive materials had been dispersed from the weapon. Dispersion patterns and relative radiation intensities, immediately available from the initial survey, may be used to guide radiation survey teams to the areas of heaviest contamination. AMS personnel will assist interpreting and correlating their information with other radiological survey data. Additional data processing will establish the identity and concentration of the isotopes involved. Subsequent surveys could provide data on the progress of clean-up operations.

(b) The first radiological photography survey conducted after a weapon accident is likely to follow this protocol and time frame:

1. The helicopter would arrive six to ten hours following notification.

2. The helicopter would then be refueled and the crew would obtain instructions within two hours.

3. A survey would then be conducted in a serpentine pattern of survey lines 0.5 to five miles apart to determine:

a. Radiological deposition outline.

b. Direction of the plume centerline.

c. Approximate radiation levels along the plume centerline.

d. Dominant isotopes.

4. Information from 3 would be transmitted by radio to base operations during the survey.

5. The analysis laboratory would arrive 4 hours (plus driving time) after notification.

6. Full analysis of flight results would be available 6 to 12 hours after the flight is completed or after the analysis laboratory arrives.

(c) After the first, broad survey is completed, a series of smaller area surveys would be initiated. The flight altitude would likely be 100 feet with 200 foot line spacings. The purpose of these surveys would be to map the contaminated area in detail. The length of time required to complete this series of surveys may be from one to five days, depending upon the area to be surveyed and the weather.

(d) The results of an aerial survey of Area 13 of the Nevada Test Site is shown in Figure 5-C-3. This was the site of a "one-point" detonation in the 1950s to simulate a weapon accident. The aerial survey data were analyzed for the 60 keV photopeak of Am241. Detailed radiological contours, such as those shown in

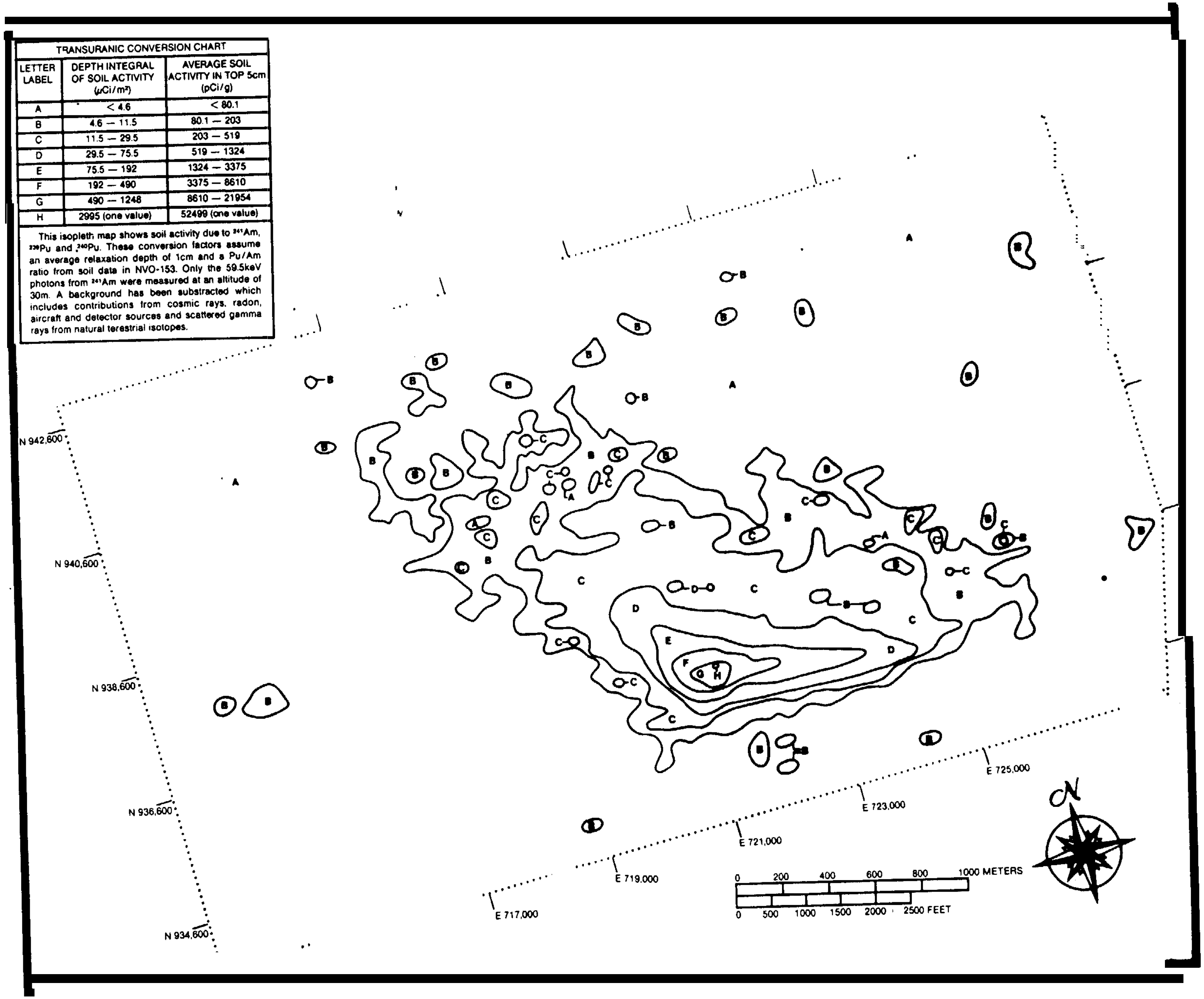
Figure 5-C-3 would be available five to eight hours after the completion of the previous survey flight.

(e) The sensitivity of the system depends upon the flight altitude, area of contamination and the interference of other isotopes (both natural and man-made). Experience has shown that the lower level of detectability y of Am241 can be expected to be 0.03 to 1.0 $\mu Ci/m^2$, and 0.03 to 0.3 $\mu Ci/m^2$ for both Cs137 and 1131. The americium concentrations indicated represents on the order of 1 to 10 $\mu Ci/m^2$ of plutonium.

(f) Comparison with ground-based survey and sample results should be done with caution. The area sampled in a single aerial measurement is on the order of 1,000 times the area sampled by a FIDLER-type instrument at one (1) foot above the ground and 1,000,000 times larger than the area sampled by an alpha probe or a soil sample. The aerial survey results average-scale averages and take into account the overall effect of roads, ditches, water bodies, vegetation cover and terrain effects.

(3) Aerial Search. In certain scenarios, the aerial search capabilities available from AMS capabilities may need to be employed. These consist of gamma and neutron detector modules designed for the DoE owned BO-105 helicopters or portable modules that can be used in helicopters, such as the UH-60 and U H- 1. This capability may be useful only for certain sources of known detectability and normally requires low altitudes (100 feet or less) and slow speeds (approximately 60 knots). Aerial search personnel will be able to determine the appropriate flight parameters when notified of the particular scenario.

(4) Aerial Photography. Two major photographic systems are used to acquire detailed serial photos over a site. One system consists of a large format aerial mapping camera operated in fixed-wing aircraft, which produces detailed aerial photographs. The second system operates out of helicopters, utilizing the Hasselblad 70mm cameras to produce color photographs. Film from the Hasselblad system can be produced and printed under field conditions. Large prints up to 20" x 24" produced to map scales can be printed on-site generally within hours of the completion of the flight.



TRANSURANIC CONVERSION CHART

LETTER LABEL	DEPTH INTEGRAL OF SOIL ACTIVITY (μCi/m²)	AVERAGE SOIL ACTIVITY IN TOP 5cm (pCi/g)
A	< 4.6	< 80.1
B	4.6 — 11.5	80.1 — 203
C	11.5 — 29.5	203 — 519
D	29.5 — 75.5	519 — 1324
E	75.5 — 192	1324 — 3375
F	192 — 490	3375 — 8610
G	490 — 1248	8610 — 21954
H	2995 (one value)	52499 (one value)

This isopleth map shows soil activity due to ^{241}Am, ^{239}Pu and ^{240}Pu. These conversion factors assume an average relaxation depth of 1cm and a Pu/Am ratio from soil data in NVO-153. Only the 59.5keV photons from ^{241}Am were measured at an altitude of 30m. A background has been subtracted which includes contributions from cosmic rays, radon, aircraft and detector sources and scattered gamma rays from natural terestrial isotopes.

Figure 5-C-3. AMS Plot (Example).

APPENDIX 5-D

AREA AND RESOURCES SURVEYS

5-D-1 SURVEYS

a. General. Extensive radiation predictions and surveys will be required to identify and characterize the area for decontamination and to develop and evaluate restoration plans. During the initial hours of the response, available radiation survey instruments and monitoring personnel for survey operations will be limited. Determining whether contamination was released by the accident must be done immediately. If a release occurred, priority must be given to those actions required to identify and minimize the hazards to people. These actions include identification of the affected area (perimeter survey) to permit identification of potentially contaminated people. Each successive survey operation will be based in part on the information gained from earlier operations. Initial radiation surveys may be based on ARAC information, if available, or only on the knowledge that contamination will be dispersed downwind. Later surveys will be based on the initial survey data and AMS plots. Days will be required to complete comprehensive contamination characterization.

b. General Survey Procedures. Selection of instrumentation, identification of the edge of contamination, determination of the location of measurements made, and data recording procedures are similar for most survey operations.

(1) Selection of Instrumentation.

(a) Alpha Instruments. Alpha instruments can detect lower levels of contamination than low energy gamma instruments. Under field conditions, however, alpha radiation has an extremely short detection range and its detection may be blocked by nothing more than surface moisture. Alpha surveys are possible only under dry conditions, for example, after any morning dew has evaporated. The fragility of the Mylar probe face on most alpha instruments combined with the short detection range of alpha radiation results in a high rate of instrument failure when field use requires measurement of contamination on rough ground or other irregular surfaces. Alpha instruments should therefore be used primarily for personnel and equipment monitoring at the hot line. Field use should be limited to only smooth surfaces like pavement and buildings.

(b) Low Energy Gamma Instruments. Instruments capable of detecting the low energy gamma- and x-ray radiations from plutonium, and its americium daughter, may be used to detect contamination. Low " energy gamma/ x-ray instruments are not subject to damage by surfaces being monitored and field surveys can be rapidly conducted. Low energy gamma instruments are, therefore, the recommended instruments for field surveys of plutonium contamination, whereas the SPA 3 probe is more useful for measuring the medium energy gamma radiation from uranium. For the best detection efficiency, low energy x-ray surveys should be conducted prior to any rainfall, and during the first five days after the accident before part of the measurable low energy radiation present is screened by the plutonium migrating into the soil. The best instrumentation for low energy gamma/x-ray surveys uses FIDLER probes, which will not normally be available until the specialized teams arrive. The type and amount of low energy gamma and x-ray radiation present depends on the age of the plutonium. Many weapons will contain plutonium over 10 years old, resulting in higher signal strengths for the same level of contamination as that produced by a "new" weapon; therefore, the age of the plutonium and projected signal strength should be determined as soon as possible. The age of the plutonium in a weapon can be obtained from the DoE ARG.

(2) Perimeter Contamination Levels. When alpha instruments are used to establish the perimeter, readings of 500 CPM are recommended for instruments with 60 cm probe area and 105 CPM for instruments with 17 cm probes be used to mark the perimeter. When low energy gamma/ x-ray instruments are used to establish the perimeter, a reading of twice background is recommended to mark the perimeter. FIDLERs are recommended to perform perimeter surveys, with alpha instruments the second choice. If FIDLERs are unavailable, and if weather or field conditions preclude the use of alpha instruments, the AN/ PDR-56F, with the x-ray probe attached, may be used. If fission products 'were caused by the accident, priority should be given to establishing a 10 mR/ hr perimeter.

(3) Fixing Survey Points.

(a) For radiation monitoring data to be useful, the point where it is collected must be identifiable on a map or aerial photo of the area, Engineering survey equipment may be unavailable to determine precise positions in the early phases of response, or the immediate need for radiological data may outweigh the time required to determine precise positions.

1. Data points should be marked in some manner so that the point can be later relocated for other actions, or the position determined precisely for later correlation of the data with other information.

2. A numbered or uniquely identified stake may be used to mark the location on soil, and a similar unique identification painted or otherwise marked on pavement or other hard surfaces for later reference. When engineering survey equipment is not being used, the monitoring log, or data collection record, should show the identification marking used at each point, and an estimated position to use immediately following data collection.

3. Estimated positions may be street addresses in urban areas, the estimated distance down a street or road from an identifiable intersection, compass bearings taken on two or more identified reference points, or any other reference which can be located on the maps being used. If a vehicle is used during the initial perimeter survey, the odometer mileage from an intersection or other known point may be adequate for identifying positions in sparsely populated areas.

(4) Recording Survey Data.

(a) If an engineering survey is being performed concurrently with the radiological survey, recording procedures must ensure that positional data being recorded at the transit position and radiological data being recorded by the monitors can be correlated. Monitoring and survey teams' records should include the following information:

1. Team member names.

2. Type instrument and serial number.

3. Date and start/stop time of survey.

4. Data location mark (stake number or other marking) when used.

5. Estimated or surveyed position,

6. Instrument reading indicating if the reading is "Gross," meaning background radiation reading has not been subtracted, or "Net" meaning the background radiation reading has not subtracted from the instrument *reading.*

(5) Perimeter Surveys.

(a) Initial Perimeter Survey. Rapid identification of the perimeter of the contaminated area is required to prevent undue alarm, to aid in identifying affected people, and to establish controls to prevent the spread of contamination. The On-Scene Commander and civil authorities will need at least a rough plot of the perimeter as soon as possible upon which to base their actions. The urgency of perimeter definition is directly related to the population in the area. Streets and roads will normally provide rapid access to populated areas, although the location of rivers or other terrain features which may hinder access to portions of the potentially contaminated area must be considered when directing the perimeter survey. The contaminated area may be a mile or more wide and several miles long, therefore use of widely separated monitoring points and a vehicle to move between monitoring points should be considered when directing the initial perimeter survey. ARAC projections, if available, will assist in determining the *area and distance* the *perimeter survey teams may* be required to cover, and perimeter survey procedures may be adjusted accordingly. If perimeter survey teams are equipped with a radio, a position report at the perimeter *locations on each traverse* will provide an *immediate* location of the perimeter to the command center and permit team progress to be tracked. While not classified, transmission of radiation readings should be discouraged on unsecure *nets.*

(b) Full Perimeter Survey. FIDLERs should be used when performing a full survey of the perimeter. This *may* not *be* possible until *after the* specialized *teams* arrive and may take weeks to complete. The procedure most likely to be used will consist of monitoring in and out along the edge of the area with readings being taken about every 50 feet. If weather or terrain require the use of the AN/ PDR-56 x-ray probe on the initial perimeter survey, the full perimeter survey can result in an expansion of the perimeter. If an alpha instrument was used for the initial perimeter survey, the perimeter established by the full perimeter survey should be about the same size or slightly smaller.

(6) Area Surveys.

(a) Radiological surveys of the contaminated area are required to identify areas requiring fixation, to support decontamination and restoration planning, and to determine decontamination effectiveness. The first survey covering the entire area will be provided most times by *the* Aerial Measurement System (AMS).

The initial AMS data will be available four-five hours after completion of survey flights. The AMS plot requires interpretation by trained analysts. Ground survey data is required to validate and support analysis of the plot. Some of the supporting ground data may be provided by the initial perimeter survey. Ground surveys to support decontamination planning will be performed with FIDLERs. Usually some form of grid survey will be used with the grid size determined by the desired accuracy of estimated activity between grid points and measurement errors associated with the instruments. From several days to over a week may be required to complete a ground survey of the entire area. Ground surveys validating decontamination effectiveness may require several months to complete due to the low levels of contamination remaining, and the desired precision.

(7) Building Surveys.

(a) Radiological surveys of buildings within the contaminated area will be required to determine the appropriate decontamination actions. Alpha instruments may be used on most building surfaces, however, use of FIDLERs may be necessary on surfaces which may damage alpha instruments, or on materials such as carpets where contamination maybe below the surface and screened from alpha instruments. The amount of removable contamination present must be determined by wiping surfaces with a piece of material, or swipe, which is then monitored for contamination it absorbed. Laboratory counting equipment should be used to determine the amount of removable contamination absorbed by the swipe. Initial building surveys should be performed only on the exterior unless the building is in use.

(b) Civil authorities should establish procedures for either building owners and/ or tenants, or an appropriate civil authority, such as a policeman, to accompany monitors when surveying building interiors. If interiors are surveyed before the surrounding area has been decontaminated, methods which minimize tracking of contamination into buildings should be used (for example, cover shoes with plastic bag immediately before entering buildings and ensure gloves are uncontaminated). Interior contamination levels will vary because of the time of year, the t ype of heating or cooling system used, and whether or not people were in the building at the time of, or following the accident. Interior contamination levels will be only a fraction of the exterior levels at the same location. The primary source of interior contamination are expected to be airborne contaminants entering the building through heating or cooling systems, and doors, windows, or other openings during the initial cloud passage; or contamination tracked or carried into the building by people or animals. The sealing of doors, windows, chimneys, and ventilators on evacuated buildings in highly decontaminated areas may minimize further contamination of the interior during contamination of the surrounding area. When monitoring the interior of a building, initial monitoring should be on the floor in the main traffic pattern (doorways, halls, and stairs), and on top of horizontal surfaces near heating or cooling duct outlets, windows and other openings into the building. If no contamination is found at these locations it is very likely no contamination entered the building. If contamination is found, additional monitoring should be performed. Monitoring results from furnace and air conditioning filters should be included in building survey records.

APPENDIX 5-E

RADIOLOGICAL MONITORING, MEASUREMENT,

AND CONTROL FORMS

Accurate records should be maintained of exposure times and levels of exposure for all personnel entering and exiting the accident area. Additionally, a complete radiological history should be made for each individual who is actually contaminated. This appendix contains examples of forms that may be used to document and record this information.

Form 1 - Personal Data Form
This form contains data which should be obtained from all personnel who enter the radiological control area.

Form 2 - Radiological Control Area Log
This form is for use at the contamination control station.

Form 3 - Bioassay Screening Log
This form is for maintaining a record of all necessary bioassay screening performed and may be used for both response force personnel and civilians who may have been contaminated as a result of the accident.

Form 4 - Radiation Health History
This form is to assist in the screening of civilians who may have been contaminated as a result of the accident.

Form 5 - Field Monitoring Data Log
This form is to assist in documenting field monitoring measurements by survey teams.

Form 6 - TLD Measurements
This form is to be used to document TLD readings.

Form 7 - Weapons Accident Environmental Radiation
This form is to be used to log samples taken from the surrounding environment.

Form 8 - FIDLER Data Form
This form is used when logging readings from the FIDLER.

FORM 1

PERSONAL DATA FORM

(Please print or place "X" in boxes as appropriate)
See Reverse for Additional Instructions

(1) SOC SEC NO ________ (2) NAME ________ (last) (first) (m.i.) (3) BIRTH OATE ________ (day)(month)(yr)

(4) MALE [ ] or FEMALE [ ]

(5A) MILITARY [ ] or (5B) CIVILIAN [ ]

(6) USA [ ] (7) GRADE ________

USAF [ ] (8) SPECIALITY CODE ________ or

USN [ ] NEC/DESIGNATOR ________

USMC [ ]

OTHER [ ] ________ (Specify)

(9A) 000 [ ]

(9B) USA [ ] USAF [ ] USN [ ] uSMC [ ] OTHER [ ]

(10) GRAOE ________ (11) SERIES ________

DOE [ ] - - - - - - - - GRADE ________ SERIES ________

OTHER [ ] - - - - - - - - PROFESSION AGENCY ________

	(Yes)	(No)
(12) HAVE YOU EVER WORN A FILM BAOGE OR OTHER 00 SIMETRICDEVICE?	c1	c 1
(13) HAVE YOU EVER BEEN CLASSIFIED AS A "RADIATION WORKER"?	[ ]	c 1
(14) HAVE YOU HAO TRAINING IN RESPIRATORY PROTECT ION EQUIPMENT (MASK)?	c1	[ ]
(15) HAVE YOU WORKED IN ANTI-CONTAMINATION CLOTHING AND Respirators?	[ ]	[ ]
(16) HAVE YOU RECEIVED A SIGNIFICANT DOSE OF RADIATION WITHIN THE LAST YEAR?	[ ]	U
(17) HAVE YOU BEEN BREIFED ON PROCEDURES FOR WORKING IN A CONTAMINATE AREA?	[ ]	[ ]

(18) YOUR ORGANIZATION/BUSINESS ADDRESS:

________ (Unit/Employer Name or Symbol) (Street, P.O. Box, Mail Stop, etc.)

________ (City or Military Base) (State or County) (ZIP Code)

(19) UNIT RESPONSIBLE FOR RECORDING YOUR RADIATION DOSIMETRY RESULTS ________ (Place "X" if unknown)

(20) YOUR ORGANIZATION/BUSINESS TELEPHONE ________ (Area Code and Number)

________ (signature) (Date)

FOR RAO HEALTH CENTER USE

FILM BADGE NO ________

EXTERNAL OOSE ________

INTERNAL 00SE ________

PERSONAL OATA FORM ACCOUNTING NUMBER

____

THIS FORM SUBJECT TO THE PRIVACY ACT.

Figure 5-E-1. Personal Data Form.

INSTRUCTIONS FOR NON-SELF EXPLANATORY ITEMS

ITEM	COMMENT
3	Show day and year as numerical and month as alphabetical; e.g., 23 Jan 65 or 01 Jun 42.
5	Check either 5A or 5B.
6	Foreign military and US Coast Guard check "OTHER. "
7	Show alphabetical/numerical grade; e.g., E3 or 05, rather than rank; e.g., PFC or CDR.
8	Show "MOS," "NE C," "AFSC, " etc., of your current duty assignment.
9B	Civilians with DOD agencies check "DOD" and appropriate service or "OTHER. "
10	DOD and DOE employees show pay schedule and level; e.g., GS-10, SES-79.
11	US government civilians other than DOD or DOE, show grade and series for profession; other civilians give short title for profession; e.g., health phys, rad monitor, or comp programmer.
12	Check "YES" if you were monitored by thermoluminescent dosimeter; i.e., TLD; check "YES" if you worked with soft beta emitters and were monitored by some means other than film" badge or TLD.
13	Check "YES" if an occupationally exposed individual or radiation worker.
14	Check "YES" if trained in use of M1 7 or M 17A protective masks.
15	Check "YES" if anti-C work was participation in training courses with or without actual radioactive contamination.
16	Check "YES" if you underwent medical treatment involving radiation or radioactive materials, if your occupational exposure is near permissible limits and/or if an accident response dose report is necessary to continue your regular radiation work.
19	Following codes may be used: "R" for Radiological Safety Officer or Radiological Protection Officer, "M" for Medical Department, "C" for Commander, "F" for USAF Master Radiation Registry.
20	In'lieu of commercial number, show "AVN" for AUTOVON or "FTS" for Federal Telecommunications System.

FORM 2

RADIOLOGICAL CONTROL AREA LOG

DATE ________ PAGE ____ OF ____

TIME ________

RECORDER ________

SSN ________

SOC SEC NO	NAME (LAST, FIRST, M.I.)	CONTROL NUMBER	FILM BADGE NUMBER	DOSIMETER IN	DOSIMETER OUT	TIME IN	OUT	FULL PROTECTION	NO RESPIRATOR	STREET CLOTHES	CONTAMINATION FOUND	DECONTAMINATED	REMARKS

THIS FORM SUBJECT TO THE PRIVACY ACT.

Figure 5-E-2. Radiological Control Area Log.

DATE ____________ PAGE ___ OF ___

START ____________ STOP ____________

RECORDER ____________

SSN ____________

RADIOLOGICAL CONTROL AREA LOG (CONTINUATION SHEET)

RECORDER	

INSTRUCTIONS FOR THE USE OF THE RADIOLOGICAL CONTROL AREA LOG

a. **Column 71** should be marked with an X if the person was wearing full anti-contamination clothing and a respirator.

b. Column 72 should be marked with an X if the person was wearing anti-contamination clothing without a respirator, or street clothing **without a** respirator.

c. Column 73 should be marked with an X if the person was wearing street clothing.

d. Column 75 should be marked with a Y if contamination was found on body or personal clothing when exiting the control area If no contamination was detected **state** "none. "

e. Column 76 should be marked with a Y if all detected contamination was removed from the person, N if not and remarks are mandatory. If no contamination was detected state "none. "

f. Any unusual incidents or additional data deemed important for radiological safety should be described in the remarks section **and sequentially numbered. The number should be** inidcated **in Columns** 77- 80. Remarks may also be used to indicate when recorders change in mid sheet. If Personal clothing was confiscated during decontamination, articles taken should be noted in remarks.

g. Each day should be started with a new form and the total number of pages entered on each sheet of the previous days forms.

FORM 3

BIOASSAY SCREENING LOG

DATE ________ PAGE ____ OF ____

TIME ________

RECORDER ________

SSN ________

SOC SEC NO	LAST NAME	MIL/CIV	RAD WORKER	RESIDENT	HEALTH HISTORY	CONTAMINATION DETECTED: CLOTHING α γ	FACE α γ	HEAD α γ	HANDS α γ	BODY α γ	SHOES α γ	DECONTAMINATED	NOSE SWIPE: OBTAINED	NOSE SWIPE: COUNT	URINE SAMPLE	FECAL SAMPLE: OBTAINED	FECAL SAMPLE: COUNT	LUNG COUNT	GI TRACT COUNT	TIME	CONTROL NUMBER	FOLLOW UP		REMARKS
1–9	10–23	24	25	26	27	28–29	30–31	32–33	34–35	36–37	38–39	40	41	42–45	46	47	48–51	52–55	58–61	62–65	67–70	71	72–76	77–80

THIS FORM SUBJECT TO THE PRIVACY ACT

Figure 5-E-3. Bioassy Screen Log.

REMARKS

DATE ________ PAGE ____ OF ____

START ________ STOP ________

RECORDER ________________

SSN ________________

BIOASSAY SCREENING LOG (CONTINUATION SHEET)

THIS FORM SUBJECT TO THE PRIVACY ACT,

INSTRUCTIONS FOR THE USE OF THE BIOASSAY SCREENING LOG

a. Columns O-23. If more than 14 characters in last name truncate as necessary.

b. Column 24 indicate with M or C,

c. Column 25 should be marked with Y if person is normally classified as a radiation worker by the Nuclear Regulatory Commission, leave blank for all others.

d. Column 26 should be marked Y if person is not associated with a DOD, Federal or state accident response organization, leave blank for all others.

e. Column 27. Insure all persons marked Y in Column 26 have completed a Radiation Health History form and check, leave blank for all others.

f, Columns 28-39 should be marked Y where appropriate if contamination was found and column number and associated reading recorded in the remarks section. All personal articles and clothing retained for decontamination or disposal should be recorded in the remarks section. If no contamination was detected leave blank,

g. Column 40 should be marked Y if all detected contamination was removed from the person, N if not and remarks are mandatory, If no contamination was detected leave blank,

h, Columns 41, 46, and 47 mark with Y if bioassay samples collected, N if not.

i, Columns 42-45, 48-51, 52-56, and 57-61 enter units used in column headers and measurements in appropriate columns.

j. Columns 62-65 enter time bioassay sample was collected.

k, Column 71 mark Y if additional bioassay samples or other data is required and specify in remarks section.

l. Any unusual incidents or other data deemed important should be described in the remarks section and sequentially numbered, The number should be indicated in Columns 77-80, Remarks may also be used to indicate when recorders change in mid sheet.

m. Each day should be started with a new form and the total number of pages entered on each sheet of the previous days forms.

FORM 4

RADIATION HEALTH HISTORY

(Please print or place "X" in boxes as appropriate)

(1) SOC SEC N O ________________ (2) NAME ____
(last) (first) (m.i.)

(3A) BIRTH DA E __________ (3B) MA E ☐ or FEMALE ☐
day/mo/yr

(4) **TEMPORARY ADDRESS** ____
TELEPHONE " ______________________________

(5) **PERMANENT ADDRESS** ____
TELEPHONE ______________________________

(6) NAME& AD DRESS OF EMPLOYER ____

(7) HAVE YOU EVER BEEN TREATED WITH X-RAYS OR RADIOACTIVE ISOTOPES? YES ☐ NO ☐

(7A) REASON FOR TREATMENT ____

(7B) DATE OF TREATMENT __________________
mo/yr

(7C) PLACE OF TREATMENT ____

(8) HAVE YOU EVER HAD ANY CANCER OR OTHER MALIGNANCY? YES ☐ NO ☐

(8A) INDICATE TYPE

LEUKEMIA ☐ **BREAST** ☐ **THYROID** ☐ **LUNG** ☐ **STOMACH** ☐ BONE ☐

INTESTINESO OTHER ☐ ______________________________
Specify type

(8B) DATE OF DIAGNOSIS __________________
mo/yr

THIS FORM SUBJECT TO THE PRIVACY ACT.

Figure 5-E-4. Radiation Health History.

(9) **HAVE** ANY BLOOD RELATE D MEMBERS OF YOUR FAMILY (G RANDPARENTS, PARENTS, BROTHERS OR SISTERS) EVER HAD CANCER OR LEUKEMIA? YES ☐ NO ☐ TYPE ____________

(lo) ARE YOU NOW TAKING MEDICATION? YES ☐ NO ☐

(1OA) WHAT MEDICATION ____________

(11) DO YOU HAVE ANY ALLERGIES? YES ☐ NO ☐

(11A) WHAT ALLERGIES ____________

(12) NAME **&** ADDRESS OF FAMILY PHYSICIAN ____________

____

(13) OATE & TIME OF POSSIBLE OR ACTUAL EXPOSURE TORADIATION/CONTAMINATION ____________ AM ☐ or PM ☐
day/mo/yr time

(14) DURATION OF EXPOSURE HOURS ________ MINUTES ________

(15) ACTIVITIES DURING PERIOD OF EXPOSURE (Meals, type work, bathing, sleeping, etc.)

____

____

____

(16) **LOCATION DURINGPERIOD OF EXPOSURE** ____________

____

____

____

(17) DO YOU OWN A PET? YES ☐ NO ☐ TYPE ____________

LOCATION ____________

(18) WHO WAS WITH YOU WHEN YOU MAY HAVE BEEN CONTAMINATEO?

NAME	ADDRESS	TELEPHONE

Form 5

Page ___ . ...01 _—_

Incident ____________

Time Dispatched: ____________

Time Returned: . ____________

Orig/Team ____________

Date - ____________

Or Serial #8 ____________

Ref. No. ____________

NAMES

1. ____________

2. ____________

FIELD MONITORING DATA 10G

NOTE: REPORT ACTUAL BACKGROUND LEVEL OR MOL

		SCINTILLATOR Model ______ Serial NO. ______ Units ______	GM Model ______ Serial No. ______ Units ______			ION CHAMBER Model ______ Serial No. ______ Units ______	AIR MONITORING _ CFM/ _ Min. Sample			SAMPLE COLLECTION			SMEAR	
				Beta Window	Height									
TIME	LOCATION Grid Co-ordinates, Crossroads, tic.	Meter Reading	Meter Reading	Open Closed	4 In. 3 ft.	Meter Reading	Background (CPM)	Gross CPM with Particulate Filler	Gross CPM without Particulate Filler	Tag No.	Type: Soil, Milk Water	Quantity and Units	CPM Per 100 CM² Unless Noted	COMMENTS (Indicate Factors Such As Peak Reading, Cloud Passage Instrument and Weather Conditions, and Other Date)

Figure 5-E-5. Field Monitoring Data Log.

Form 6

TLD MEASUREMENTS
COLLECTION ANO ANALYSIS

INCIDENT ______________________

PAGE ______ OF ______

LABORATORY ______________________

LAB MANAGER ______________________

ROUTETO ______________________
OEA

LOCATION (BE SPECIFIC, GRID COORDINATES, ETC.)	TEAM/ ORGANIZATION	PLACED		RETRIEVED		READING	ASSUMED BACK-GROUND	NET READING	UNITS	READOUT		TRANSIT/ STORAGE OOSE	COMMENTS
		DATE	TIME	OATE	TIME					OATE	TIME		

Figure 5-E-6. TLD Measurement Collection and Analysis Form.

5-E-18

WEAPONS ACCIDENT ENVIRONMENTAL RADIATION

ALPHA PROBE DATA FORM

NOTE: REPORT ACTUAL BKG OR MDL

Incident ______________ Date ________ Data Type: Alpha __ Beta ____ Gamma ____

Agency /Org. ______________ Team/Monitor ______________

Detector Type ______________ Model No. ______________ Serial No. ______________

Instrument BKG ______________ Calibration Date ______________ Conversion Factor ______________

Instrument MDL ______________

Time	Locations Grid Coordinates. Crossroads. etc.	Reading	Units	Sample Collection: Tag No.	Sample Collection: Type: Soil. Milk. Waler, Air Filter	Comments [Indicates Factors Such As Peak Reading. Cloud Passage, Instrument and Weather Conditions. and Other Data]

Figure 5-E-7. Weapons Accident Environ"mental Radiation Alpha Probe Data Form,

Form 8

FIDLER DATA FORM

Incident ______________________ Date __________ FIDLER S/N ______________

Agency /Org. ______________ Team/Monitor ______________ Check One: — Scaler — Rate Meter

Calibration Date ______________ Radionuclide ______________ Check Source: Quantity ______________ μCi

Background Counting Time: ___ Minutes RC Time Constant: ___ Minutes

Energy Window (keV)	Background (CPM)	Check Source (CPM)	K-Factor (m^2)
17			
60			
Other			

Self Shielding (17 keV) ________ (0 -1: 0 = No Absorption in Check Source, 1 = 100% Aborption)

Source-to-Detector Height ____________ cm 1 μCi Am-241 = ____________ Alpha μCi Pu Mix (excludes PI-I-241 (Beta))

Time	Location	Reading	CPM or Counts	If Scaler Counting Time (Min)	Alpha Activity Mix $\frac{\mu Ci}{m^2}$	Alpha Activity Mix $\frac{\mu g}{m^2}$	Comments

Figure 5-E-8. FIDLER Data Form.