HEALTH PHYSICS SOCIETY

Specialists in Radiation Safety

Background Information on "Guidance for Protective Actions Following a Radiological Terrorist Event" Position Statement of the Health Physics Society*

Approved by the Scientific and Public Issues Committee

Introduction

In 2004, the Health Physics Society's (HPS) Scientific and Public Issues Committee issued a position statement titled "GUIDANCE FOR PROTECTIVE ACTIONS FOLLOWING A RADIOLOGICAL TERRORIST EVENT." This document provides background information for that position statement and should be considered an adjunct to the position statement and not a stand-alone document.

Background

Except in times of war or declared national emergencies, the responsibility for the health and safety of members of the public in an emergency rests with state government officials. When management of the emergency and/or its consequences is beyond the capabilities of a state, the state can ask for assistance from the Federal Government and its agencies. For emergencies involving radioactive material or radiation, the Federal Government also provides guidance for state decision makers on appropriate protective actions for members of the public due to the presence of the radioactive material or radiation. The federal infrastructure, including protective action guidance, for responding to an accidental release of radioactive materials into the environment has been evolving for almost three decades and is well established. However, now there is a need to develop guidance for responding to an intentional release of radioactive materials, or use of radiation, in connection with a terrorist act, i.e., a radiological terrorist event.

Scope

The position statement defines a radiological terrorist event as "the intentional release of radioactive material to the environment or use of a source of radiation for the purpose of harming the health or safety of the public. It includes any type of device or method used to disperse radioactive material, including conventional explosive materials (i.e., a dirty bomb) and improvised nuclear weapons." As indicated by the title, the positions and recommendations in the statement are for actions *following* the event. This position does not address protective actions that should be taken *before* the event if there is intelligence that a radiological terrorist event may occur. Therefore, the actions pertain to protecting people once there is a known contaminated area due to a dispersal event and if the dispersal event is still in progress.

Nature of a Radiological Terrorist Event

The variety of postulated methods to disperse radioactive material into the environment is limited only by the bounds of the human imagination. The National Council on Radiation Protection and Measurements (NCRP) broadly classifies terrorist incidents that could have radiological consequences into two categories. The first is the use of conventional explosives or other mechanisms to disperse radioactive materials (radiological dispersal device or RDD) and the other is the use of a nuclear weapon or improvised nuclear device (IND) (NCRP 2001).

A likely dispersal device would involve use of conventional explosive material to disperse a source of radioactive material. An explosion includes a large amount of dust and debris and a relatively small amount of very fine particles. Only the fine particles will be found much beyond the blast zone (Alvarez 2003).

Regarding dispersal devices, the NCRP concludes the exposure to individuals would be expected to be low. Thus, the harm is primarily psychosocial, and whatever low dose is received should produce no immediate adverse health effects and only a small probability of long-term health effects (NCRP 2001).

Therefore, the HPS takes the position that it is extremely unlikely that a radiological terrorist dispersal event can disperse sufficient radioactive material for the resulting air and ground contamination to pose an immediate personal health hazard to people in the area or to first responders.

Further, the HPS position statement makes the recommendation that lifesaving and actions taken to secure the area from further terrorist activities should always take precedence over radiological considerations following a radiological terrorist event, with the possible exception of the area near ground zero soon after a nuclear explosion.

Existing Federal Agency Responsibilities for Response to a Nuclear Incident

The federal infrastructure for responding to an accidental release of radioactive materials into the environment has been evolving for several decades. Changes in the past three decades have been primarily related to emergency preparedness for an accident in a nuclear power plant. In 1975 the US Environmental Protection Agency (EPA) issued the first Protective Action Manual for a nuclear reactor accident (US EPA 1975).

In 1978, a joint task force of the EPA and US Nuclear Regulatory Commission (NRC) developed the planning basis for off-site emergency preparedness efforts considered “necessary and prudent” for power reactor facilities (NRC/EPA 1978). During the development of the planning basis, the task force received substantial input from other federal agencies and the Interorganizational Advisory Committee on Radiological Emergency Response Planning and Preparedness of the Conference of State Radiation Control Program Directors, which also included representatives of the National Association of State Directors for Disaster Preparedness and the US Civil Defense Council.

Subsequently, the planning basis has been adopted by the Federal Emergency Management Agency (FEMA), which assumed the federal lead role in off-site radiological emergency planning and preparedness responsibilities under order from President Jimmy Carter in 1979 and continues in that capacity in the

Department of Homeland Security. Under regulations issued by FEMA (FEMA 1982), the EPA was given responsibilities for, among others, (1) establishing Protective Action Guides (PAGs) and (2) preparing guidance on implementing PAGs, including recommendations on protective actions, to protect members of the public in the event of a nuclear incident (a nuclear incident is defined in the discussion below). The latest document intended to respond to these two responsibilities is the "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents," commonly referred to as the PAG Manual (EPA 1992).

The PAG Manual incorporated US Food and Drug Administration (FDA) recommendations, which were published in 1982, for taking protective actions in the event that an incident causes the contamination of human food or animal feeds (FDA 1982). The FDA updated these recommendations with new recommendations in 1998 (FDA 1998).

The PAG Manual also adopted FDA (FDA 1978) guidance and FEMA (FEMA 1985) policy for the use and distribution of potassium iodide (KI) in the event of a radiation emergency involving the release of radioactive iodine. FDA has also recently updated this guidance (FDA 2001) and policy (FDA 2002).

Because the events of September 11, 2001, and subsequent terrorist activities introduced the public to a threat that had not previously been thought likely, there has been a significant effort to create new Federal Government infrastructure to be responsible for the prevention of and response to these threats, such as the creation of the Department of Homeland Security. Regarding terrorist events involving radioactive materials, the prevention and crisis-management aspects of any malicious dispersal of radioactive materials or clandestine placement of a radiation source may require some new processes and infrastructure (e.g., different source security requirements and increased distribution of detection equipment), but the responsibilities for establishing recommendations to the responding state and federal agencies is well established and appropriate for responding to an RDD.

Therefore, the HPS takes the position that protective actions and protective action guides following a radiological terrorist event should be consistent with the existing federal guidance for nuclear incidents.

Appropriateness of Existing PAGS and Protective Actions

The stated purpose of the EPA PAG Manual is to "assist [public] officials in establishing emergency response plans and in making decisions during a nuclear incident. It provides radiological guidance that may be used for responding to *any type* of nuclear incident or radiological emergency, except nuclear war (emphasis added)." The PAG Manual defines a nuclear incident as "an event or a series of events, either *deliberate* or accidental, leading to the release, or potential release, into the environment of radioactive materials in sufficient quantity to warrant consideration of protective actions (emphasis added)."

A terrorist event involving radioactive material, which will simply be called a radiological terrorist event in this paper, clearly falls within the intended purpose and definition of a nuclear incident covered by the PAG Manual.

As to the applicability of the PAG Manual guidance to a terrorist event, the Manual explains, "This [guidance] has been developed primarily for incidents at nuclear power facilities. Although this implementation guidance is intended to be useful for application at other facilities or uses of radioactivity, emergency response plans will require the development of additional implementation procedures when physical characteristics of the radionuclides involved are different from those considered here."

Therefore, the HPS position statement considers the PAG Manual guidance to be appropriate and adapts the guidance to the likely characteristics of a radiological terrorist event.

Existing Protective Action Framework

The PAG Manual establishes protective actions based on the ability to control exposure to the radioactive material and the exposure pathways that are expected to exist as a nuclear incident progresses. This approach results in classifying the response to a nuclear incident into three phases, i.e., early, intermediate, and late (recovery) phase.

The early phase of a nuclear incident is from the beginning of the incident until the release of radioactive material is under control and is characterized by the need to make immediate decisions for protective actions. The intermediate phase is the period beginning after the release of radioactive material has been brought under control or has stopped and is characterized by the ability to obtain reliable radiological measurements as a basis for decision making. The late (recovery) phase is the period in which recovery actions are conducted to bring radiation levels to levels acceptable for the area to be returned to unrestricted use.

The HPS position statement considers this framework to be generally applicable to a radiological terrorist event.

In the case of a radiological terrorist event in which the dispersal of the radioactive material is by use of a conventional explosive device, i.e., a "dirty bomb," the early phase will be the period following the explosion until emergency responders have determined the existence and extent of the contamination and made a decision if sheltering or evacuation in the contaminated area is required for radiation exposure control. Since the most significant portion of a contaminated area from a dirty bomb will probably be localized, i.e., not much greater than the blast area of the explosive, protective actions for the early phase will be able to be taken relatively quickly and the radiological response will move into the intermediate phase, probably before all emergency response actions to the effect of the blast are completed.

Therefore, the HPS position statement notes that it is unlikely that this phase will be applicable to a localized dispersal event like a "dirty bomb."

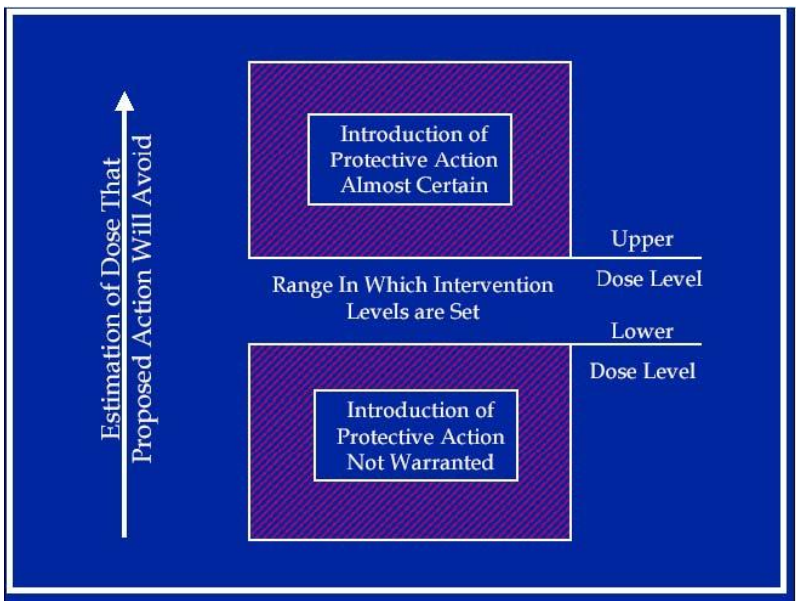
For a localized dispersal, the intermediate phase will exist as long as there are restrictions on the use of the contaminated area, and the late phase will exist while the recovery actions are underway to clean up the area to levels that allow unrestricted use of the area.

In the case of a radiological terrorist event in which the dispersal of the radioactive material is by use of a device that releases radioactive material into the atmosphere where it can be widely spread, the phases of the emergency will be similar to that for a release from a nuclear power plant or nuclear facility, with the exception that the time from initiation of the event to release of radioactivity is considered the early phase.

This difference is discussed in greater detail in the "PAGs and Protective Actions for the Early Phase" section below.

Existing PAG Framework

In a radiological emergency, a protective action is only protective for radiation exposures that are going to occur from the start of the protective action. There is no protection for radiation exposure already received. Therefore, the quantity of interest in deciding whether or not to invoke a protective action is how much radiation dose will be *avoided* by taking the action as compared to taking no action at all. When deciding to intervene by taking a protective action, there is a level of dose below which intervention is not appropriate. Conversely, there is a level of dose above which intervention should most certainly be done. These values of dose avoided form the lower and upper bounds of the range in which intervention should be done. A PAG should fall in the range of these bounds (see the following figure).



In the PAG Manual the EPA established four criteria that the PAGs should meet in the early and intermediate phase of the emergency. The criteria are (1) deterministic (i.e., acute) health effects should be avoided, (2) the risk of delayed health effects should not exceed a level that is judged to be adequately protective of health in an emergency situation, (3) any reduction of risk to public health achievable at acceptable cost should be done, and (4) the risk to health from a protective action should not exceed the risk to health from the dose that is avoided.

The analysis done by the EPA had the following results. For the early phase, criteria (1), i.e., avoid acute health effects, and criteria (4), i.e., the protective action should do more good than harm, serve as upper and lower bounds of the PAG region, respectively. Criterion (1) results in an upper bound of the PAG range of 0.1 Sv (10 rem) based on the assumed threshold for acute health effects in the fetus. Criteria (4) results in a lower bound of the PAG range of 0.03 mSv (3 mrem) based on the risk of the dose avoided compared to the risk of evacuation (traffic accident). The PAGs are set between these bounds based on criteria (2), i.e., they limit the risk of delayed effects on health to levels adequately protective of public health under emergency conditions. Specifically, the PAG is based on an avoided dose of 5 mSv (500 mrem), which is the acceptable annual dose to the general population from all sources from nonrecurring exposure and is also the maximum total dose to the fetus from occupational exposure of the mother.

The HPS considers that these criteria and ranges are applicable to PAGs in the early phase following a radiological terrorist event and have recommended PAGs for the early phase consistent with this approach.

For the *intermediate* phase, criteria (1) and criteria (4) serve as upper and lower bounds just as in the case of the *early* phase. Also, criteria (2) serves as the PAG basis for the PAG. Specifically, the PAG is based on an *avoided* dose of 50 mSv (5 rem) for a lifetime, i.e., 50 years, which results in an average annual dose of 1 mSv (100 mrem) over a lifetime. This is taken as an acceptable dose to the general population from all sources from routine (chronic), nonaccidental exposure.

The HPS considers that these criteria and ranges are applicable to PAGs in the intermediate phase following a radiological terrorist event and have recommended PAGs for the intermediate phase consistent with this approach.

The EPA has not established PAG criteria or specific PAGs for the *late* (*recovery*) phase. The basis for the HPS recommended PAGs is discussed in the "PAGs and Protective Actions for the Late (Recovery) Phase" section below.

PAGS and Protective Actions for the Early Phase

The early phase of the emergency is characterized by a plume of radioactive material dispersing in the atmosphere and depositing on the ground and structures, resulting in a contaminated area. The primary exposure pathways from this plume and contaminated area are by inhalation of radioactive materials, external exposure from the radioactive material for someone immersed in the plume, and external exposure from the contamination deposited on the ground and structures for someone standing in the contaminated area. These pathways are referred to as the inhalation, submersion, and deposition doses respectively. There are other minor exposure pathways, such as exposure from contamination on an individual's skin or clothes, but they are not significant when compared to the inhalation, submersion, and deposition pathways.

The protective actions to reduce exposure via these three pathways are actions that either move people out of the plume and contaminated area (i.e., evacuation) or simply out of the cloud (i.e., sheltering). The PAG Manual guidance was developed primarily for incidents at nuclear power facilities. A characteristic of an incident at a nuclear power facility is that the most likely postulated scenarios take hours to develop from the first indication of plant failure to the start of a release into the environment. The EPA analysis of likely exposures from a passing plume, which is the exposure condition characterizing the *early* phase, concludes that approximately one-half the dose will be avoided by evacuating, compared to the alternative action of sheltering, assuming the evacuation is performed before the plume reaches the population. Therefore, the PAG Manual recommends evacuation as the primary protective action with sheltering as the secondary protective action.

As discussed in the "Existing PAG Framework" section above, PAGs in the *early* phase are based on a *dose* to be *avoided* of 5 mSv (500 mrem) or greater. Therefore, the existing PAG Manual PAG for the *early* phase is to evacuate if the projected dose is 10 mSv (1 rem), representing an avoided dose of 5 mSv (500 mrem), with provisions to extend the evacuation action up to a projected dose of 50 mSv (5 rem) if conditions adverse to evacuation exist and up to 100 mSv (10 rem) for special groups for which evacuation puts them or the public at risk. Examples of special groups are people on medical life-support systems or institutionalized criminals. However, the PAG Manual directs that sheltering should be performed whenever it is more protective than evacuation.

In the case of a radiological terrorist event with wide dispersal of the radioactive material, the time from initiation of the event to release of radioactive material to the environment will not be a matter of hours, but will likely be minutes. Therefore, the protective action of evacuation cannot be completed before the plume reaches the population, except perhaps for distant populations if it is a very large dispersal area. An evacuation during the *early* phase of a radiological terrorist event will very probably expose people to a greater dose while trying to evacuate in a passing plume than sheltering out of the plume.

Sheltering is likely to be more protective than evacuation in responding to a radiological terrorist event. Therefore, the HPS recommends that sheltering be the preferred protective action. The PAG for sheltering is the same as the existing evacuation PAG, i.e., 10 mSv (1 rem), with the minimum level for initiation being the same as the existing PAG, i.e., 1 mSv (100 mrem).

The existing PAG Manual establishes levels for evacuation during hazardous conditions, which are higher than those for normal conditions. The HPS believes that the existence of a terrorist event constitutes a potential hazardous condition for evacuation considering the possibility that further terrorist activity may accompany the radiological event.

Therefore, the HPS recommends the minimum level for initiation of evacuation be the same as the existing levels for evacuation under hazardous conditions, i.e., 50 mSv (5 rem) for the normal population and 100 mSv (10 rem) for special groups for which evacuation puts them or the public at greater risk.

As stated in the "Existing Federal Agency Responsibilities for Response to a Nuclear Incident" section above, the PAG Manual includes a PAG in the *early* phase for consideration of administration of potassium iodide (KI) for protection of the thyroid if the release involves radioactive iodine. The FDA has recently updated this guidance and policy (US FDA 2001, US FDA 2002). The HPS position statement does not specifically contain a PAG recommendation for administration of KI in case the release contains radioactive iodine. Radioactive iodine is unlikely to be used in a terrorist event. The varieties (i.e., isotopes) that emit radiation with sufficient energy to be detected, and therefore to incite fear, and with sufficient energy to result in an appreciable dose to a person, have relatively short half-lives, making it difficult to disperse significant quantities into the environment before it decays away. However, the HPS considers Position 2 of the position statement, which endorses the consistency with existing protective actions and protective action guides, endorses the PAGs that are contained in that guidance if the event involves radioiodine.

PAGs and Protective Actions for the Intermediate Phase

A contaminated area, in which people are, or were, living and working, exists during the intermediate phase, which follows the dissipation of the plume from the dispersal event.

The primary exposure pathway is from external exposure due to the contamination deposited on the ground (i.e., deposition dose). Another pathway that may exist is inhalation of radioactive material resuspended into the air from the contaminated ground (i.e., inhalation dose). Although the inhalation pathway could be significant, it should be evaluated on a case-by-case basis and is not included in the basis for the PAG. The skin and clothing contamination pathways are minor compared to the other pathways and are not included in the basis for the PAG.

The primary protective action for the intermediate phase is relocation from the contaminated area. Relocation is different from evacuation in that it is done in an orderly and planned manner such that it does not incur any significant risk in performing the protective action.

The deposition dose PAG for the intermediate phase is based on the projected dose at which it is appropriate to have people relocate from their residences for an extended period. The primary PAG of 20 mSv (2 rem) for the dose received during the first year is based on meeting two long-term "objectives," which are not receiving greater than 5 mSv (500 mrem) in any year after the first year of the incident and not receiving greater than 50 mSv (5 rem) over the 50 years following the incident. The primary PAG for the first year is based on a projected mix of radioactive nuclides released in a serious accident in a nuclear power plant. The application of these intermediate phase PAGs is an example of a situation in which the EPA cautions "emergency response plans will require the development of additional implementation procedures when physical characteristics of the radionuclides involved are different from those considered here."

For radiological terrorist events it is likely the radionuclide(s) will have a half-life longer than the "effective" half-life of the radionuclide mix, which is approximately 0.5 year for the first year, assumed for establishing the intermediate phase PAG. (After the short-lived radionuclides in the mix decay, the "effective" half-life of the remaining radionuclides is longer.) Two likely radionuclides for use in a radiological terrorist event are cobalt-60 and cesium-137, with half-lives of approximately 5.3 and 30 years, respectively. Also, in the case of a radiological terrorist event, the affected area is likely to be in a highly populated area and not a residential area. Therefore, the projection is likely to be for operation of businesses and not relocation of residents, which is the basis for the PAG Manual PAGs.

Even considering the characteristics of a radiological terrorist event that differ from a nuclear power plant accidental release, **the HPS position statement recommends the projected dose of 20 mSv (2 rem) also be applied to the projected first-year dose from a radiological terrorist event**. Although the radionuclide in a radiological terrorist event may have a half-life longer than that upon which the PAG in the PAG Manual is based, it is likely that cleanup actions will begin fairly soon after the event because the contaminated area is likely to be in a high-use/highvalued area, and because of the attention and response actions that are likely to follow a terrorist event. Therefore, reduction of contamination by cleanup methods will likely be more effective than radioactive decay and weathering effects, which are the only removal mechanisms considered by the PAG Manual. Also, in an industrial/business area, other actions such as restrictions on the hours of operation of the businesses can help reduce the projected dose as compared to the PAG Manual assumption that no restrictions or institutional controls are used.

For the long-term objectives, **the HPS position statement adopts the objective that actions should be taken to reduce the projected dose in any year after the first year of the event to 5 mSv (500 mrem).** This is consistent with the HPS position statement (HPS 2003) in which the HPS recommends, “In special (infrequent) circumstances, an effective dose up to 5 mSv (500 mrem) in a year may be permitted.”

However, the HPS position statement does not adopt the long-term PAG objective for the intermediate phase that the projected 50-year dose is less than 50 mSv (5 rem). A 50-year dose objective is not appropriate for an “intermediate phase” PAG, but should be considered as part of the late (recovery) phase.

The PAG Manual also contains FDA guidance for protective actions and PAGs if human food or animal feeds are contaminated in the event, which is applicable in the intermediate phase. Since a radiological terrorist event is not likely to involve contamination of large rural areas, it is not likely that significant amounts of human food or animal feeds will be contaminated.

However, in the event human food or animal feeds are contaminated, the HPS position statement adopts the FDA guidance for protective actions.

PAGs and Protective Actions for the Late (Recovery) Phase

The PAG Manual does not have any protective actions or PAGs for the late (recovery) phase. At the time it was issued the EPA thought that the activities that were underway to establish cleanup standards for previously contaminated sites would be able to be used for this section. However, that has not turned out to be the case.

The HPS considers that the PAG for the late (recovery) phase should be consistent with its recommendations for public exposure limits (HPS 2003) in which the HPS recommends, “Radiation exposures of the public from controllable sources should be maintained as low as reasonably achievable (ALARA), economic and social factors being taken into account” and the HPS position that “supports the establishment of an acceptable dose of radiation of 1 mSv/y (100 mrem/y) above the annual natural radiation background. At this dose, risks of radiation-induced health effects are either nonexistent or too small to be observed.”

The HPS also recommends constraints be placed on a controllable source of public exposure, with 0.25 mSv (25 mrem) being appropriate in most cases, but it also recommends, “In special circumstances, an effective dose higher than 0.25 mSv in a year may be permitted.” The HPS considers response and cleanup following a radiological terrorist event is a special circumstance and does not recommend a constraint below 1 mSv (100 mrem).

Therefore, the HPS position statement recommends that continued cleanup during the late phase should be subject to the principles of ALARA, economic and social factors being taken into account, with a minimum level of continued cleanup of 1 mSv/y (100 mrem/y).

Projected Dose

The entire protective action and PAG framework is based upon the concept of calculating a "projected dose," which is then used to compare to the PAGs. The method of calculating a potential dose to people in the future can be complicated and has many uncertainties. These complications and uncertainties add to the complications of responding to an emergency such that effective decision making could be affected. Emergency planning has an objective of reducing the complexities that prevail during an emergency. Therefore, it is important that standardized methodologies for calculating projected doses that are used to compare to PAGs be established beforehand as part of the emergency-planning process.

The PAG Manual establishes methodologies for calculating projected doses in the early and intermediate phase. These methodologies use the information that is likely to be available during the different phases to support decision making in a time frame that is appropriate for the phase. For example, decisions in the early phase may have to be made with little data on the radiological aspects of the event. However, the methodologies for calculating a projected dose in the PAG Manual range from a simple technique using one radiation dose rate measurement to complex methods that use computer-generated dispersion equations, radiological measurements, and meteorological data. It is important for emergency managers to realize that projected doses calculated in the context of using PAGs for decision making *are not real doses to individuals*, but are part of an emergency-response framework to reduce the complexities of decision making during the emergency.

The current PAG manual methodologies are appropriate for projecting doses in a radiological terrorism event, with the exception that the factors that are used to calculate an individual's dose from an exposure involving inhalation or ingestion of radioactive materials, i.e., the "internal dose conversion factors," are based on work by the International Committee on Radiological Protection (ICRP) from 1971 as published in a 1988 EPA guidance document (EPA 1988). The ICRP has published more recent dose conversion factors that outdate the work of 1971 (ICRP 1995).

Therefore, the HPS position statement recommends that the methods for calculating projected doses for comparison to the early and intermediate phase protective action guides should be consistent with those currently existing in the PAG Manual but should be based on the latest available dose conversion factors.

As stated above, the PAG Manual does not contain protective actions and PAGs for the late phase. Therefore, there are no established methodologies for calculating projected doses for the late phase in the context of emergency planning. The late phase is very similar to the restoration of previously used and contaminated sites, such as those covered by the NRC in its "Decommissioning Rule." The HPS considers the same general approach as that used by the NRC, i.e., dose modeling to demonstrate compliance with an established upper limit, is appropriate for cleanup after a radiological terrorist event.

Therefore, the HPS position statement recommends that the methods for calculating projected doses for comparison to the late phase (recovery) protective action guides should use dose-assessment computer programs or methodologies accepted by federal agencies using realistic exposure scenarios for the intended actual use of the radioactively contaminated areas.

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*The Health Physics Society is a nonprofit scientific professional organization whose mission is excellence in the science and practice of radiation safety. Since its formation in 1956, the Society has represented the largest radiation safety society in the world, with a membership that includes scientists, safety professionals, physicists, engineers, attorneys, and other professionals from academia, industry, medical institutions, state and federal government, the national laboratories, the military, and other organizations. Society activities include encouraging research in radiation science, developing standards, and disseminating radiation safety information. Society members are involved in understanding, evaluating, and controlling the potential risks from radiation relative to the benefits. Official position statements are prepared and adopted in accordance with standard policies and procedures of the Society. The Society may be contacted at 1313 Dolley Madison Blvd., Suite 402, McLean, VA 22101; phone: 703-790-1745; fax: 703-790-2672; email: HPS@BurkInc.com.