Annex 15a. – Accident Assessment (Post-Plume Phase)

INGESTION PATHWAY

The Emergency Planning Zone (EPZ) for the ingestion pathway extends to a radius of 50 miles through 360 degrees from a nuclear power plant. Major potential pathways for ingestion include fresh fluid milk and other food commodities (especially those consumed fresh, such as leafy vegetables and fruit), and public water supply systems using surface water.

This section summarizes the protective action guidance and appropriate protective actions for each major ingestion pathway. Criteria are established for initiation of ingestion protective actions.

Dose commitment resulting from the ingestion pathway is separate and distinct from doses received in other incident phases.

MILK AND FOOD

MILK AND FOOD PROTECTIVE ACTION GUIDES (PAGs)

The PAGs used for milk and food were developed by HHS/FDA, and published as Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies by FDA on August 13, 1998 (FDA 1998). These values are intended to include both the milk and food components of the diet and represent the dose commitment from ingestion over the entire episode.

Calculation of projected dose commitment from the ingestion pathway is described in Attachment 1, "Ingestion Pathway Dose Projections Procedure".

FDA guidance is described below.

Ingestion Protective Action Guides (PAGs)

A Protective Action Guide (PAG) is the committed effective dose equivalent (CEDE) or committed dose equivalent (CDE) to an individual tissue or organ that warrants protective action following a release of radionuclides.

The Ingestion Pathway PAGs are:

0.5 rem (5 mSv) committed effective dose equivalent (CEDE),

-or-

5.0 rem (50 mSv) committed dose equivalent (CDE) to an individual tissue or organ, whichever is most limiting.

<u>Derived Intervention Levels (DILs)</u>

A Derived Intervention Level (DIL) corresponds to the radionuclide concentration in food present throughout the relevant period that, in the absence of any intervention, could lead to an individual receiving a radiation dose equal to the most limiting PAG. The Derived Intervention Levels are found in Figure 1. This figure is taken from the FDA guidance. Implementation and use of the DILs for nuclear reactor accidents (and other large-scale nuclear events) is described in Attachment 1, "Ingestion Pathway Dose Projections Procedure".

DILs for specific radionuclides have been calculated by FDA considering the assumed annual dietary intake by critical segments of the population, the fraction of the food intake assumed to be contaminated, and related factors. DILs for specific radionuclides are calculated using the following equation:

$$\text{DIL (Bq/kg)} = \frac{\text{PAG (mSv)}}{\text{f x Food Intake (kg) x DC (mSv/Bq)}}$$

Where:

DIL = Derived Intervention Level
PAG = Protective Action Guide
DC = Dose coefficient
Food Intake = Quantity of food consumed in an appropriate period
f = Fraction of food intake assumed to be contaminated

NOTE: In the FDA 1998 guidance, the SI units are used. Traditional units (such as uCi and rem) can be substituted, with appropriate conversion factors employed.

For each radionuclide of concern, DILs were calculated for six age groups using Protective Action Guides, dose coefficients, and dietary intakes relevant to each radionuclide and age group. The age groups included 3 months, 1 year, 5 years, 10 years, 15 years, and adult (>17 years). The dose coefficients used were from ICRP Publication 56 (ICRP 1989). The DILs were based on the entire diet for each age group, not for individual foods or food groups. The calculation presumed that contamination would occur in thirty percent of the dietary intake. (The expectation was that normally less than ten percent of the annual dietary intake of most members of the population would consist of contaminated food. This ten percent value was then adjusted by a factor of three to account for limited subpopulations that might be more dependent on local food supplies.) An exception was made for I-131 in the diets of the 3-month and 1-year age groups, where the entire intake was assumed to be contaminated. The most limiting of the six age groups DILs for the most limiting of the applicable PAGs was selected to be the DIL for that radionuclide. The radionuclides of concern were then classed into radionuclide groups, each having common characteristics (see Figure 8-1).

The FDA DILs provided a large margin of safety for the public because each DIL is set according to a conservatively safe scenario for the most vulnerable group of individuals. In addition, protective action would be taken if radionuclide concentrations were to reach or exceed a DIL at any point in time, even though such concentrations would need to be sustained throughout the relevant extended period for the radiation dose to reach the PAG. In practice, when FDA DILs are used, radiation doses to most of the affected public would be very small fractions of the PAG.

For a food, the individual radionuclide DILs are to be applied independently. DIL fraction contributions for individual radionuclide groups in a food are <u>not</u> added together. DILs for individual radionuclide groups are based on different critical organs, different critical age groups, and different ingestion characteristics (e.g., length of exposure, fraction of intake assumed contaminated).

Food with concentrations of radionuclides below the DILs is permitted to move in commerce without restriction. Food with concentrations at or above the DILs is not normally permitted into commerce. However, State and local officials have the flexibility in whether to apply restrictions in special circumstances, such as permitting use of food by a population group with a unique dependency on certain food types.

The recommended DILs are for radionuclides expected to deliver the major portion of the radiation dose from ingestion during the first year following an accident.

The principal radionuclides for which DILs were developed for a nuclear reactor accident are: I-131; Cs-134 + Cs-137; Ru-103 + Ru-106. (NOTE: For a spent fuel accident, the principal radionuclides are: Sr-90; Cs-137; Pu-239 + Am-241.)

The recommended DILs may be applied immediately following an accident. Early identification of other radionuclides that may be present in food is not required. However, the recommended DILs should be evaluated as soon as possible after an accident to ensure that they are appropriate for the situation.

The DILs as stated in FDA 1998 are applicable to foods as prepared for consumption (see Note (b) in Figure 1). However, in the interest of protecting the population and in keeping with the existing institutional conservatism in radiation protection, in West Virginia the DILs will be applied at whatever point in the production, processing, distribution, or preparation process the sample is taken.

The limiting age groups for the radionuclide DILs listed in Figure 1 are:

Radionuclide	Limiting Age Group
Sr-90	15 years
I-131	1 year
Cs group	Adult
Ru-103	3 months
Ru-106	3 months
Pu + Am group	3 months

FIGURE 1

Recommended Derived Intervention Level (DIL) or Criterion for each Radionuclide Group (Notes a, b)

All Components of the Diet

Radionuclide Group	(Bq/kg)	(pCi/kg)
Sr-90	160	4300
I-131	170	4600
Cs-134 + Cs-137	1200	32,000
Pu-238 + Pu-239 + Am-241	2	54
Ru-103 + Ru-106 (Note c)	$\frac{C\text{-}3}{6800} + \frac{C\text{-}6}{450} < 1$	$\frac{C\text{-}3}{180,000} + \frac{C\text{-}6}{12,000} < 1$

Notes:

(a) The DIL for each radionuclide group (except for Ru-103 + Ru-106) is applied independently (see discussion in FDA 1998, Appendix D). Each DIL applies to the sum of the concentrations of the radionuclides in the group at the time of measurement.

(b) Applicable to foods as prepared for consumption. For dried or concentrated products such as powdered milk or concentrated juices, adjust by a factor appropriate to reconstitution, and assume reconstitution water is not contaminated. For spices, which are consumed in very small quantities, use a dilution factor of 10.

(c) Due to the large difference in DILs for Ru-103 and Ru-106, the individual concentrations of Ru-103 and Ru-106 are divided by their respective DILs and then summed. The sum must be less than one. C-3 and C-6 are the concentrations, at the time of measurement, for Ru-103 and Ru-106, respectively (see discussion in FDA 1998, Appendix D).

Reference: FDA 1998.

FRESH FLUID MILK

Although several radionuclides can be released to the atmosphere during an incident, only a few are biologically significant in the milk pathway. These include isotopes of iodine; and the potassium congeners, the isotopes of cesium.

Much attention is placed on the protection of fresh fluid milk. The bases for this concern include:

-- The pasture-cow-milk-child thyroid pathway is very sensitive to transport of radioiodines. For example, a plume capable of delivering one rem to a child thyroid by inhalation will deliver up to several hundred rem to a child thyroid through ingestion of milk produced by cows grazing on a pasture visited by the plume. This is known as an amplification effect.

-- Milk makes up a significant part of the diet of infants and young children.

-- The physical and chemical properties of radioiodines tend to make these contaminants more available to the environment than solid nuclides.

-- Due to the amplification effect, areas requiring protection of the milk supply may not require protective actions against direct plume exposure. Also, areas requiring protection of the milk supply may be significantly larger than those requiring protective action against direct plume exposure. This is the basis for the Ingestion Planning Zone having a 50-mile radius.

-- The population at risk through milk consumption is usually larger than that at risk from direct plume exposure.

-- The time between harvest and marketing of milk is several days, allowing little time for removal of Iodine-131 by radioactive decay.

Factors Influencing Milk Contamination

The degree of contamination depends on several factors:

-- The quantity of radioiodines, particularly I-131, released to the atmosphere is a major component for milk contamination. Other iodines (I-132, I-133, I-134 and I-135) are included in inhalation dose projections but will not significantly contribute to milk contamination, due to their relatively short half-lives. (Assuming equivalent deposition, the intake of I-133 via milk is about 2% of the I-131 intake.)

-- Farming practices will affect milk contamination. Dairy animals subsisting greatly on contaminated pasture will produce higher concentrations than similar animals at the same location subsisting on stored feed.

-- The occurrence of precipitation during plume passage will increase iodine deposition on pasture due to atmospheric scrubbing.

-- For a given pasture contaminated with radioiodines, pastured goats will produce significantly higher milk concentrations than will pastured cows.

-- Radionuclides other than iodines may be released to the atmosphere during severe incidents, including isotopes of cesium (Cs-134 and Cs-137), isotopes strontium (Sr-89 and Sr-90), isotopes of ruthenium (Ru-103 and Ru-106), and the iodine precursor, Tellerium-132. For severe incidents, however, protective actions against I-131 contamination in milk will protect the pathway from the other contaminants. An exception to this may be severe accidents involving spent fuel, since the radioiodine in the spent fuel will have decayed to low levels.

-- Assuming a one-shot deposition, the maximum concentration of iodines in milk will occur in 2 to 4 days; the maximum concentration of cesium in 6 to 8 days.

Fresh Fluid Milk Protective Actions

Protective actions for fresh fluid milk will be discussed under two headings: (a.) Protective Actions for Milk Prior to Confirmation of Contamination; and, (b.) Protective Actions for Milk Confirmed to be Contaminated.

Protective Action for Milk Prior to Confirmation of Contamination

Protective actions which can be taken for fresh fluid milk prior to confirmation of contamination consist of:

-- Simple precautionary actions to avoid or reduce the potential for contamination of milk (by moving dairy animals to shelter and providing protected feed and water), and

-- Temporary embargoes to prevent the introduction into commerce of milk which is likely to be contaminated.

Protective actions can be taken before the release or arrival of contamination if there is advance knowledge that radionuclides may accidentally contaminate the environment.

Moving Dairy Animals to Shelter and Providing Protected Feed and Water

The protective action policy in this plan for milk is early intervention to reduce or entirely avoid contamination of fresh fluid milk. This is accomplished by moving dairy animals from pasture to shelter and providing protected feed and water.

In West Virginia, the pasturing season runs from May through October, during which time removal from pasture is an important protective action option. However, half of the dairy farms are year-round feed lot operations, where pasturing is not a significant part of the regimen and where sheltering animals and providing them with protected feed and water may become a moot point.

This option is most effective when the action is completed before the actual deposition of iodines on pasturage. Some iodine may be detectable in milk even with the implementation of this option, due to cattle uptake by inhalation. This may amount to a few percent of what would have been seen if pasturing continued.

The viability of this option will depend on the availability of stored feed. Silage is at low ebb in late spring before the first mowing.

The major objective in moving dairy animals to shelter and providing them with protected feed and water is achieving the greatest protection against actual contamination of the product. This requires the timely development of a PAR. The PAR for moving dairy animals to shelter and providing them with protected feed and water will generally be based on dose projections and plant conditions. Field team sample results for airborne iodine may contribute to the decision but are not required for PAR development.

Moving dairy animals from pasture to shelter and providing them with protected feed and water, to <u>10 miles</u>, is indicated when:

Projected child thyroid CDE from I-131 by inhalation exceeds one mrem (0.01 mSv) in one hour,

<u>OR</u>

Declaration of General Emergency (or Site Area Emergency, at the discretion of the Accident Assessment Manager).

Moving dairy animals from pasture to shelter and providing them with protected feed and water, to 50 miles, is indicated when:

Projected child thyroid CDE from I-131 by inhalation exceeds one mrem (0.01 mSv) in one hour at 10 miles,

OR

Accident conditions are such that particulates (such as Cs) may be released to the atmosphere.

IMPLEMENTATION OF PROTECTIVE ACTIONS FOR DAIRY ANIMALS WILL BE FOLLOWED BY SAMPLING OF MILK PRODUCERS IN THE PLUME PATH TO THE PAR DISTANCE (10 or 50 miles), AND SAMPLING OF MILK PROCESSORS SUPPLIED BY PRODUCERS WITHIN THE PAR DISTANCE. An initial milk sampling and analysis plan is found in WV Field Sampling Team SOP Annex B.

Temporary Embargo

A temporary embargo of milk prevents the consumption of milk that is likely to be contaminated. Distribution and use of possibly contaminated milk are halted until the situation can be evaluated and monitoring and control actions instituted. Temporary embargoes are applied when the radionuclide concentrations are not yet known. Because there is potential for negative impact on the community, justification for this action must be significant. The embargo should remain in effect at least until results are obtained. A temporary embargo should be issued only upon declaration of General Emergency AND if predictions of the extent and magnitude of the off-site contamination are persuasive. Implementation of a temporary embargo will be in the plume path to the PAR distance (10 or 50 miles).

Temporary embargoes will originate at the milk producer.

<u>Protective Actions for Milk Confirmed to be Contaminated</u>

Protective actions which should be implemented when the contamination in milk equals or exceeds the DILs consist of:

-- Diversion of Contaminated Milk to Processed Food Products, and

-- Temporary embargoes to prevent the contaminated milk from being introduced into commerce.

Diversion of Contaminated Milk to Processed Food Products

Diversion of fresh milk to processed food products may be a protective action option in certain situations where milk concentrations exceed the DILs. It is a viable option only when the contaminant is I-131 or a similarly short-lived nuclide. This protective action uses time as a decontaminating mechanism, through radioactive decay. This option will have limited application since processing capacity for large volumes of milk is not always available. The manufacture of processed foods normally uses about 45% of the milk produced in Pennsylvania.

For this option, certain parameters must be known, and certain controls must be used. These include:

-- The I-131 concentration in the milk, or an upper concentration limit, must be known to calculate the total time required for I-131 removal by radioactive decay.

-- The customary storage time of the processed product must be long enough to allow for I-131 decay.

-- The process must be sampled to verify that the I-131 is retained in the product expected to be stored, and not inadvertently directed to another product. For example, in cheese making, iodine is understood to become protein bound. The whey should be uncontaminated and could be used in other products. Sampling is needed to verify that this holds for the process used.

-- The finished product should be radio-assayed to verify radiological acceptability.

Temporary Embargoes to Prevent Contaminated Milk from Being Introduced into Commerce

A temporary embargo to prevent the introduction into commerce of contaminated milk should be considered when the amount of contamination equals or exceeds the DILs, or when the presence of contamination is confirmed, but the concentrations are not yet known. The temporary embargo would continue until measurements confirm that concentrations are below the DILs.

For milk concentrations equal to or exceeding the DILs for I-131, condemnation and disposal is the protective action, unless adequate processing and storage for I-131 decay become available.

Deliberate dilution or blending to achieve acceptable concentrations is not an option, because this is a violation of the Federal Food, Drug and Cosmetic Act (FDA 1991). Dilution occurring during customary collection practices is not deliberate.

Consideration of condemnation and disposal will be discussed with PA Department of Agriculture, USDA, and HHS/FDA prior to implementation.

FOOD CROPS

Attention to potential food crop contamination will begin when the projected I-131 air concentration in offsite areas is enough to produce a projected child thyroid CDE from I131 by inhalation exceeding one mrem (0.01 mSv) in one hour. (3.8E-10 uCi/cc [1.4E-5 Bq/cc] in air, averaged over one hour, produces one millirem (0.01 mSv) projected child thyroid CDE by inhalation.)

Factors Influencing Food Crop Contamination

During a reactor incident, food crops can become contaminated by foliar deposition (surface contamination) from airborne iodines and particulates, or by uptake by plant roots from soil contaminated by surface deposition.

The degree of food crop contamination is affected by several factors. Protective action options will depend on the following conditions:

-- Incidents releasing no plume at all or a plume consisting only of noble gases will not lead to contamination of surfaces, including crops in the field.

-- Incidents which release iodines or particulates, and which occur just before harvest, will have the most impact on contamination of non-root crops by way of foliar deposition.

-- Accidents which release iodines or particulates, and which occur between harvest and planting (winter), will not lead to foliar deposition. Contamination of food crops may occur by uptake of dissolved particulates through the plant root system, however, iodines will decay away before the succeeding growing season. Some surface contamination on foliage from particulates is also possible as a result of cultivation of the crop.

-- Incidents which release iodines and particulates during the growing season may contaminate different kinds of food crops to varying degrees. Root crops are not directly contaminated by foliar deposition. For above-ground crops and fruit in areas of equal ground deposition, the degree of contamination will depend on the footprint of the crop itself.

Food Crop Protective Actions

Protective actions for food crops will discussed under two headings: (a.) Protective Actions for Food Crops Prior to Confirmation of Contamination; and, (b.) Protective Actions for Food Crops Confirmed to be Contaminated.

For incidents occurring during the growing season, environmental monitoring/sampling will focus on identification of food crop acreage with deposition of I-131 and/or particulates. Food crops from these areas will be sampled and assessed at harvest, before proceeding to market. Evaluation of these food crops is tasked to the FRMAC.

For incidents not during the growing season, environmental monitoring/sampling will focus on identification of food crop acreage with deposition of particulates. Evaluation of future agriculture use of this acreage is tasked to the FRMAC.

Protective Actions for Food Crops Prior to Confirmation of Contamination

Protective actions which can be taken for food crops prior to confirmation of contamination consist of:

-- Temporary embargoes to prevent the introduction into commerce of food crops which are likely to be contaminated.

Protective actions can be taken before the release or arrival of contamination if there is advance knowledge that radionuclides may accidentally contaminate the environment.

Temporary Embargo

A temporary embargo of food crops prevents the consumption of food that is likely to be contaminated. Distribution and use of possibly contaminated food crops are halted until the situation can be evaluated and monitoring and control actions instituted. Temporary embargoes are applied when the radionuclide concentrations are not yet known. Because there is the potential for negative impact on the community, justification for this action must be significant. The embargo should remain in effect at least until results are obtained. A temporary embargo should be issued only upon declaration of General Emergency AND if predictions of the extent and magnitude of the off-site contamination are persuasive. Implementation of a temporary embargo will be in the plume path to the PAR distance for milk protective actions (10 or 50 miles).

Temporary embargoes will originate at the producer.

<u>Protective Actions for Food Crops Confirmed to be Contaminated</u>

Protective actions which should be implemented when the contamination in food crops equals or exceeds the DILs consist of:

-- Normal food production and processing actions that reduce the amount of contamination in or on the food to below the DILs, and

-- Temporary embargoes to prevent the contaminated food from being introduced into commerce.

Normal Food Production and Processing Actions That Reduce the Amount of Contamination In or On the Food to Below the DILs

Normal food production and processing procedures that could reduce the amount of radioactive contamination in or on the food crops include:

-- Diversion of food crops to processed food products: This may be a protective action option when the only contaminant is I-131 or a similarly short-lived nuclide. This protective action uses time as a decontaminating mechanism, through radioactive decay. Food crops should be sampled prior to processing, with a recommended storage time depending on the decay time needed.

-- Holding to allow for radioactive decay: This may be a protective action option when the only contaminant is I-131 or a similarly short-lived nuclide. This protective action uses time as a decontaminating mechanism, through radioactive decay. Food crops should be sampled prior to holding, with a recommended storage time depending on the decay time needed.

-- Removal of surface contamination by brushing, washing, or peeling: This mechanical mechanism removes contamination from the surface of the food crop. It is quite effective against contamination from foliar deposition.

-- However, it is not effective against internal contamination which occurs by uptake of dissolved particulate through the plant root system into the plant.

Temporary Embargo

A temporary embargo to prevent the introduction into commerce of food from a contaminated area should be considered when the amount of contamination equals or exceeds the DILs or when the presence of contamination is confirmed, but the concentrations are not yet known. The temporary embargo would continue until measurements confirm that concentrations are below the DILs.

For food crops equal to or exceeding the DILs, evaluation of these crops will be tasked to the FRMAC. Consideration of condemnation and disposal will be discussed with WV Department of Agriculture, USDA, and HHS/FDA prior to implementation.

Deliberate blending of contaminated food with uncontaminated food to achieve acceptable concentrations is not permitted because this is a violation of the Federal Food, Drug, and Cosmetic Act.

MEAT

In certain incident situations, intake of cesium in meat for adults may exceed the milk pathway dose. Therefore, areas with cesium concentrations in milk approaching the DIL should lead to surveillance and protective actions for meat.

ANIMAL FEEDS

Limits on concentrations of radionuclides permitted in animal feeds are not given in FDA 1998. However, protective actions for animal feeds are included in FDA 1998 as measures to reduce or prevent subsequent contamination of human food.

Protective Actions for Animal Feeds Prior to Confirmation of Contamination

Protective actions which can be taken within the area likely to be affected and prior to confirmation of contamination consist of:

-- Simple precautionary to avoid or reduce the potential for contamination of animal feeds: These include modest adjustment of normal operations prior to arrival of contamination. Typical precautionary actions include covering exposed products, moving animals to shelter, corralling livestock and providing protected feed and water.

-- Temporary embargoes to prevent the introduction into commerce of animal feeds which are likely to be contaminated: Distribution and use of possibly contaminated animal feeds is halted until the situation can be evaluated and monitoring and control actions instituted. Temporary embargoes are applied when the concentrations are not yet known. Because there is potential for negative impact on the community, justification for this action must be significant. The embargo should remain in effect at least until results are obtained. A temporary embargo on animal feeds should be issued only upon declaration of General Emergency and if predictions of the extent and magnitude of the off-site contamination are persuasive. Implementation of a temporary embargo will be in the plume path to the PAR distance for milk protective actions (10 or 50 miles).

Protective actions which can be taken for animal feeds confirmed to be contaminated:

-- Protective actions to reduce the impact of contamination in or on animal feeds, including pasture and water, should be taken on a case-by-case basis. Accurately forecasting the transfer of radioactive contamination through the agricultural pathway, from animal feed to human food, is problematic. The forecast is influenced by many factors, such as: the type of feed (e.g., fresh pasture, grain), other intakes (e.g., other feeds, supplements), the chemical form of the radionuclide, medications being administered, the animal species, and the type of resulting human food (e.g., milk, meat, eggs).

-- Protective actions that can be taken when animal feeds are contaminated include the substitution of uncontaminated water for contaminated water and the removal of lactating dairy animals and meat animals from contaminated feeds and pasture with substitution of uncontaminated feed.

--Corralling livestock in an uncontaminated area could also be effective. Evaluation of contaminated animal feeds and animal feed acreage is tasked to the FRMAC.

DRINKING WATER

During a reactor incident, surface water may become contaminated as a result of the release of incident-related liquid radwaste from the plant. The release may be controlled, as part of a planned maneuver to protect against greater risks, or uncontrolled, as in the case of the rupture or overflow of a liquid radwaste treatment or storage tank. The water supplies at risk are downstream users of the receiving stream.

Water contamination can also occur due to direct deposition of airborne activity on the surface of supply streams, reservoirs, and other uncovered impoundments during plume passage. Surface water supplies in any direction can be impacted by plume deposition.

Runoff from contaminated land areas to supply streams can also lead to contaminated water supplies.

DRINKING WATER PAG ANALOGUES

Protective Action Guides (PAGs) for drinking water have not been formally promulgated by EPA. EPA has published National Primary Drinking Water Regulations (NPDWR) (40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides") for use during normal operating conditions. Under the NPDWR, the average annual concentration of beta particles and photon radioactivity from man-made radionuclides in drinking water must not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year (0.04 mSv/year). The Maximum Contaminant Levels (MCLs) for individual radionuclides used to compute the dose commitment in drinking water are based on data found in National Bureau of Standards (NBS) Handbook 69. The MCL values are found in Appendix B of EPA-570/9-76-003, National Interim Primary Drinking Water Regulations.

In addition, FEMA has published guidance on evaluating drinking water contaminated with radionuclides in Chapter 2 of FEMA's Guidance on Offsite Emergency Radiation Measurement Systems, Phase 3 -- Water and Non-Dairy Food Pathway, FEMA REP-13, May 1990. Both early emergency phase and long-term derived preventive response levels for drinking water are provided. The associated dose commitment at the preventive PAG is 0.5 rem (5 mSv) whole body, bone marrow, and other organs, and 1.5 rem (15 mSv) thyroid.

(Note: FDA 1998 guidance is currently not applied to drinking water, pending EPA review.)

Airborne Releases

For airborne releases which result in direct deposition and runoff from contaminated land, the derived preventive response levels for drinking water in FEMA REP-13, Chapter 2 are used, and are applied to finished drinking water. WV REP Plan Annex 15 "Accident Assessment (Plume Phase), is used to evaluate water contaminated by an airborne release.

Liquid Releases

For liquid releases into surface water during an emergency, PAG analogues related to the MCLs in Appendix B of EPA-570/9-76-003 are used. These analogues were originally developed during the response to the accident at Three Mile Island in 1979. Three distinct situations involving nonroutine radionuclide releases to waterways are considered in deciding if drinking water from the affected waterway should be consumed.

Controlled Releases

For controlled liquid releases to surface water during the emergency phase, the MCLs in EPA-570/9-76-003, Appendix B, will apply to the finished drinking water. The associated dose commitment to any organ is 4 millirem (0.04 mSv) per year.

Uncontrolled Releases

For uncontrolled liquid releases to surface water during the emergency phase, the EPA570/9-76-003, Appendix B concentrations multiplied by 12 will apply to finished drinking water. This criterion assumes that uptake time will not exceed one year. The associated dose commitment to any organ is 50 millirem (0.5 mSv).

Crisis Conditions

When no other source of drinking water is available, and the duration of the uptake is 30 days or less, the concentration in finished drinking water may reach 1,000 times the EPA- 570/9-76-003, Appendix B concentrations. The associated dose commitment to any organ is 330 millirem (3.3 mSv).

DRINKING WATER PROTECTIVE ACTIONS

For liquid releases of radwaste from the plant, the most appropriate protective action available is curtailment of intake at public drinking waters systems during passage of the contaminated water.

For water contamination from direct deposition or rainwater runoff from contaminated area, protective action options are less straightforward. Protective actions must be developed after characterization of deposition patterns and will consider the operational features of the water treatment and storage facilities in question.

When contamination concentrations in domestic water supplies exceeds the PAGs, the water may still be useful for other purposes, such as firefighting and sanitation. Uses such as bathing, laundering, decontamination, and certain non-food production industrial uses will require evaluation at the time.

Attachment 1
Ingestion Pathway Dose Projection Procedure

PURPOSE:

The purpose of this procedure is to project dose commitment to members of the general public from all components of the diet, as a result of the release of radioisotopes from a nuclear reactor facility, or other large-scale radiological event. Decisions on continued consumption of the various diet components can then be made based on the dose commitment projections.

This procedure uses the results of laboratory analysis of milk, food, and water for projection of the dose commitment from the ingestion pathway.

INGESTION PATHWAY DOSE PROJECTIONS

BACKGROUND

In the event of an unplanned release of radioactive material from a nuclear power plant, (or other types of accidents where a significant radiation dose could be received by ingestion) the consequences to individuals in critical populations of the general public from ingesting radioisotopes must be determined.

This procedure determines the dose commitment from ingestion of milk, food, and water contaminated with radioisotopes. Based on the dose commitment calculations, decisions on continued consumption of milk, food, and water can be made.

The Protection Action Guides (PAGs) for Ingestion are:

Milk and Food

0.5 rem (5 mSv) committed effective dose equivalent (CEDE),

or

5.0 rem (50 mSv) committed dose equivalent (CDE) to an individual tissue or organ,

whichever is most limiting.

These PAGs are based on the 1998 FDA, Accidental Radioactive Contamination of Human Foods and Animal Feeds: Recommendations for State and Local Agencies

By measuring the radioisotope concentration in milk and food an estimate of the dose commitment can be made. This estimate is made using Derived Intervention Levels (DIL's), which are concentrations of radioisotopes in milk and food, which will give a dose commitment at the Protection Action Guide (PAG) if the milk or food is consumed at the assumed rate for the exposed individual. By design, the computed dose commitments describe the maximum dose commitment expected to be seen in an exposed individual.

Drinking Water

0.5 rem whole body, bone marrow or other organs

or

1.5 rem thyroid

These PAGs are based on FEMA REP-13, 1990, Guidance on Offsite Emergency Radiation Measurement Systems, PHASE 3- Water and Non-Dairy Food Pathway (Note: FDA 1998 guidance is currently not applied to drinking water, pending EPA review.)

By measuring the radioisotope concentration in water, and estimating the quantity of the contaminated item consumed, an estimate of the dose commitment can be made. This estimate is made using Derived Preventive Response Levels (DRL's), which are concentrations of radioisotopes in water, which will give a dose commitment at the Preventive Protection Action Guide (PAG) if the water is consumed at the assumed maximum rate for the maximum exposed individual. By design, the computed dose commitments describe the maximum dose commitment expected to be seen in an exposed individual.

REFERENCES

References: See these documents for a full discussion of ingestion pathway dose commitments --

a. "Guidance on Offsite Emergency Radiation Measurement Systems, Phase 3 Water and Non-Dairy Food Pathways", FEMA REP - 13, May 1990.
b. "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", EPA 400-R-92-001, EPA, October 1991.
c. "Accidental Radioactive Contamination of Human Food and Animal Feeds; Recommendations for State and Local Agencies", U.S. Food and Drug Administration, August 13, 1998

GENERAL PROCEDURE

A. For the nature of the radiological accident and the ingestion pathway of concern, select the appropriate Appendix of this procedure.

The Appendixes are:

Section A -- RADIOLOGICAL ACCIDENT AT NUCLEAR REACTOR SITE -

Estimates the dose commitment to a member of the population from I-131, the Cesium and Ruthenium Groups and additional radioisotopes. The estimates for milk and other foods are calculated using the section A-1. The estimates for water are calculated using section A-2. (Accidents involving spent nuclear fuel stored at a nuclear reactor site are addressed in Section B)

Section A-1 -- MILK and FOOD: Estimates the fraction of the Derived Intervention Levels (DILs) from the consumption of fluid milk and foods based on the measured radioisotope concentration in milk and food.

Section A-2 -- DRINKING WATER: Estimates the fraction of the Derived Preventive Response Level (DRL) received by a member of the critical population (infant -- child less than one year old) from consuming contaminated water. The calculation is based on the measured radioisotope concentration in water consumed, and an assumed consumption rate.

Section B-- OTHER LARGE-SCALE RADIOLOGICAL ACCIDENTS - Estimates the dose commitment to a member of the population from specific long-lived radioisotopes expected from these types of accidents. These include accidents at or involving nuclear fuel reprocessing plants, nuclear waste storage facilities, nuclear weapons, radioisotope thermoelectric generators or radioisotope heater units. The isotopes of concern are Sr-90, Cs-137, Am-241, Pu-238 and Pu-239.

B. Follow the procedure outlined in the Section to compute the Dose Commitment, Fraction of the Derived Intervention Level (DIL) or Derived Response Level (DRL) received from consuming the contaminated milk, food, or water.

C. Notify the WV Department of Agriculture of the results of the calculation for milk and foodstuffs. Notify the DEP Emergency Response Coordinator of the results of the calculation for drinking water.

Section A -- RADIOLOGICAL ACCIDENT AT NUCLEAR REACTOR SITE

MILK AND FOOD

The PAGs used for MILK and FOOD were developed by HHS/FDA and are listed in the Reference (c). These values are intended to include both the milk and food components of the diet and represent the dose commitment from ingestion over the entire episode.

A Protective Action Guide is the committed effective dose equivalent (CEDE) or committed dose equivalent (CDE) to an individual tissue or organ that warrants protective action following a release of radioisotopes.

The Ingestion Pathway PAGs for milk and food are:

0.5 rem (5 mSv) committed effective dose equivalent (CEDE),

-or-

5.0 rem (50 mSv) committed dose equivalent (CDE) to an individual tissue or organ, whichever is most limiting.

A Derived Intervention Level (DIL) corresponds to the radioisotope concentration in food present throughout the relevant period that, in the absence of any intervention, could lead to an individual receiving a radiation dose equal to the most limiting PAG.

DILs for specific radioisotopes have been calculated by FDA considering the assumed annual dietary intake by critical segments of the population, the fraction of the food intake assumed to be contaminated, and related factors.

For a food, the individual radioisotope DILs are to be applied independently. DIL fraction contributions for individual radioisotope groups in a food are not added together. DILs for individual radioisotope groups are based on different critical organs, different critical age groups, and different ingestion characteristics (e.g., length of exposure, fraction of intake assumed contaminated).

DRINKING WATER

NOTE: Use this procedure for fallout, rainout, or atmospheric deposition.

For drinking water, Preventive Protection Action Guides (PAG's) and corresponding Early Emergency Phase and Long-Term Derived Preventive Response Levels (DRL's) for drinking water are published in FEMA REP-13, Reference (a).

For airborne releases which result in direct deposition and runoff from contaminated land, the Derived Preventive Response Levels for drinking water in FEMA REP-13, Chapter 2 are used, and are applied to finished drinking water. For an initial evaluation of drinking water use the Long-Term Derived Preventative Response Levels. (If only raw water samples are available, the DRLs may be applied to the raw water in order to evaluate the degree of contamination and the suitability of the water for treatment and consumption.)

For water the radioisotope DRLs are summed for a total DRL, to project the dose commitment due to contaminated drinking water. A Sum DRL of > 1.0 will deliver a committed dose above the Preventive Protection Action Guide (PAG).

<u>Section A-1 -- THE MILK AND FOOD PATHWAY</u>

Protective Action Guides (PAGs) and corresponding Derived Intervention Levels (DIL's) are based on U.S. FDA guidance published in Reference (c). This information is used to estimate the dose commitment to an individual that consumes the milk or food.

> NOTE: An individual Attachment A-1 "RADIOLOGICAL ACCIDENT AT NUCLEAR REACTOR SITE FOOD/MILK DIL FRACTION CALCULATION", must be prepared and maintained for each sample. Special care must be taken to complete the header for each location. *<u>The "WV Food and Milk" Excel Spreadsheet may be used in place of the form.</u>*

1. Complete header information.

<u>PRINCIPAL RADIOISOTOPES</u>

The recommended DILs may be applied immediately following an accident. Early identification of radioisotopes other than the principal radioisotopes that may be present in food is not required. However, the recommended DILs for the principal radioisotopes should be evaluated as soon as possible after an accident to ensure that they are appropriate for the situation.

2. Obtain radioisotope results from the appropriate laboratory. Record results for I-131, Cs-134, Cs-137, Ru-103, Ru-106 in Column 2.
   Results are to be entered in pCi/kg. (1 Bq = 27 pCi)
   (NOTE: For milk, assume 1 liter = 1 kilogram.)

3. Using the formula in Column 3, calculate the DIL Fraction for each Radioisotope group and record in Column 4.

   For a food, the individual radioisotope DILs are to be applied independently. DIL fraction contributions for individual radioisotope groups in a food are <u>not</u> added together. DILs for individual radioisotope groups are based on different critical organs, different critical age groups, and different ingestion characteristics (e.g., length of exposure, fraction of intake assumed contaminated).

<u>PROTECTIVE ACTION TO BE INITIATED WHEN ANY RADIOISOTOPE DIL FRACTION ≥ 1 IF ANY DIL FRACTION IS ≥ 1 NOTIFY THE WV DEPARTMENT OF AGRICULTURE IMMEDIATELY, RECOMMENDING THE ITEM NOT BE CONSUMED</u>

<u>ADDITIONAL RADIOISOTOPES</u>

4. Laboratory sample results for radioisotopes other than the principal radioisotopes may also be available. If laboratory results for additional radioisotopes are available, they may be entered and evaluated on page 3 of Appendix A-1, when time permits.

ATTACHMENT A-1 -- RADIOLOGICAL ACCIDENT AT NUCLEAR REACTOR SITE FOOD/MILK DIL FRACTION CALCULATION

Distance from Plant: _______miles Direction from Plant: _______ Degrees from North

County/Township___________________________

Address: ____

Additional Sample Location Information _______________________________________
(land owner, plant name, etc.)

Operation: Farm ________ Processor ________

Home ________ Retail Mkt. ________

Other ______________________________________

Type of Sample: ______________________________________ Collection Date/Time __________________________________

Calculation performed by _______________________ Date/Time _________/________

PRINCIPLE ISOTOPES

1	2	3	4
Isotope	**Sample Concentration (pCi/kg)**	**Sample Activity to Isotope Group DIL Fraction Formula (pCi/kg)**	**Sample Isotope DIL Fraction**
I-131		$= \frac{\text{I-131}}{4600}$	
Cs-134		$= \frac{\text{Cs-134} + \text{Cs-137}}{32{,}000}$	
Cs-137			

Ru-103		**Ru-103 Ru-106** **= ---------- + --------** **180,000 12,000**	
Ru-106			

Column 1 -- As Given Column 3 -- As Given Column 2 -- As Reported by Lab
Column 4 -- As Calculated
PROTECTIVE ACTION TO BE INITIATED WHEN ANY ISOTOPE DIL FRACTION ≥ 1

ADDITIONAL ISOTOPES

1	2	3	4
Isotope	**Sample Concentration (pCi/kg)**	**Sample Activity to Isotope Group DIL Fraction Formula (pCi/kg)**	**Sample Isotope DIL Fraction**
Sr-89		**= Sr-89 ÷ 38000**	
Y-91		**= Y-91 ÷ 32,000**	
Zr-95		**= Zr-95 ÷ 108,000**	
Nb-95		**= Nb-95 ÷ 324,000**	
Te-132		**=Te-132 ÷ 119,000**	
I-129		**= I-129 ÷ 1500**	
I-133		**= I-133 ÷ 189,000**	
Ba-140		**= Ba-140 ÷186,000**	
Ce-141		**=Ce-141 ÷ 194,000**	
Ce-144		**=Ce-144 ÷ 14,000**	
Np-237		**= Np-237 ÷ 110**	
Np-239		**=Np-239 ÷ 756,000**	
Pu-241		**= Pu-241 ÷ 3200**	

Cm-242		**= Cm-242 ÷ 510**	
Cm-244		**= Cm-244 ÷ 54**	

Column 1 -- As Given Column 3 -- As Given Column 2 -- As Reported by Lab
Column 4 -- As Calculated

PROTECTIVE ACTION TO BE INITIATED WHEN ANY ISOTOPE DIL FRACTION ≥ 1

Section A-2 -- THE DRINKING WATER PATHWAY

NOTE: Use this procedure for fallout, rainout, or atmospheric deposition.

This procedure utilizes Long-Term Derived Preventive Response Levels (DRL's) for Drinking Water (One Year Ingestion Period) based on Preventive Protective Action Guides (PAG's) to assess the consequences of a radiological event which contaminates drinking water. The infant (child less than one year old) is taken to be the critical exposed population for all isotopes. The Derived Preventive Response Levels (DRL's) for Drinking Water (One Year Ingestion Period) are found in Table A2-2, which is taken from Reference (a). The Long-Term levels assume a contaminated water ingestion period equivalent to the shorter time interval of the radioisotope mean lifetime or one year.

NOTE: FEMA REP-13, Reference (b), also provides Early Emergency Phase Derived Preventive Response Levels for Drinking Water (Five Day Ingestion Period). These Early Emergency Phase levels assume a contaminated water ingestion period equivalent to the shorter time interval of the radioisotope mean lifetime or 5 days. The Early Emergency Phase Derived Preventive Response Levels for Drinking Water (Five Day Ingestion Period) are presented for information in Table A2-1, which is taken from Reference (a). These Early Emergency Phase levels may be used in place of the Long-Term levels in this procedure, if desired, to determine the short-term suitability of water for consumption.
It is also noted that the EPA has published the National Primary Drinking Water Regulations, EPA,40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides" (Issued December 7, 2000). This document also addresses the issue of radioisotope concentrations in drinking water.

The Preventive Protection Action Guides (PAG's) give a dose commitment of 1.5 Rem thyroid or 0.5 Rem whole body, bone marrow or other organs. This procedure calculates the Sum Total of the Fractional DRL's for an exposure to contaminated drinking water. A Sum DRL of > 1.0 will deliver a committed dose above the Preventive Protection Action Guide (PAG).

NOTE: An individual Attachment A-2, "Drinking Water Activity and Total DRL Fraction" must be prepared and maintained for each sample location. Special care must be taken to complete the header for each location. *The "WV Water Calc" Excel Spreadsheet may be used in place of the form.*

1. Complete header information

2. Obtain the radioisotope sample results from the appropriate laboratory. Enter the Isotope in Column 1, and the Sample Concentration (in μCi/liter) in Column 2.

3. Obtain the Long-Term Derived Response Levels for Drinking Water for each isotope from Table A2-2. Use the "INFANT" column of Table A2-2. Enter the value in Column 3.

4. Compute the Fractional DRL for each isotope by dividing the value in Column 2 by the value in Column 3. Enter this value in Column 4.

5. Sum the Total DRL values in Column 4.

NOTE: IF THE SUM TOTAL OF THE DRL VALUES IN COLUMN 5 IS > 1.0, NOTIFY THE DEP EMERGENCY RESPONSE COORDINATOR IMMEDIATELY, RECOMMENDING THAT THE CONTAMINATED WATER NOT BE CONSUMED. NOTIFICATION OF THE PUBLIC WILL BE COORDINATED BY DEP.

TABLE A2-1

Early Emergency Phase
Derived Preventive Response Levels for Drinking Water
(Five Day Ingestion Period)[a]

Nuclide	Organ[c]	Initial Water Concentration Equivalent to the Preventive PAG Ingestion Dose Commitment[b] Adult[d] (µCi/liter)	Teenager[d] (µCi/liter)	Child[d] (µCi/liter)	Infant[d] (µCi/liter)
I-131	Th	1.2E-1[e]	1.1E-1	4.5E-2	2.5E-2
I-132	Th	1.2E+1	1.4E+1	4.9E+0	3.5E-1
I-133	Th	2.4E+0	2.6E+0	9.1E-1	5.8E-1
Rb-86	Lv	2.6E+0	5.6E+0	1.9E+0	7.1E-1
Cs-134	Lv	7.4E-1	3.6E-1	1.9E-1	9.4E-1
Cs-136	Lv	2.2E+0	2.4E+0	1.3E+0	9.3E-1
Cs-137	Lv	8.2E-1	4.8E-1	2.2E-1	1.6E+0
Te-127m	Kd	1.8E+0	1.9E+0	8.8E-1	7.8E-1
Te-131m	GI	2.4E+0	3.1E+0	2.9E+0	4.4E+0
Te-132	GI	1.0E+0	1.6E+0	2.5E+0	2.7E+0
Sb-127[f]	GI	1.1E+0	1.7E+0	2.6E+0	4.8E+0
Sr-89	Bo	4.3E+0	1.7E-1	5.6E-2	5.9E-1
Sr-90	Bo	7.1E-2	8.6E-3	4.2E-3	4.5E-2
Ba-140	GI	1.4E+0	1.9E+0	9.8E-1	7.4E-1
Mo-99	Kd	9.1E+0	9.4E+0	4.6E+0	5.9E+0
Ru-103	GI	2.4E+0	3.5E+0	3.9E+0	6.4E+0
Ru-106	GI	2.8E-1	3.8E-1	3.9E-1	6.1E-1
Rh-105[f]	GI	1.2E+1	1.8E+1	2.9E+1	5.4E+1
Co-58	GI	3.4E+0	5.5E+0	7.0E+0	1.3E+1
Co-60	GI	1.2E+0	2.0E+0	2.4E+0	4.3E+0
Y-90	GI	4.9E-1	6.3E-1	6.1E-1	9.3E-1
Y-91	GI	6.6E-1	8.9E-1	9.2E-1	1.4E+0
Zr-95	GI	1.7E+0	2.4E+0	2.8+0	4.6E+0
Zr-97	GI	3.4E+0	4.0E+0	3.3E+0	4.9E+0
Nb-95	GI	2.5E+0	3.8E+0	4.6E+0	8.0E+0
La-140	GI	6.1E-1	8.3E-1	8.2E-1	1.3E+0
Ce-141	GI	2.2E+0	3.0E+0	3.0E+0	4.7E+0
Ce-143	GI	4.0E+0	5.1E+0	4.7E+0	7.1E+0
Ce-144	GI	3.0E-1	4.1E-1	4.2E-1	6.5E-1
Pr-143	GI	1.4E+0	1.9E+0	1.9E+0	2.9E+0
Nd-147	GI	1.7E+0	2.2E+0	2.3E+0	3.6E+0
Np-239	GI	4.5E+0	5.8E+0	5.5E+0	8.4E+0
Pu-238[f]	Bo	7.5E-3	9.9E-3	4.8E-3	6.9E-3
Pu-239[f]	Bo	6.4E-3	8.4E-3	3.4E-3	5.8E-3
Pu-240[f]	Bo	6.4E-3	8.4E-3	3.4E-3	5.8E-3
Pu-241[f]	Bo	3.1E-1	4.0E-1	2.0E-1	2.8E-1
Am-241[f]	Bo	1.2E-3	2.0E-2	7.8E-4	1.1E-3
Cm-242[f]	Bo	5.9E-2	7.8E-2	3.8E-2	5.3E-2
Cm-244[f]	Bo	2.5E-3	3.2E-3	1.6E-3	2.3E-3

TABLE A2-1 (Continued)

Nuclide	Organ[c]	Initial Water Concentration Equivalent to the Preventive PAG Ingestion Dose Commitment[b] Adult[d] (µCi/liter)	Teenager[d] (µCi/liter)	Child[d] (µCi/liter)	Infant[d] (µCi/liter)

a Assumes a contaminated water ingestion period equivalent to the shorter time interval of the radionuclide mean lifetime or 5 days (see Appendix A). Water is ingested at the rates given in Reference 9 for the maximum exposed individual.

b The derived response level for each radionuclide is capable of producing the preventive PAG dose. Therefore, if more than one radionuclide is present in the sample, the sum of ratios technique must be used to estimate the individual radionuclide concentrations that are permissible, e.g.

$$\frac{\text{Conc A}}{\text{Response Level A}} + \ldots + \frac{\text{Conc X}}{\text{Response Level X}} = \leq 1.$$

c Th=thyroid, Lv=liver, Kd=kidney, Bo=bone, Wb=whole body, GI=gastrointestinal tract. These are the critical organs for the corresponding radionuclides.

d Calculated concentrations may vary if calculation assumptions concerning ingestion rates and dose conversion factors are different from those presented in Reference 9.

e $1.2E\text{-}1 = 1.2 \times 10^{-1} = 0.12$.

f Adult dose conversion factors (DCF's) were obtained from ICRP-30;[10,11,12] dose conversion factors for other age groups were estimated by multiplying these adult DCF's by DCF ratios $\left(\frac{\text{other age group}}{\text{adult}}\right)$ presented in Reference 9 for other nuclides having similar critical organs and retention times.

REFERENCE: FEMA REP-13, Pages 2-5, 2-6

TABLE A2-2

Long-Term Derived Preventive Response Levels for Drinking Water[a] (One Year Ingestion Period)

Nuclide	Organ[c]	Initial Water Concentration Equivalent to the Preventive PAG Ingestion Dose Commitment[b]			
		Adult[d] (μCi/liter)	Teenager[d] (μCi/liter)	Child[d] (μCi/liter)	Infant[d] (μCi/liter)
I-131	Th	6.3E-2[e]	5.7E-2	2.4E-2	1.3E-2
I-132	Th	1.2E+1	1.4E+1	4.9E+0	3.5E-1
I-133	Th	2.4E+0	2.6E+0	9.1E-1	5.8E-1
Rb-86	Lv	6.4E-1	1.4E+0	4.7E-1	1.8E-1
Cs-134	Lv	1.2E-2	5.8E-3	3.0E-3	1.5E-2
Cs-136	Lv	7.6E-1	8.2E-1	4.3E-1	3.2E-1
Cs-137	Lv	1.1E-2	6.6E-3	3.0E-3	2.2E-2
Te-127m	Kd	8.5E-2	8.5E-2	4.0E-2	3.6E-2
Te-129	Kd	4.0E+4	3.1E+4	9.1E+2	5.2E+2
Te-131m	GI	2.4E+0	3.1E+0	2.9E+0	4.4E+0
Te-132	GI	1.0E+0	1.6E+0	2.5E+0	2.7E+0
Sb-127[f]	GI	9.8E-1	1.5E+0	2.4E+0	4.4E+0
Sr-89	Bo	4.1E-1	1.6E-2	5.3E-3	5.6E-2
Sr-90	Bo	9.9E-4	1.2E-4	5.8E-5	6.2E-4
Ba-140	GI	4.7E-1	6.5E-1	3.4E-1	2.6E-1
Mo-99	Kd	9.1E+0	9.4E+0	4.6E+0	5.9E+0
Ru-103	GI	3.0E-1	4.3E-1	4.9E-1	7.9E-1
Ru-106	GI	5.1E-3	6.9E-3	7.2E-3	1.1E-2
Rh-105[f]	GI	1.2E+1	1.8E+1	2.9E+1	5.4E+1
Co-58	GI	2.4E-1	3.8E-1	4.9E-1	8.8E-1
Co-60	GI	1.8E-2	2.8E-2	3.6E-2	6.3E-2
Y-90	GI	6.8E-3	8.8E-3	8.5E-3	1.3E-2
Y-91	GI	5.5E-2	7.5E-2	7.7E-2	1.2E-1
Zr-95	GI	1.3E-1	1.9E-1	2.1E-1	3.5E-1
Zr-97	GI	3.4E+0	4.0E+0	3.3E+0	4.9E+0
La-140	GI	2.1E-1	2.9E-1	2.9E-1	4.5E-1
Ce-141	GI	3.2E-1	4.4E-1	4.5E-1	7.0E-1
Ce-143	GI	4.0E+0	5.1E+0	4.7E+0	7.1E+0
Ce-144	GI	5.9E-3	7.9E-3	8.2E-3	1.3E-2
Pr-143	GI	4.6E-1	6.1E-1	6.2E-1	9.6E-1
Nd-147	GI	6.5E-1	8.9E-1	9.1E-1	1.4E+0
Np-239	GI	4.5E+0	5.8E+0	5.5E+0	8.4E+0
Pu-238[f]	Bo	1.0E-4	1.4E-4	6.5E-5	9.6E-5
Pu-239[f]	Bo	8.8E-5	1.2E-4	5.4E-5	8.0E-5
Pu-240[f]	Bo	8.8E-5	1.2E-4	5.4E-5	8.0E-5
Pu-241[f]	Bo	4.4E-3	5.6E-3	2.8E-3	4.0E-3
Am-241[f]	Bo	1.7E-5	2.2E-5	1.1E-5	1.5E-5
Cm-242[f]	Bo	2.1E-3	2.7E-3	1.3E-3	1.8E-3
Cm-244[f]	Bo	3.5E-5	4.5E-5	2.2E-5	3.2E-5

TABLE A2-2 (Continued)

Nuclide	Organ[c]	Initial Water Concentration Equivalent to the Preventive PAG Ingestion Dose Commitment[b] Adult[d] (µCi/liter)	Teenager[d] (µCi/liter)	Child[d] (µCi/liter)	Infant[d] (µCi/liter)

[a] Assumes a contaminated water ingestion period equivalent to the shorter time interval of the radionuclide mean lifetime or 365 days (see Appendix A). Water is ingested at the rates given in Reference 9 for the maximum exposed individual.

[b] The derived response level for each radionuclide is capable of producing the preventive PAG dose. Therefore, if more than one radionuclide is present in the sample, the sum of ratios technique must be used to estimate the individual radionuclide concentrations that are permissible, e.g.

$$\frac{\text{Conc A}}{\text{Response Level A}} + \ldots + \frac{\text{Conc X}}{\text{Response Level X}} = \leq 1.$$

[c] Th=thyroid, Lv=liver, Kd=kidney, Bo=bone, Wb=whole body, GI=gastro-intestinal tract. These are the critical organs for the corresponding radionuclides.

[d] Calculated concentrations may vary if calculation assumptions concerning ingestion rates and dose conversion factors are different from those presented in Reference 9.

[e] $6.3E\text{-}2 = 6.3 \times 10^{-2} = 0.063$.

[f] Adult dose conversion factors (DCF's) were obtained from ICRP-30;[10,11,12] dose conversion factors for other age groups were estimated by multiplying these adult DCF's by DCF ratios ($\frac{\text{other age group}}{\text{adult}}$) presented in Reference 9 for other nuclides having similar critical organs and retention times.

Reference: FEMA REP-13, Pages 2-8, 2-9

ATTACHMENT A-2 -- DRINKING WATER ACTIVITY AND TOTAL DRL FRACTION

Sample Location: Distance from Plant: ______miles Direction from Plant: ______Degrees from N

River Name: ________________ Location Name: ____________ (Intake Name: ________________)

Address: ____

Additional Sample Location information ____
(land owner, plant name, etc.)

Sample Type: **Sample Source:**

Raw __________ Surface _________ Finished __________ Well _________
Catchment _________

Collection Date/Time ___________________ County/Township__________________________

Calculations Performed by ________________________ Date/Time ______________

1	2	3	4
Isotope	Sample Concentration (µCi/liter)	Derived Response Level -- DRL (µCi/liter) (Table A2-2)	Fractional DRL = Column 2 / Column 3
		Total DRL =	

Column 1 -- As Reported by Lab. **Column 3 -- From Table A2-2**

Column 2 -- As Reported by Lab. **Column 4 = Column 2 ÷ Column 3**

Section B - OTHER LARGE-SCALE RADIOLOGICAL ACCIDENTS

SECTION B-1 -- FOOD/MILK DIL FRACTION CALCULATION

This is a list of large-scale radiological accidents and associated principal radioisotopes from FDA 1998:

Location/Type of Accident	Principal Isotopes
Nuclear Fuel Reprocessing Plant	Sr-90, Cs-137, Pu-239, Am-241
Nuclear Waste Storage Facilities (includes spent nuclear fuel)	Sr-90, Cs-137, Pu-239, Am-241
Nuclear Weapons (dispersal of nuclear material w/o detonation)	Pu-239
Radioisotope Thermoelectric Generators or Radioisotope Heater Units (used in space vehicles)	Pu-238

The radioisotopes listed are expected to be the predominant contributors to radiation dose through ingestion. Several radioisotopes could be released by an accident at a nuclear fuel reprocessing plant or nuclear waste storage facility, while only the specific radioisotope used in a nuclear weapon or space vehicle would be released in that type of accident. When more than one radioisotope is released, the relative contribution that a radioisotope makes to radiation dose from ingestion of subsequently contaminated food depends on the specifics of the accident and the mode of release.

In unique circumstances, such as transportation accidents, other radioisotopes may contribute radiation doses through the food ingestion pathway. These situations are not specifically treated in this procedure. An evaluation of the radiation dose from ingestion of these other radioisotopes should be performed, however, to determine if the PAGs would be exceeded.

For the large-scale radiological accidents and associated principal radioisotopes listed above, the Sample Activity to Isotope Group DIL Fraction Formulas are:

Sample Activity to Isotope Group DIL Fraction Formula

Sr-90 $\quad$ Sr90(pCi/kg) ÷ 4300

Cs-137 $\quad$ Cs-137(pCi/kg) ÷32000

Pu-238
Pu-239
Am-241

$$= \frac{\text{Pu238(pCi/kg) + Pu-239(pCi/kg) + Am-241(pCi/kg)}}{54}$$

Protective Action Guides (PAGs) and corresponding Derived Intervention Levels (DIL's) are based on U.S. FDA guidance published in Reference (c). This information is used to estimate the dose commitment to an individual that consumes the milk or food.

NOTE: An individual Attachment B-1, "OTHER LARGE-SCALE RADIOLOGICAL ACCIDENT FOOD/MILK DIL RATIO CALCULATION", must be prepared and maintained for each sample. Special care must be taken to complete the header for each location.

1. Complete header information.
2. Obtain radioisotope results from the appropriate laboratory. Record results for Principal radioisotopes listed above in Column 1 and Column 2.
3. Record the appropriate Sample Activity to Isotope Group DIL Fraction Formula listed above in Column 3. Calculate the DIL Fraction for each Radioisotope group and record in Column 4.

PROTECTIVE ACTION TO BE INITIATED WHEN ANY RADIOISOTOPE DIL FRACTION ≥ 1 IF ANY DIL FRACTION IS ≥ 1 NOTIFY THE WV DEPARTMENT OF AGRICULTURE IMMEDIATELY, RECOMMENDING THE ITEM NOT BE CONSUMED

SECTION B-2 -- DRINKING WATER DRL FRACTION CALCULATION

The dose commitment due to contaminated drinking water due to other large-scale radiological accidents is calculated using the same method identified in Section A-2.

ATTACHMENT B-1 -- OTHER LARGE-SCALE RADIOLOGICAL ACCIDENT FOOD/MILK DIL FRACTION CALCULATION

Site of Accident ________________________ Type of Accident _____________________

County____________________________

Address: ____

Sample Location information ____

____

____

Type of Sample: _______________________________________

Collection Date/Time ___________________________________

Calculation performed by ___________________________ Date/Time __________/_________

1	2	3	4
Isotope	Sample Concentration (pCi/kg)	Sample Activity to Isotope Group DIL Fraction Formula (pCi/kg)	Sample Isotope DIL Fraction

Column 1 -- For Accident Type - See App. B, Sect. 1
Column 2 -- As Reported by Lab
Column 3 -- See App. B, Sect. 1
Column 4 -- As Calculated

PROTECTIVE ACTION TO BE INITIATED WHEN ANY ISOTOPE DIL FRACTION ≥ 1

Attachment 2
Reentry, Return, Relocation and Recovery Procedures

PURPOSE:

This procedure provides implementing procedures for Reentry, Return, Relocation, and Recovery which are to be followed for a fixed nuclear facility accident or incident when uncontrolled radioactive releases have terminated.

The basic guidance on Reentry, Return, Relocation, and Recovery are contained in WV REP Plan Annex 7 – "Recovery, Reentry, Return, and Relocation".

This implementing procedure addresses issues of:

-- Description of Position Functions

-- Dose Projection

during Reentry into the 10-mile plume EPZ and other areas affected directly or indirectly because of the incident; Return or Relocation of the population; and Recovery operations.

This implementing procedure assumes that Emergency Phase PARs have been implemented by the State/County; the Accident Assessment team is mobilized for emergency operations; and Federal technical assistance has been requested and has responded.

REENTRY, RETURN, RELOCATION, AND RECOVERY PROCEDURES

DEFINITIONS

Advisory Team for Environment, Food and Health (Advisory Team) – Develops coordinated advice and recommendations concerning environmental, food health and animal health matters. Contains representatives from DHS, EPA, USDA, and FDA. Operates from FRMAC.

Aerial Measurement System (AMS) -- Determination of plume and ground deposition locations by aircraft. It is accessible through DOE.

Consequence Management Response Team (CMRT)-- A DOE team that rapidly responds to the scene of a serious radiological incident. Provides expertise in radiation monitoring, sampling, analysis, assessment, health and safety, and logistics and support. Prepares for arrival of FRMAC.

Federal Radiological Monitoring and Assessment Center (FRMAC) -- Established and managed by the Department of Energy (DOE) to provide extended technical support on radiation monitoring and assessment in support of the state. The timeframe for establishment and full operation for the FRMAC in Pennsylvania is normally 24-48 hours from the time of a request.

Interagency Modeling and Atmospheric Assessment Center (IMAAC) – A Federal interagency group responsible for production, coordination, and dissemination of consequence predictions for an airborne hazardous materials release. The IMAAC generates the single Federal prediction of atmospheric dispersions and their consequences utilizing the best available resources from the Federal Government.

Joint Field Office (JFO) – A temporary Federal facility established locally to provide a central point for Federal, State, local, and tribal executives with responsibility, for incident oversight, direction, and/or assistance to effectively coordinate protection, prevention, preparedness, response and recovery actions.

National Atmospheric Release Advisory Capability (NARAC) -- A sophisticated computer system used for estimating meteorological factors, plume travel, population doses, and other parameters. It is accessible through the FRMAC.

National Response Framework (NRF) -- The Federal plan which defines the federal response to major disasters and other emergencies, including emergencies at nuclear power plants, and major radiological incidents.

Recovery -- The efforts to reduce offsite contamination to acceptable levels for unrestricted use. The major considerations in recovery are the operation of a long-term surveillance program to verify and control exposure to the general population, and systematic decontamination of affected areas. Recovery also includes the restoration of vital services and infrastructure.

Reentry -- (also called “Controlled Entry”) -- The temporary return of authorized personnel for a prescribed period into restricted zones for the purposes of protection of valuable property, and functions including law enforcement, firefighting, securing property, removing property, tending livestock, control of industrial processes, and public utilities.

Relocation -- Relocation is a protective action focusing on moving populations still residing in restricted zones out of the restricted zones.

Relocation Protective Action Guide (PAG) -- The projected TEDE (whole body) dose above which relocation of the population is necessary. EPA-400 proposes the use of a projected dose of 2 Rem over the first year as the Protective PAG. It further indicates that the projected dose during pregnancy should be limited to 0.5 Rem, with the fetus as the critical population. This plan uses a projected dose of 0.5 Rem TEDE over the first year as the relocation PAG. EPA-400 also proposes relocation PAGs for the second year, and for the entire period from 0-50 years. As recommended by EPA-400, the second-year relocation PAG is 0.5 Rem TEDE, and the 50-year relocation PAG is 5 Rem TEDE.

Restricted Zone -- Restricted Zones are those areas where whole body dose (TEDE) to the general public from ground deposition and inhalation of resuspended material is expected to exceed relocation PAGs. It may also include a buffer zone to prevent radionuclides from being deposited in unrestricted zones.

Return -- (also called “Controlled Return”) -- The return of evacuees to unrestricted zones, following verification of the boundaries of the restricted zones. Since unrestricted zones may include contaminated areas, ingestion pathway controls may be in operation in these unrestricted zones.

Unrestricted Zone -- Unrestricted Zones are those areas outside restricted zones. Since unrestricted zones may include contaminated areas, ingestion pathway controls can be in operation in these zones.

DOSE PROJECTIONS

The Relocation Protective Action Guide (PAG) used by the West Virginia is 2 Rem TEDE (Whole Body) in the first year of exposure. The second year Relocation PAG is 0.5 Rem TEDE in the second year of exposure. The 50-year Relocation PAG is 5 Rem TEDE in the entire period 050 years.

Two pathways must be considered in computing dose projections:
-- Ground Shine
-- Inhalation of Resuspended Nuclides.
Ground shine will be the major dose contribution.

Attachment 2-1 provides for the computation of projected dose by Ground Shine from gamma emitters deposited on the ground.

Attachment 2-2 provides for the computation of projected dose by Inhalation of Resuspended Nuclides.

Discussion and tables of Dose Conversion Factors are found in, "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents", EPA 400-R-92-001, EPA, May 1992.

Note: The "WV Relocation and Recovery" Excel Spreadsheet may be used in place of the forms below.

Ground Shine Projected Dose -- Attachment 2-1

The following steps are used to calculate:

a. First year, second year, and fifty-year TEDE doses, based on individual nuclide contributions.

b. Dose Conversion Factors which convert gamma exposure rate measurements taken at waist level directly into dose that an individual would receive during the first year of exposure, the second year of exposure, and 50 years of exposure.

c. The exposure rate which corresponds to the Relocation PAG, for the first year of exposure. This value is the dose rate that would define the boundary of the Restricted Zone.

This calculation does not take credit for weathering.

1. Obtain gamma spectral analysis of deposited radionuclides and determine the relative abundance of the principal gamma emitting radionuclides. Analysis of samples from several locations may be necessary to determine whether the relative concentrations of radionuclides are constant. The results should be expressed in pCi/sq. meter. Enter in Column 2 of Attachment 1.

2. Multiply the concentrations in Column 2 by the corresponding values in Column 3 to determine the relative contribution to the gamma exposure rate (mR/hr) at 1 meter and enter the result in Column 7.

3. Multiply the concentrations in Column 2 by the corresponding value in Column 4. Enter the results in Column 8. This gives the first-year integrated dose contribution of each radionuclide.

4. Multiply the concentrations in Column 2 by the corresponding value in Column 5. Enter the result in Column 9. This gives second year integrated dose contribution of each radionuclide.

5. Multiply the concentrations in Column 2 by the corresponding value in Column 6. Enter the result in Column 10. This gives the fifty-year integrated dose contribution of each radionuclide.

6. Sum the results in Column 7 to determine a total exposure rate (mR/hr) at one meter for the sample being considered. Enter the total value at the bottom of Column 7.

7. Sum the results in Column 8 to determine a total first year integrated dose (mrem). Enter the total value at the bottom of Column 8.

8. Sum the results in Column 9 to determine a total second year integrated dose (mrem). Enter the total value at the bottom of Column 9.

9. Sum the results in Column 10 to determine a total fifty-year integrated dose (mrem). Enter the total value at the bottom of Column 10.

10. Calculate the Dose Conversion Factors for the first year, second year, and fifty years, by dividing the Columns 8, 9, and 10 totals (mrem) by the Column 7 total (mR/hr). Enter in the appropriate space for Dose Conversion Factors.

11. Calculate the Exposure Rate (mR/hr) at one meter at the Restricted Area Boundary corresponding to the Relocation PAG for the first year of exposure by:

$$\text{Restricted Area Boundary Exposure Rate at 1-meter (mR/hr)} = \frac{\text{500 mrem (Relocation PAG)}}{\text{Year 1 DCF (mrem/mR/hr)}}$$

12. Provide the results of the calculation to the Accident Assessment Manager.

Inhalation Projected Dose -- Attachment 2-2

The dose from inhalation should be relatively small when compared to the dose from ground shine from gamma emitters. The following procedure may be used to project the first year and second year inhalation dose.

This procedure does not account for weathering.

1. Obtain results of gamma isotopic and Sr-90/Y-90 analysis of air samples from laboratory.

2. Convert if necessary, to pCi/m^3, and enter in Column 2 of Attachment 2.

3. Multiply the entry in Column 2 by the DCF in Column 3 to obtain the first-year dose commitment in mrem for each respective radionuclide and enter the result in Column 5.

4. Sum the results in Column 5 to obtain the total first year dose commitment and enter the result at the bottom of Column 5.

5. Multiply the entry in Column 2 by the DCF in Column 4 to obtain the second-year dose commitment in mrem for each respective radionuclide and enter the result in Column 6.

6. Sum the results in Column 6 to obtain the total second year dose commitment and enter the result at the bottom of Column 6.

7. Report the results to the Accident Assessment Manager.

ATTACHMENT 2-1 -- GROUND SHINE PROJECTED DOSE

Location: ____ Date: _________

NOTE: NO CREDIT TAKEN FOR WEATHERING.

1	2	3	4	5	6	7	8	9	10
NUCLIDE	SAMPLE CONC (pCi/sq.m)	mR/hr / pCi/sq. m @ 1 m (a)	Year 1 mrem / pCi/sq.m	Year 2 mrem / pCi/sq.m	0-50 Years mrem / pCi/sq. m	Calculated (mR/hr)	Dose Year 1 (mrem)	at 1 Year 2 (mrem)	meter 0-50 Years (mrem)
Zr-95		1.2E-8	3.8E-5	8.0E-7	3.9E-5				
Nb-95		1.3E-8	(b)	(b)	(b)				
Ru-103		8.2E-9	7.8E-6	0	7.8E-6				
Ru-106		3.4E-9	1.5E-5	7.6E-6	3.0E-5				
Te-132		4.0E-9	3.3E-6	0	3.3E-6				
I-131		6.6E-9	1.3E-6	0	1.3E-6				
I-132		3.7E-8	(b)	(b)	(b)				
I-133		1.0E-8	2.1E-7	0	2.1E-7				
I-135		2.4E-8	1..6E-7	0	1.6E-7				
Cs-134		2.6E-8	1.3E-4	9.6E-5	4.7E-4				
Cs-137		1.0E-8	6.0E-5	5.9E-5	1.8E-3				
Ba-140		3.2E-9	1.2E-5	0	1.2E-5				
La-140		3.5E-8	(b)	(b)	(b)				
					TOTALS:				

(a.) Estimated exposure rate at 1 meter above the contaminated ground.

(b.) Radionuclides that have short-lived daughters (Zr/Nb-95, Ru/Rh-106, Te/I-132, Cs-137/Ba-137m, Ba/La-140) are assumed to quickly reach equilibrium. The integrated dose factors listed are the effective gamma dose due to the parent and daughter.

Reference: EPA 400-R-92-001, May 1992.

Dose Conversion Factors:

Year 1 DCF = Total of Column 8 (mrem) / Total of Column 7 (mR/hr) = ________________ mrem / mR/hr

= ____________ mrem / mR/hr

ATTACHMENT 2-1 -- GROUND SHINE PROJECTED DOSE (Continued)

$$\text{Year 2 DCF} = \frac{\text{Total of Column 9 (mrem)}}{\text{Total of Column 7 (mR/hr)}} = \_\_\_\_\_\_\_\_\_\_\_\_ \frac{\text{mrem}}{\text{mR/hr}}$$

$$= \_\_\_\_\_\_\_\_\_\_\_\_\_ \frac{\text{mrem}}{\text{mR/hr}}$$

$$\text{0-50 Year DCF} = \frac{\text{Total of Column 10 (mrem)}}{\text{Total of Column 7 (mR/hr)}} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \frac{\text{mRem}}{\text{mR/hr}}$$

$$= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \frac{\text{mrem}}{\text{mR/hr}}$$

Exposure Rate at Restricted Area Boundary:

$$\text{Exposure Rate (mR/hr) at Restricted Area Boundary} = \frac{\text{2000 mrem (Relocation PAG -- Year 1)}}{\text{Year 1 DCF (mrem/mR/hr)}}$$

$$= \frac{\text{2000 mrem}}{\_\_\_\_\_\_ \text{ mrem/mR/hr}}$$

$$= \_\_\_\_\_\_\_\_\_\_\_ \text{ mR/hr}$$

ATTACHMENT 2 -- INHALATION OF RESUSPENDED MATERIALS PROJECTED DOSE

Location: ____ Date: __________

NOTE: NO CREDIT TAKEN FOR WEATHERING.

1	2	3	4	5	6
Radionuclide	Concentration (pCi/ cu.m)	mrem/pCi/cu.m Year 1	mrem/pCi/cu.m Year 2	Inhalation Dose (mrem) Year 1	Inhalation Dose (mrem) Year 2
Sr-90/Y-90		1.4E+1	1.3E+1		
Zr-95/Nb-95		7.9E-2	-----		
Ru-103		1.5E-2	-----		
Ru-106/Rh-106		3.7E+0	1.9E+0		
Te-132/I-132		1.3E-3	-----		
I-131		1.1E-2	-----		
Cs-134		4.1E-1	3.0E-1		
Cs-137/Ba-137m		3.3E-1	3.2E-1		
Ba-140/La-140		4.7E-3	-----		
Ce-144/Pr-144		2.7E+0	9.8E-1		
			TOTALS:		

NOTE: Short lived daughters are not listed separately because the entries include the dose from both the daughter and the parent. These factors are based on the concentration of the parent only, at the beginning of the exposure period.

Reference: EPA 400-R-92-001, May 1992.

Attachment 3
Isotope Half-lives

Isotope	Half-Life
Am-241	432.7 years
Ba-140	12.75 days
Ce-141	32.5 days
Ce-143	1.377 days
Ce-144	284.6 days
Cm-242	162.8 days
Cm-244	18.1 years
Co-58	70.88 days
Co-60	5.271 years
Cs-134	2.065 years
Cs-136	13.1 days
Cs-137	30.07 years
I-129	1.57E7 years
I-131	8.023 days
I-132	2.283 hours
I-133	20.8 hours
I-135	6.57 hours
La-140	1.678 days
Mo-99	2.7476 days
Nb-95	34.99 days
Nd-147	10.98 days
Np-237	2.14E6 years
Np-239	2.356 days
Pr-143	13.57 days
Pu-238	87.7 years
Pu-239	2.410E4 years
Pu-240	6.56E3 years
Pu-241	14.29 years
Rb-86	18.65 days
Rh-105	35.4 hours
Ru-103	39.27 days
Ru-106	1.017 years
Sb-127	3.84 days
Sr-89	50.61 days
Sr-90	28.8 years
Te-127m	106 days
Te-129	33.6 days
Te-131m	1.36 days
Te-132	3.2 days
Y-90	2.669 days
Y-91	58.5 days

Zr-95	64.02 days
Zr-97	16.75 hours

Half-lives as listed in the "*Seventh Edition Nuclides and Isotopes: Chart of the Nuclides" (2009)*