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United States Nuclear Regulatory Commission
Protecting People and the Environment

Capabilities and Practices of Offsite Response Organizations for Protective Actions in the Intermediate Phase of a Radiological Emergency Response

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ABSTRACT

This report documents the results of a study conducted to better understand the capabilities and practices of offsite response organizations (OROs) for protective actions in the intermediate phase of a radiological emergency response. The research consisted of:

- Interviews with state OROs regarding protective action decisions (PADs) and capabilities.
- Review of Federal Emergency Management Agency (FEMA) after action reports (AARs) from the Radiological Emergency Preparedness Program ingestion pathway exercises.
- Review of a sample of state radiological emergency response plans.

Nine states voluntarily participated in the interview process, including at least one state from eight of the nine FEMA regions with nuclear power plants. State practices were largely consistent in several areas, including using Federal guidelines and scientific procedures to inform protective action decision-making; working within and across various levels of government to develop and implement PADs; and utilizing resources from the Federal Government or mutual aid sources as needed.

The review of AARs yielded 35 with relevant information from 25 states. This review, combined with the review of 23 state radiological emergency response plans from 21 states, augmented the interview results. Results from the interviews and the documentary reviews may be used by the Nuclear Regulatory Commission to inform modeling assumptions.

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ABBREVIATIONS AND ACRONYMS

AAR	After Action Report
A-Team	Advisory Team
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
CST	Civil Support Team
DIL	Derived Intervention Level
DOE	Department of Energy
DRL	Derived Response Level
EAS	Emergency Alert System
EMAC	Emergency Management Assistance Compact
EOC	Emergency Operations Center
EOP	Emergency Operations Plan
EPA	Environmental Protection Agency
EPZ	Emergency Planning Zone
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FR	Federal Register
FRMAC	Federal Radiological Monitoring and Assessment Center
GIS	Geographic Information System
HSEEP	Homeland Security Exercise and Evaluation Program
JIC	Joint Information Center
JIS	Joint Information System
LFA	Lead Federal Agency
MACCS	MELCOR Accident Consequence Code System
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NPDWR	National Primary Drinking Water Regulations for Radionuclides
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
ORO	Offsite Response Organization
PAD	Protective Action Decision
PAG	Protective Action Guide
PAR	Protective Action Recommendation
PIO	Public Information Officer
RAP	Radiological Assistance Program
REP	Radiological Emergency Preparedness

UC	Unified Command
USC	U.S. Code
USDA	Department of Agriculture

1 INTRODUCTION

1.1 Purpose

The Nuclear Regulatory Commission (NRC) seeks to better understand offsite response organization (ORO) capabilities and practices for protective action decisions (PADs) in the intermediate phase of a radiological emergency response in order to inform the modeling of offsite consequence analyses. Accordingly, the NRC sponsored a two-phase study: phase 1 involved the examination of After Action Reports (AARs) from evaluated ingestion pathway exercises and a sample of state radiological emergency response plans; phase 2 involved interviews with state-level ORO decision-makers and staffs.

Both phases of this study focused on six topics identified in consultation with NRC staff:

1. Identification of radiological hot spots outside of initially evacuated areas;
2. Relaxation of evacuation and relocation orders;
3. Food condemnation or embargo;
4. Drinking water safety;
5. Evacuation beyond the 10-mile Emergency Planning Zone (EPZ); and
6. Best practices or alternative practices in the intermediate phase.

This report summarizes the results of both phases of the study.

1.2 Background

The response to a radiological incident can be divided into three phases: early, intermediate, and late. The Environmental Protection Agency (EPA) defines each phase as follows:

- Early Phase — The beginning of a radiological incident for which immediate decisions for effective use of protective actions are required and must therefore be based primarily on the status of the radiological incident and the prognosis for worsening conditions. When available, predictions of radiological conditions in the environment based on the condition of the source or actual environmental measurements may be used. Protective actions based on EPA's protective action guides (PAGs) may be preceded by precautionary actions during the period. This phase may last from hours to days.
- Intermediate Phase — The period beginning after the source and releases have been brought under control (has not necessarily stopped but is no longer growing) and reliable environmental measurements are available for use as a basis for decisions on protective actions, and extending until these additional protective actions are no longer needed. This phase may overlap the early phase and late phase and may last from weeks to months.
- Late Phase — The period beginning when recovery actions designed to reduce radiation levels in the environment to acceptable levels are commenced, and ending when all recovery actions have been completed. This phase may extend from months to years.[1]

The study topics were developed to improve the NRC's understanding and modeling of certain protective measures taken by OROs. While the focus of this study is on the intermediate phase, the phases of a radiological incident cannot be represented by precise periods of time and may

[1] Definitions from EPA, *PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents*, p. 5. See https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf (accessed February 20, 2017).

even overlap. The study topics are intended to ensure continuity in the modeling of activities from the end of the early phase and into and throughout the intermediate phase.

With respect to modeling, the MELCOR Accident Consequence Code System (MACCS) is the NRC's code to perform probabilistic offsite consequence assessments for hypothetical atmospheric releases of radionuclides from nuclear power plants (NPPs). MACCS models atmospheric transport and dispersion, emergency response and long-term protective actions, exposure pathways, and early and long-term health effects, as well as land contamination and economic costs. The NRC uses MACCS for a variety of applications including consequence studies, probabilistic risk assessments, cost-benefit assessments and risk-informing decision making.

Modeling protective actions in MACCS relies on an understanding of what OROs can and will do. The NRC commissioned this study to enhance its understanding of ORO practices in the intermediate phase. **Table 1-1** suggests the linkages between the study topics and aspects of MACCS modeling. In MACCS, the protective action associated with the intermediate phase of the model is continuation of relocation begun in the early phase; users may even treat the intermediate phase of the model as optional and set its duration to zero. Other protective actions that might begin in the intermediate phase in the real world—such as those to prevent eventual ingestion of contaminated food or water—are addressed in the late phase of the MACCS model.[2]

Many protective actions are meant to keep people, individually and collectively, from unnecessarily receiving a radiation dose that could lead to unwanted outcomes, whether acute effects or chronic effects like increased incidence of cancer above a certain threshold. Federal agencies have developed guidelines to help state and local decision-makers decide when to undertake certain protective actions in emergency situations. EPA has published a manual of PAGs for the principal protective actions available to public officials during a radiological incident. A PAG is the projected dose to an individual at which a specific protective action to reduce or avoid that dose is recommended. EPA published an updated revision to their manual in 2017.[3] Similarly, in 1998 the Food and Drug Administration (FDA) published derived intervention levels (DILs), or limits on the concentration of radioactivity in human food distributed in commerce, along with recommended protective actions for animal feed.[4] One interest of the study is whether ORO decision-makers intend to use these, or still more conservative criteria, in protective action decision-making for the intermediate phase.

[2] For additional information on MACCS see http://maccs.sandia.gov/ (accessed February 20, 2017).

[3] See EPA, *PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents*, EPA-400/R-17/001 (January 2017). Available at https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf (accessed February 20, 2017). This document superseded the 1992 edition, a 2013 interim use version, and a 2016 edition. The 2017 final version incorporated a new PAG for drinking water.

[4] See FDA, *Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies* (August 13, 1998). Available at: https://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM094513.pdf (accessed February 20, 2017).

Table 1-1 Potential Relevance of Study Questions to MACCS Modeling

Questionnaire Topics	Potential MACCS Relevance
Hot Spots Beyond Initially Evacuated Areas • Intent (plans vs. operations) • Resources • Exercises	*Early Phase Relocation Models in MACCS* • Resources may affect timing assumptions of hot spot relocations.
Relaxation of Evacuation and Relocation Orders • Purposes/Priorities for Reentry • Criteria for Reentry • Criteria for Relocation • Criteria for Return • Public Guidance • Verification of Relocations	*Intermediate Phase Relocation and Habitability Assessment in MACCS* • Criteria used would inform modeling (confirm criteria typically used by OROs and local authorities)
Food Condemnation or Embargo • Criteria • Extent/Boundary • Disposition (release criteria) • Disposition (reducing boundaries) • Disposition (disposal)	*Long-term Phase Agricultural Restrictions in MACCS* • Criteria, condemnation, embargo, and disposal results would inform modeling; maximum allowable food doses are user-specified
Water • Plans/Exercises/Incidents • Criteria	*Long-term Phase Societal Dose Assessment in MACCS* • MACCS models societal dose from atmospheric deposition onto surface water but does not model dose from releases directly to surface waters; Actions to monitor and restrict water intake may affect assumptions regarding societal dose
Evacuation Beyond the 10-Mile EPZ • Plans • Real-World Evacuation Experience	*Early Phase in MACCS* • Ability/intent/experience with larger evacuation *may* inform modeling of evacuation beyond the EPZ; timing (if discussed) is also relevant
Best Practices in the Intermediate Phase • Alternative Protective Actions • Radioactive Waste Management	*Not directly applicable to model*

1.3 Organization

Chapter 2 of this report describes the methodology of the study. Chapter 3 summarizes the interview results and trends and is organized by study topic, with subsections representing question sub-topics. The questions within each sub-topic are identified in text boxes along with their question numbers. The results are non-attributional and do not identify any specific individual or state in association with a particular response. Chapter 4 describes the results of the review of post-plume, ingestion pathway exercise AARs. Chapter 5 presents the results of the review of a sample of state radiological emergency response plans. Chapters 4 and 5 are organized by study topic, with each section describing the document review results and consistency between the

review results and the interview results. Chapter 6 presents aggregate findings from both the interviews and document review. Chapter 7 provides conclusions from the overall study.

See **Appendix A** for a read-ahead document provided to interviewees, **Appendix B** for the interview questionnaire used for interviewing the OROs, and **Appendix C** for the document review guide used to examine AARs and state radiological emergency response plans.

2 STUDY METHODOLOGY

2.1 Interview Methodology

Figure 2-1 displays the interview methodology used for this study. The sections below describe each step in more detail.

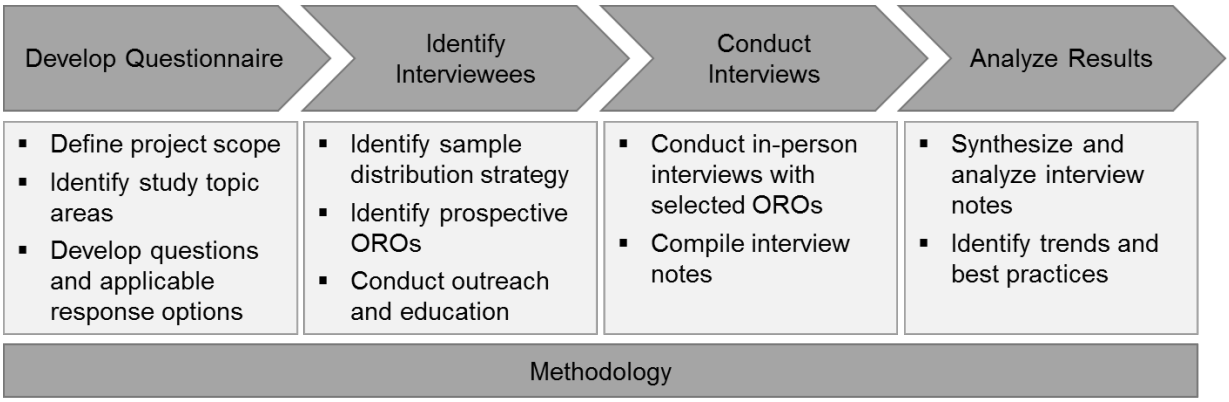

Figure 2-1 Interview Methodology

2.1.1 Developing the Questionnaire and Study Topics

The interview questionnaire was developed in consultation with NRC staff (see **Appendix B**). The questionnaire consists of 39 questions divided into the following six study topics:

1. Identification of radiological hot spots outside of initially evacuated areas;
2. Relaxation of evacuation and relocation orders;
3. Food condemnation or embargo;
4. Drinking water safety;
5. Evacuation beyond the 10-mile EPZ; and
6. Best or alternative practices in the intermediate phase.

2.1.2 Identifying the Interviewees

Per the Paperwork Reduction Act (44 USC 3501 et seq.), Federal agencies may not pose the same questions to 10 or more non-Federal respondents without approval from the Office of Management and Budget to collect this information. Without this approval, the study would be limited to nine interviews. The study team, in consultation with the NRC, determined that nine interviews with a selection of states from across the country, along with data gathered from a review of AARs and state plans, would provide a broad enough dataset to produce reasonable confidence in any conclusions drawn about ORO capabilities and practices in the intermediate phase.[5]

The study team worked with the NRC to identify nine states with NPPs for interviews. Through both direct solicitation and solicitation of volunteers at outreach opportunities, the NRC found states from each of the four NRC Regions displayed in **Figure 2-2** and eight of the nine Federal

[5] From all sources—interviews, plans, and AARs—the study ultimately gathered data from 34 unique states.

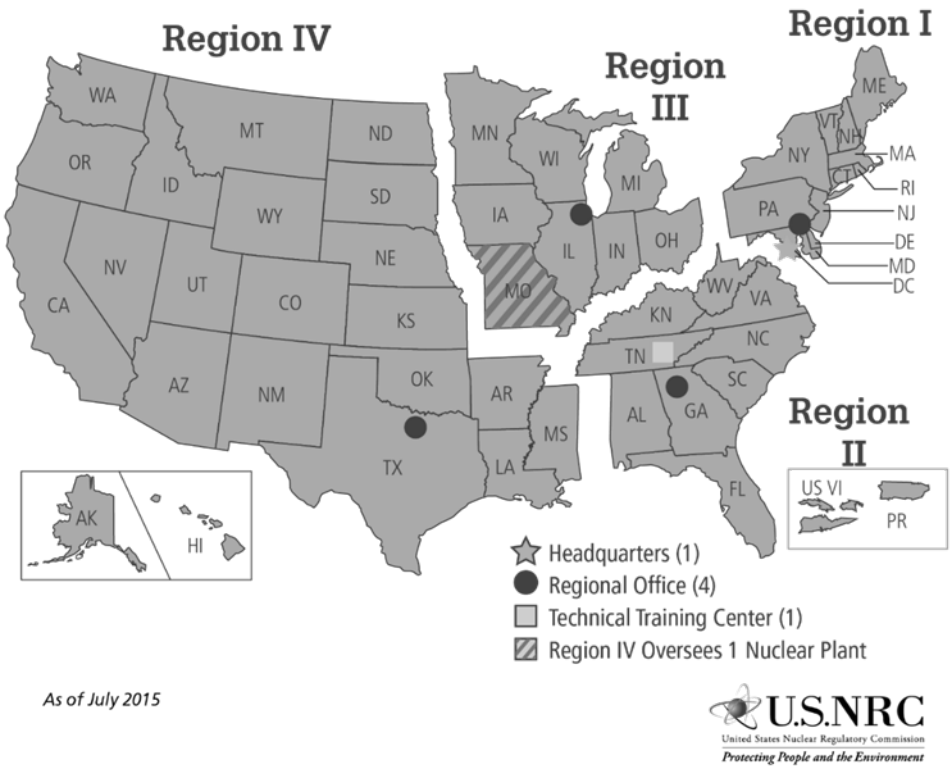

Figure 2-2 NRC Regions[6]

Figure 2-3 FEMA Regions[7]

[6] Map available online at: https://www.nrc.gov/reading-rm/doc-collections/maps/nrc-regions.html (accessed March 23, 2017).

[7] Map available online at: https://www.fema.gov/regional-contact-information (accessed March 23, 2017).

Emergency Management Agency (FEMA) Regions with NPPs displayed in **Figure 2-3** (there are no commercial NPPs in FEMA Region VIII). The interviews were conducted in a non-attribution format, and none of the nine participating states is identified by name in this report. **Table 2-1** shows aggregate characteristics of this non-random sample of the 30 states with NPPs.

Table 2-1 Aggregate Characteristics of Non-Random Sample of States with NPPs

Characteristics	States with NPPs	Interviewed States	Interviewed States as Percentage of States with NPPs
Number of States[a]	30	9	30.0%
Number of Operating Commercial NPP Sites[a]	60	19	31.7%
Number of Operating Commercial NPP Reactors[a]	100	33	33.0%
Population[b]	264,750,000	88,890,000	33.6%
Area (square miles)[b]	1,760,821	524,274	29.8%
Average Population Density (people per square mile)[b]	150	170	N/A

[a] Data obtained from NRC. See https://www.nrc.gov/reactors/operating/list-power-reactor-units.html (accessed March 23, 2017).
[b] Data obtained from the Census Bureau. See https://www.census.gov/geo/reference/guidestloc/select_data.html (accessed March 23, 2017).

2.1.3 Conducting the Interviews

The study team conducted in-person interviews with ORO representatives from each of the nine states. A facilitator and a note-taker represented the study team for each interview. Each state was encouraged to involve key agencies and individuals in the interview process. The study team provided the interview questionnaire and a read-ahead sheet to the representatives before each interview in order to provide background information on the study and to allow the representatives to prepare their responses in advance (see **Appendix A** for the read-ahead sheet and **Appendix B** for the interview questionnaire).

To encourage open discussion, the study team informed the interviewees that the interview results will be non-attributional and that the final report will not identify any specific individual or state in association with a particular response. For the purposes of this report, states are identified by letter from A to I. Additionally, the study team informed the interviewees that the study is for research purposes and not meant to drive new regulations, seek changes to offsite oversight, or evaluate any ORO. Each interview lasted approximately 90 minutes.

After each interview, the study team prepared a report detailing the interview results. The study team shared the results with the states for their review to ensure that the study team accurately captured their responses.

2.1.4 Analyzing the Interview Responses

The study team compiled the interview results in a matrix and analyzed the responses by identifying trends, commonalities, and unique responses using both qualitative and quantitative methods. The study team reviewed the text of the responses across the questions in each study

topic and counted similar answers in order to determine any trends and commonalities among the states. Interview data is summarized in quantitative form when possible.

2.2 After Action Report Review Methodology

Figure 2-4 displays the methodology used to review FEMA Radiological Emergency Preparedness (REP) Program AARs, which capture observations of an exercise, evaluate exercise outcomes against certain criteria, and make recommendations for post-exercise improvements.[8] The sections below describe each step in more detail.

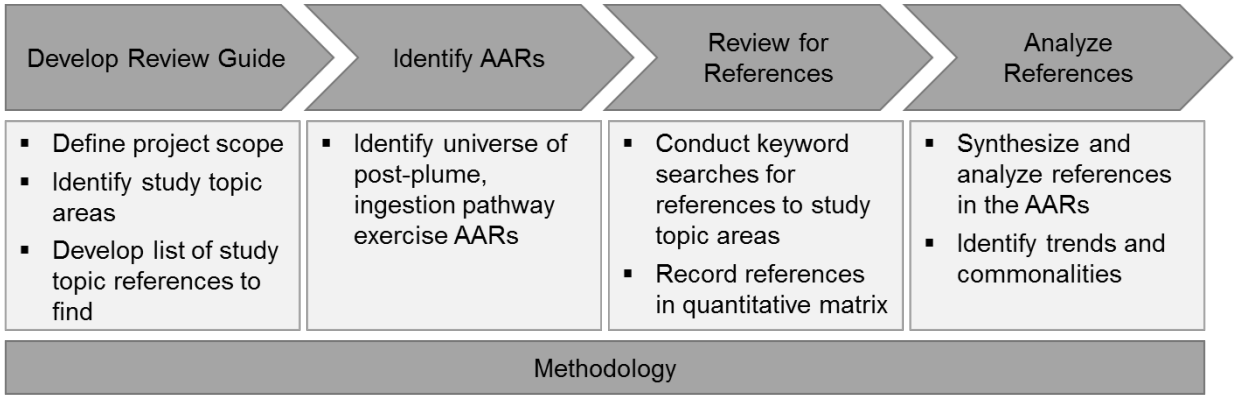

Figure 2-4 After Action Report Review Methodology

2.2.1 Developing the Document Review Guide and Study Topics

The six study topics selected for the interview process were also used for the review of the AARs. The topics were streamlined into a review guide that lists specific references, such as the criteria for decision-making, to find in the reports (see **Appendix C** for the document review guide).

2.2.2 Identifying the AARs

The study team screened all FEMA REP Program exercise AARs listed at the NRC website, "FEMA After Action Reports and Communication Related to Specific Emergency Exercises."[9] The website had available 641 documents from 411 dates regarding 64 sites in 31 states from the years 1985 to 2016. From these, the study team identified 50 AARs from post-plume, ingestion pathway exercises and related drills involving 25 states.

The study team acknowledges expecting to find additional relevant AARs, given the requirement through December 2011 for an evaluated ingestion pathway exercise to take place every six years (and then every eight years following revisions to regulations at 10 CFR 50.47). However, the sample of 50 AARs was large enough to suggest conclusions that could be drawn from the full universe of evaluated post-plume, ingestion pathway exercises and related drills.

[8] Per FEMA's Emergency Management Institute. See https://training.fema.gov/programs/emischool/el361toolkit/glossary.htm (accessed February 20, 2017).

[9] See http://www.nrc.gov/about-nrc/emerg-preparedness/related-information/fema-after-action-reports.html (accessed February 20, 2017).

2.2.3 Reviewing the AARs for Relevant References

Having identified 50 post-plume, ingestion pathway exercise AARs from 1993 to 2013, the study team used the review guide to screen all AARs for information relevant to the six study topics. References were recorded in a matrix to determine the number of references to each study topic. Of the 50 AARs, 35 from NPP sites in 21 states contained relevant information. Across those 35 AARs, 25 states (including the District of Columbia) participated in the exercises and provided references to the study topics. The 35 AARs with relevant information are:

- FEMA Region I
  - Millstone (Connecticut, 2004[10] and 2010)
- FEMA Region II
  - Indian Point (New York, 1999)
  - James A. FitzPatrick (New York, 2011)
  - Oyster Creek (New Jersey, 2003)
  - R.E. Ginna (New York, 2005)
  - Salem/Hope Creek (New Jersey, 2010)[11]
- FEMA Region III
  - Beaver Valley (Pennsylvania, 2004 and 2010)
  - Calvert Cliffs (Maryland, 2003[12] and 2009[13])
  - Limerick (Pennsylvania, 2011)
  - North Anna (Virginia, 2008)
  - Susquehanna (Pennsylvania, 2004)
- FEMA Region IV
  - Brunswick (North Carolina, 2002)
  - Browns Ferry (Alabama, 2011)
  - Edwin I. Hatch (Georgia, 2010)
  - Grand Gulf (Mississippi, 2011)
- FEMA Region V
  - Watts Bar (Tennessee, 1993 and 2003)
  - Monticello (Minnesota, 2003)
  - Palisades (Michigan, 2012)
  - Perry (Ohio, 2012)
  - Point Beach (Wisconsin, 2009)
- FEMA Region VI
  - Arkansas Nuclear One (Arkansas, 2008)
  - Comanche Peak (Texas, 1999)
  - River Bend (Louisiana, 2010)
  - South Texas (Texas, 2004)
- FEMA Region VII
  - Wolf Creek (Kansas, 2001)
- FEMA Region IX
  - Palo Verde (Arizona, 1999 and 2011)

[10] Contains references from both Connecticut and Rhode Island.

[11] Delaware was the only state to participate in this exercise.

[12] Contains references from Maryland, Delaware, and the District of Columbia.

[13] Contains references from Maryland and the District of Columbia.

- FEMA Region X
    - Columbia (Washington, 1999[14], 2000[15], 2001[16], and 2002)

Table 2-2 shows the number of states with references to the study topics in the AARs. The study team found most relevant references in the "Exercise Evaluation and Results" or "Analysis of Capabilities" sections of the AARs. The "Analysis of Capabilities" sections began appearing in FEMA REP AARs following the REP Program's integration of Homeland Security Exercise and Evaluation Program (HSEEP) doctrine in late 2011. Prior to this, FEMA REP exercise AARs contained "Exercise Evaluation and Results" sections featuring checklists indicating whether REP exercise evaluation criteria were met. Narrative descriptions in those sections were reserved only for deficiencies (now referred to as "Level 1 Findings"), areas requiring corrective action (now referred to as "Level 2 Findings"), or plan issues.

Table 2-2 Number of States with References to Study Topics in the AARs

Study Topic	Number of States
Food condemnation and embargoes	22
Water	22
Relaxation of evacuation and relocation orders	12
Hot spots beyond initially evacuated areas	6
Evacuation beyond the 10-mile EPZ	-
Best practices in the intermediate phase	-

Any absence of a reference to a study topic in the AARs does not indicate any lack of detail or deficiency of a particular emergency plan.

2.2.4 Analyzing References

In analyzing the AARs, the study team identified trends and commonalities across the reports. For example, multiple AARs stated that FDA DILs would be used as criteria for determining the safety of contaminated or potentially contaminated food products. However, there was an inadequate quantitative basis to give a numerical probability for modeling purposes that states would rely on FDA DILs. The study team therefore was also attentive to any limiting cases that might invalidate a hypothetical assumption (for example, a case in which a state said it would not rely on FDA DILs would invalidate the assumption that FDA DILs will always be used). Most of the AAR analysis is qualitative due to the nature and limited amount of relevant information contained in the documents reviewed.

2.3 State Radiological Emergency Response Plans Review Methodology

Figure 2-5 displays the methodology used to review the state radiological emergency response plans. The analysis methodology is similar to that used for reviewing AARs. The sections below specifically describe how the study team identified the plans and reviewed them for references to the study topics.

[14] This AAR is for Oregon's ingestion drill.

[15] Contains references from both Washington and Oregon.

[16] This AAR is for Washington's food control area drill.

2.3.1 Identifying the Plans

From among publicly available state radiological emergency response plans, the study team selected at least one from each FEMA Region with an NPP to serve as a sample documenting state ORO practices and capabilities. The study team also included plans for two states without NPPs (Oregon and West Virginia) that partially fall within the 50-mile ingestion pathway planning zone for other states' NPPs. For two states (Arizona and Ohio) the study team examined two plan documents. The 23 plans selected were relatively recent, having been issued between 2012 and 2016.

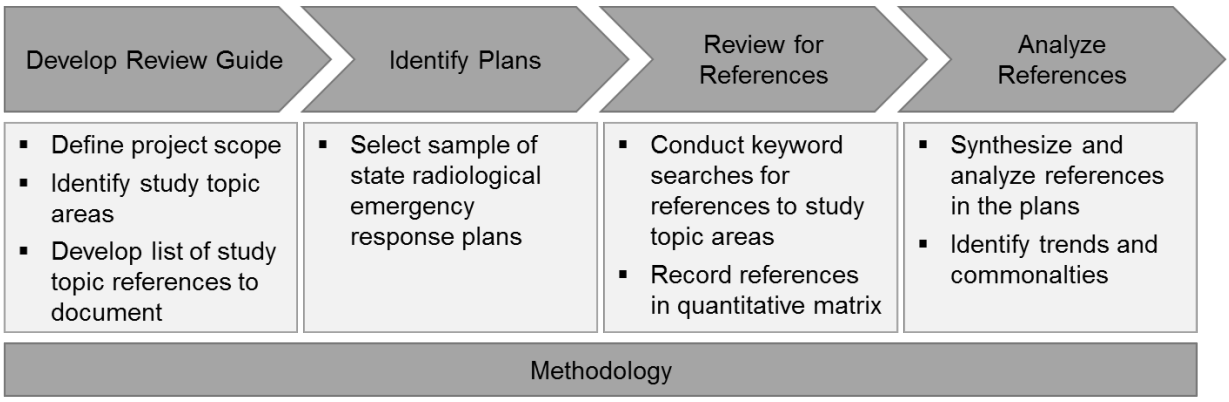

Figure 2-5 Plan Review Methodology

2.3.2 Reviewing the Plans for Relevant References

The review process involved analyzing the state radiological emergency response plans, searching specifically for areas addressing the six study topics. All 23 state radiological emergency response plans from 21 states were deemed to contain relevant information (Ohio and Arizona each had two plans with relevant information). The 23 plans are:

- FEMA Region I
  - Vermont Radiological Emergency Response Plan (Vermont, 2012)[17]
  - State of New Hampshire State Emergency Operations Plan: Radiological Emergency Response for Nuclear Facilities, Incident Annex (New Hampshire, 2016)
  - Commonwealth of Massachusetts Radiological Emergency Response Plan (Massachusetts, 2015)
- FEMA Region II
  - New York State Comprehensive Emergency Management Plan: Radiological Hazards Annex For Fixed Nuclear Facilities (New York, 2012)

[17] This study reviewed the 2012 plan. In 2016, after the study was underway, Vermont revised its plan to reflect the changed status of Vermont Yankee. Vermont Yankee ceased operations in December 2014 and has spent fuel in a spent fuel pool. Vermont's plan states that "[u]ntil all of the spent fuel at Vermont Yankee is removed, the state will plan to respond as necessary during an incident at that facility" (p. 1). Much information from the previous plan is retained, but the highest emergency action level is ALERT. Vermont's current plan is available online at http://demhs.vermont.gov/sites/demhs/files/pdfs/plans/state/Incident%20Annex%209a_Radiological%20Emergency%20Response%20Plan_2016_08.pdf (accessed February 20, 2017).

- FEMA Region III
  - Commonwealth of Virginia Emergency Operations Plan Hazard-Specific Annex #1 Radiological Emergency Response (Virginia, 2012)
  - West Virginia Radiological Emergency Preparedness Plan (West Virginia, 2014)
- FEMA Region IV
  - State of Alabama Emergency Operations Plan: Incident Annex E – Nuclear/Radiological Response Incident (Alabama, 2012)
  - The State of Florida Radiological Emergency Preparedness Plan (Florida, 2014)
  - North Carolina Emergency Operations Plan (NCEOP) Annex B - Appendix 8 Radiological Emergency Response Plan For Nuclear Power Facilities (NC REP) (North Carolina, 2008)
  - South Carolina Operational Radiological Emergency Response Plan (South Carolina, 2014)
- FEMA Region V
  - Michigan Emergency Management Plan: Disaster-Specific Procedures, Nuclear Power Plant Incidents (Michigan, 2014)
  - State of Minnesota Emergency Operations Plan (Minnesota, 2015)
  - Ohio Emergency Operations Plan: Emergency Support Function #10 Hazardous Materials and Weapons of Mass Destruction - Tab B Radiological Emergency Preparedness (REP) Incident Response Plan (Ohio, 2015)
  - The Ohio Radiological Emergency Preparedness (REP) Operations Manual (Ohio, 2015)
  - Wisconsin Emergency Response Plan: Radiological Incident Annex (Wisconsin, 2015)
- FEMA Region VI
  - Arkansas Comprehensive Emergency Management Plan (ARCEMP) 2015: Annex N Radiological Protection System and Annex V Radiological Response System (Arkansas, 2015)
  - Louisiana Peacetime Radiological Response Plan (Louisiana, 2013)
  - State of Texas Emergency Management Plan: Annex D - Radiological Emergency Management (Texas, 2013)
- FEMA Region VII
  - Kansas Response Plan 2014: Nuclear/Radiological Incident Annex (Kansas, 2014)
- FEMA Region IX
  - Arizona Department of Health Services Radiological Emergency Response Plan (Arizona, 2012)
  - State of Arizona Emergency Response and Recovery Plan: Nuclear/Radiological Incident Annex (Arizona, 2016)
- FEMA Region X
  - Washington State Fixed Nuclear Facility Protection Plan (Washington, 2014)
  - State of Oregon Emergency Operations Plan: IA 9- Nuclear/ Radiological (Oregon, 2014)

Table 2-3 shows the number of states with references to the study topics in their plans. Any absence of a reference to a study topic in the state plans does not indicate any lack of detail or deficiency of a particular emergency plan. Additionally, the publicly available state plans may not contain all radiological emergency response plans and procedures for a state. Other plans or procedures that are not publicly available may contain additional references to the study topics.

Table 2-3 Number of States with References to the Study Topics in the Plans

Study Topic	Number of States
Food condemnation and embargoes	21
Water	20
Relaxation of evacuation and relocation orders	16
Hot spots beyond initially evacuated areas	3
Evacuation beyond the 10-mile EPZ	-
Best practices in the intermediate phase	-

3 INTERVIEW RESULTS

3.1 Hot Spots Beyond Initially Evacuated Areas

3.1.1 Intent

B1. *Do your state's/jurisdiction's plans address conducting radiological surveys outside of initially evacuated areas in order to identify hot spots and determine if others should evacuate?*

B2. *Regardless of your plans, would your state/jurisdiction seek to identify hot spots requiring additional evacuations?*

Eight out of the nine states interviewed indicated that their plans do address conducting radiological surveys outside of initially evacuated areas in order to identify hot spots.[18] Additionally, all states indicated that, regardless of their plans, they would seek to identify hot spots requiring additional evacuations (or post-evacuation relocations). Five states elaborated on the actions they would take to identify hot spots. Actions included conducting aerial surveys to identify areas of contamination and sending out field monitoring and sampling teams with mobile detection capabilities to seek out hot spots. These states also noted that they would conduct aerial surveys using either their own in-state resources, resources from the Federal Government, or resources obtained through mutual aid. One state expressed concern about "manpower issues" and explained that it would need to rely on the Federal Government and mutual aid from nearby states to help identify hot spots.

3.1.2 Responsibility and Federal Assistance

B3. *What state agency is responsible for identifying and measuring radiological contamination? (Note all that apply and identify responsible sub-organization, if applicable, e.g., Bureau of Radiation Protection.)*

B4. *Would the state rely primarily on Federal assets to perform hot spot survey functions? Note that this may involve a wait of 24-36 hours.*

The agencies responsible for identifying and measuring radiological contamination vary across the states. In four states, the Department of Health[19] is responsible for identifying and measuring radiological contamination. In two states, the Department of Health provides assistance to another agency. The Department of Environmental Protection is responsible in two states and provides assistance in one state. Five states involve other agencies in the process of identifying and measuring radiological contamination, either as a responsible or assisting agency. **Table 3-1** on the next page displays the agencies involved in identifying and measuring radiological contamination across the states.

[18] NRC defines a hot spot as a region in a radiation/contamination area where the level of radiation/contamination is significantly greater than in neighboring regions in the area.

[19] Naming conventions for state departments and agencies vary; the titles of departments and agencies in this report have been generalized in order to eliminate any attribution of results and findings.

Table 3-1 Agencies Involved in Identifying and Measuring Radiological Contamination

Types of Agencies	State A	State B	State C	State D	State E	State F	State G	State H	State I
Health	X	X	X			X		X	X
Environmental Protection			X		X		X		
Other(s)	X			X	X		X	X	

As summarized in **Table 3-2**, seven states indicated that they would not rely primarily on Federal resources to perform hot spot survey functions. The states indicated they would start the surveying process using their own resources and then augment those resources through mutual aid and/or Federal assistance. Only two states said they would rely primarily on Federal resources, emphasizing that they may need aerial assets from the Federal Government. At the Federal level, states would ask for resources from the Department of Energy (DOE), the Federal Radiological Monitoring and Assessment Center (FRMAC), and/or the Radiological Assistance Program (RAP). Three states indicated that they would utilize mutual aid through the Emergency Management Assistance Compact (EMAC) or other regional mutual aid agreements. Additionally, three states noted that their National Guard Civil Support Teams (CSTs) could provide assistance in surveying for hot spots.

Table 3-2 Primary Source of Resources for Hot Spot Surveys

Source	Number of States
Federal	2
State and/or Mutual Aid	7

3.1.3 Exercises

B5. *Have your jurisdictions exercised requirements for additional evacuations due to hot spots?*

Eight of the nine states indicated that they had exercised requirements for additional evacuations due to hot spots through discussion-based or decision-making exercises. Two states said they discussed additional evacuations specifically during ingestion pathway exercises. States C and H both noted that, during their latest ingestion pathway exercises, they discussed evacuations and locations of hot spots. Additionally, State C mentioned that it used a similar thought process when handling a real-world hazmat incident involving a non-radiological plume moving toward the state. State I had not exercised requirements for additional evacuations due to hot spots but stated that the closest scenario it had exercised involved a “sudden inject which changes a wind direction” that would “extend the plume to areas outside the typical EPZ.”

3.2 Relaxation of Evacuation and Relocation Orders

3.2.1 Priorities

C1. *For what purposes would the state (or local authorities) allow temporary reentry?*

C2. *Which of these purposes has the highest priority?*

The purposes for allowing temporary reentry varied across the states, with many states elaborating beyond the options provided in the questionnaire (see **Appendix B**). **Table 3-3** lists several of the purposes (not listed by priority) mentioned by the states. The most common purpose mentioned was tending to agriculture, livestock, and/or pets. A majority of the states also mentioned providing essential services and maintaining utilities or equipment as purposes for temporary reentry. Other purposes identified by the states were incident stabilization, access to a military base, retrieval of possessions and business records, select institutional functions, recovery activities, and life safety.

Table 3-3 Purposes for Temporary Reentry

Purpose	Number of States
Tending to agriculture, livestock, and/or pets	8
Providing essential services	5
Maintaining utilities or equipment	5
Other	5
Maintaining critical infrastructure	4
Controlling industrial functions	4
Life safety	3

In general, the states emphasized life safety and maintenance of critical infrastructure, equipment, and utilities as high priority purposes for temporary reentry. Only State E responded with an ordered list of priorities, listing life safety as the first priority, followed by maintaining critical infrastructure and tending to pets and farm animals. Additionally, State A indicated that their priorities would be situation-dependent, and State B said that "the governor has the ultimate authority to make reentry decisions" under the advisement of the state's Department of Health.

3.2.2 Criteria

C3. *What are the criteria for temporary reentry?*

C4. *What are the criteria for relocation after initial evacuation?*

C5. *For areas initially evacuated but found to be contaminated at levels below the Environmental Protection Agency's (EPA's) relocation Protective Action Guides (PAG), what are the criteria for the public to permanently return?*

For temporary reentry, five states indicated that they would rely on the EPA PAGs. Two states noted that the criteria for temporary reentry would be situation-dependent, with State G also noting the criteria would "depend on the function and purpose of reentry." State A said that it

would use “exposure limits” as its criteria for temporary reentry. State B said that its radiological emergency response plan defines its criteria.

When discussing the criteria for relocation after an initial evacuation, all states said they would rely on the EPA PAGs. State G further indicated that it would “develop a buffer zone based on a fraction of the EPA PAG for conservatism until ground deposition is characterized” and that the relocation area would be “revised as environmental data is collected.”

For areas initially evacuated but found to be contaminated at levels below the EPA relocation PAG, seven of the nine states said that they would use the EPA PAGs as their criteria for the public to permanently return. In contrast, State F said that it had “not developed or identified criteria for return” and thus “the issue would be considered on a case-by-case basis.” Additionally, State E indicated that it would “allow evacuated persons to return immediately if exposure rates are not more than twice the normal background levels.” **Table 3-4** details the responses about the criteria the states would use for temporary reentry, relocation after initial evacuation, and permanent return.

Table 3-4 Number of States Using Criteria for Reentry, Relocation, and Return

Criteria	Temporary Reentry	Relocation	Permanent Return
EPA PAGs	5	9	7
Determined on case-by-case basis	2	0	1
Other	2	0	1

3.2.3 Public Information

C6. *Has the state developed guidance to the public for relocation, reentry, and/or return?*

Six states indicated that guidance to the public for relocation, reentry, and/or return would be situation-dependent and developed at the time of need. In particular, four states mentioned that they had developed some generic guidelines or pre-scripted messages. For example, State H said that “local procedures include site-specific plans and pre-scripted messages with checklists and guidance to tell the public what to do in certain events.” Two states also indicated that they would use the Joint Information Center (JIC)[20] as part of their procedures for providing information to the public. For example, State C said, “information efforts would be coordinated through the JIC, making sure not to duplicate systems.” Additionally, State H said that the “Public Information Officer (PIO) would work with the JIC and county PIOs to make sure that information gets to the public.”

[20] The JIC is a facility established to coordinate all incident-related public information activities. It is the central point of contact for all news media. See the National Incident Management System (NIMS) for more details: https://www.fema.gov/pdf/emergency/nims/NIMS_core.pdf (accessed February 20, 2017).

3.2.4 Verification

C7. *Does the state verify that relocations are completed?*

All nine states indicated that they would verify relocations, with five states noting that this would specifically be a local responsibility. For example, State H said that "counties would implement and verify relocations" and "liaisons in the county and in Unified Command"[21] would help with the verification process. Additionally, State G noted that "once relocations are complete, there would be checks to make sure no one returns and access control points would be set up." Five states mentioned that law enforcement would participate in verifying relocations. Two states also recognized the difficulties surrounding verification, pointing out that complete verification would be a challenge and that there would be no assurance that every member of the public has relocated.

3.3 Food Condemnation or Embargo

3.3.1 Criteria

D1. *What criteria would be used to determine the safety of contaminated or potentially contaminated food products (crops, livestock, milk, etc.)?*

D2*. If criteria other than the Food and Drug Administration's (FDA's) would be used, they are:*

All states indicated that they would use the FDA's derived intervention levels (DILs) to determine the safety of food products. State I specified that it did not have the "capability or reason to push the limit lower." State C also noted that it would "track everything at one tenth of the DILs." Additionally, States G and E discussed potentially using other criteria. State G indicated that, if the state used criteria other than the DILs, the state would "take local expertise and economic consequences into consideration" and the state's Department of Agriculture would "make adjustments as it sees fit." State E noted that it would maintain the option of using more conservative criteria on a case-by-case basis.

3.3.2 Extent

D3. *How would the boundaries of a food control area be set?*

D4. *If more widely, why?*

The states' responses varied when describing how they would set the boundaries of food control areas. Five states mentioned that they would use sampling to determine or refine boundaries. For example, State C would determine its food control area boundaries "by following the DILs and the sampling results." State H provided a detailed process for determining its food control area, explaining that it would do so "by performing a dose assessment using worst-case meteorology appropriate for the release, filtration, and source term, [and] using the outermost boundary of the projected deposition plume as the food control area boundary." After analyzing samples, State H's

[21] Unified Command (UC) is an Incident Command System application used when more than one agency has incident jurisdiction or when incidents cross political jurisdictions. Agencies work together through the designated members of the UC, often the senior persons from agencies and/or disciplines participating in the UC, to establish a common set of objectives and strategies and a single Incident Action Plan. See the NIMS for more details: https://www.fema.gov/pdf/emergency/nims/NIMS_core.pdf (accessed February 20, 2017).

food control area "would be refined by calculating the DILs." Additionally, six states mentioned that they would use clearly defined or recognizable boundary lines, such as roads, political boundaries, and/or natural landmarks, to mark the perimeter of a food control area.

Five states also mentioned that they would establish large food control areas or add buffer zones to their food control areas. For example, State I said it would apply a "buffer distance" for "comfort" and to "rebuild confidence." Additionally, State F said that "boundaries would be set more widely than the criteria would indicate." Two states noted that it would be easier to relax a widely-set food control area than to expand one. Seven states indicated that they would set wide boundaries in order to include all potentially contaminated areas.

3.3.3 Responsibility and Federal Assistance

D5. *What agency or organization is responsible for determining the boundaries of a food control area? Identify all that apply, and explain their roles in the determination.*

D6. *Will the responsible agency or organization defer to a Federal recommendation? If so, from which organization?*

All nine states indicated that they would involve multiple state-level agencies in determining the boundaries of food control areas. Some of the types of state-level agencies that would be involved include Departments of Agriculture, Emergency Management, Health, and Environmental Protection. **Table 3-5** details how many states would involve these state-level agencies in determining food control areas. Three states also mentioned that counties would be involved in determining the boundaries of food control areas. State G said that the Department of Environmental Protection "would initially set large food control areas based on deposition estimates from the National Atmospheric Release Advisory Center's predictive plume plot products for food interdiction." Meanwhile, State A said that it would make a recommendation to the jurisdictional authority about the boundaries of a food control area. Five states emphasized that determining the boundaries would involve collaboration and coordination with relevant agencies and/or local governments.

Table 3-5 State-Level Agencies Involved in Determining Food Control Areas

State-Level Agencies	Number of States
Agriculture	7
Health	5
Environmental Protection	4
Emergency Management	3
Other(s)	2

All states said that they would consult with the Federal Government to determine the boundaries of a food control area, but no states indicated they would defer to a Federal recommendation. For example, State G noted that it would "value the input" of the Federal Government's Advisory

Team[22] (A-Team) but that it "would not defer to their recommendation." Additionally, State E said that, "determining the food control area would be a collaborative, interagency effort that would involve coordination with all groups at all levels of government." Five states specifically mentioned that they would consult with the A-Team in determining food control areas.

3.3.4 Release

D7. *Will food crops and livestock be released from the food control area?*

D8. *If yes, what determines the areas and the crops or livestock within them that may be safely introduced into commerce? Note all that apply. Discuss any limitations.*

D9*. What is the process for reducing or eliminating the food control area?*

D10. *Is that process documented in a plan or procedure?*

Only one state was explicitly against releasing food crops and livestock from a food control area. State E said that they would destroy food crops and livestock in order to "restore public confidence." State E also noted that destroying the food would "cut down on the measurements that need to be taken" and help the public distinguish between clean and contaminated food sources. Meanwhile, State F indicated that "food crops and livestock would be released if shown not to be contaminated at any detectable level." Other states responded similarly, indicating they might release crops and livestock from the food control area depending on their contamination levels. Two states specifically mentioned that the concentration of contamination in crops and livestock in the food control area would have to be below the DILs before they would make recommendations for release.

Seven of the eight states that might release food crops and livestock from a food control area stated that they would rely on scientific procedures to release food from the area, using sampling and/or monitoring to determine whether crops and livestock within an area could be introduced into commerce. For example, State G said it "would use science [i.e., evidence from monitoring, sampling, and/or testing] to make decisions about what would be released from the food control area" and that it "would collect samples, send them to labs, and use the results to determine what is contaminated and not contaminated and what is safe and not safe." **Table 3-6** (next page) summarizes the monitoring, sampling, and laboratory resources that would be used by the respondents.

Additionally, each state described its process for reducing or eliminating the food control area, with seven states indicating that they would use monitoring, sampling, and testing to help reduce or eliminate a food control area. Other states mentioned that they would look at market considerations. State G said that the process for reducing a food control area would come "down to economics and cost" but also suggested that time would help to reduce the control area and that the state could look into other actions that "could help limit the uptake of contamination."

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[22] The Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans describes the Advisory Team as follows: "The Advisory Team (A-Team) for Environment, Food, and Health includes representatives from the EPA, USDA, HHS (FDA), the CDC, and other Federal agencies as needed. The A-Team, supported by the Federal Radiological Preparedness Coordinating Committee, develops coordinated advice and recommendations on environmental, food, health, and animal health matters for the Incident Command/Unified Command, the Joint Field Office, the UCG [Unified Coordination Group], the Federal agency with primary authority, and/or state and local governments, as appropriate" (p. 41). See https://www.fema.gov/media-library-data/1478636264406-cd6307630737c2e3b8f4e0352476c1e0/NRIA_FINAL_110216.pdf (accessed February 20, 2017).

When asked about plans or procedures, eight states indicated the process for reducing or eliminating a food control area is documented in a plan or procedure.

Table 3-6 Resources Used in Reducing Food Control Areas

Resource[+]	Number of States
RADIOLOGICAL MONITORING	
State monitoring teams	4
Federal monitoring teams	4
Mutual aid monitoring teams (e.g., via EMAC)	3
Contract monitoring teams	2
SAMPLING	
State agriculture/radiation protection teams	3
Federal agriculture/radiation protection teams	3
Mutual aid sampling teams	2
Contract sampling teams	2
LABORATORY TESTING	
State laboratory resources	3
Federal laboratory resources	3
Contract laboratory resources	3
Mutual aid laboratory resources	2

[+]Only four states answered question D8 using the resources provided in the questionnaire, which are reflected in this table.

3.3.5 Public Information

D11. *How will the safety of released crops, livestock, and farmland be communicated to the media and the public?*

Eight of the nine states indicated they would use a Joint Information System (JIS)[23] to communicate the safety of crops, livestock, and farmland to the media and the public. Four states noted that local governments would be involved in the communication process. Two states indicated that they would involve their Departments of Agriculture in coordinating the information communicated to the public, and two states mentioned that their local agricultural extension services would also participate in the communication process.

3.3.6 Waste

D12. *What will be done with affected livestock and their by-products?*

Most states did not detail specific actions they would take to deal with affected livestock and their by-products. However, State C had a clear action in mind, saying that affected livestock and their

[23] The JIS is a structure that integrates incident information and public affairs into a cohesive organization designed to provide consistent, coordinated, accurate, accessible, timely, and complete information during crisis or incident operations. See the NIMS for more details: https://www.fema.gov/pdf/emergency/nims/NIMS_core.pdf (accessed February 20, 2017).

by-products would be “dispatched and burned.” State G indicated that it would “set up some temporary waste sites” but would need to address the long-term storage of low-level waste. Two states indicated that their actions would be situation-dependent, and two other states mentioned that they would seek advice from the A-Team about how to deal with affected livestock. Additionally, two states mentioned that they would consult with their own Departments of Agriculture and Departments of Environment to determine what to do. One state did not provide a response to the question.

3.4 Water

3.4.1 Applicability and Plans

E1. *Is potential radioactive contamination of drinking water a concern for your jurisdiction?*

E2. *Is potential drinking water contamination addressed in your radiological emergency preparedness (REP) plan?*

Eight states indicated that they would be concerned about radioactive contamination of drinking water. State B indicated that contamination of drinking water would not be a large concern “because there are only two municipalities that take water from the river” and there are procedures in place to notify the relevant counties about contamination. All nine states indicated that their REP plans address potential drinking water contamination.

3.4.2 Exercises or Real-World Experience

E3. *How have you dealt with drinking water contamination in exercises or real-world (non-radiological) incidents?*

Six states said that they had dealt with drinking water contamination in exercises. Two specifically noted that they addressed the issue during ingestion pathway exercises. State E indicated that “lab testing exercises occur frequently.”

Seven states described their real-world experiences with contaminated drinking water. One state, State E, indicated that it had gained real-world experience addressing concerns about radiological contamination when several of its agencies met regarding Fukushima’s iodine plume. Additionally, State E indicated that it had issues with radium in its water supplies and as a result “municipal water treatment plants needed to install technology to reduce radium levels.” Seven states mentioned that they dealt with non-radiological drinking water contamination in real-world situations. For example, during a recent hurricane, State G provided bottled water to the public while water treatment plants were down. State C indicated that non-radiological incidents occur frequently, including water main breaks that result in boil water advisories. In dealing with drinking water issues, State C “monitors systems, sends people out to the scene, and drafts after action reports.”

3.4.3 Criteria

E4. *After a radiological incident, what criteria would your jurisdiction use to determine that water is safe to drink?*

When asked about the criteria they would use to determine drinking water safety, five states specifically noted that they would use EPA's Safe Drinking Water Act standards. Three states noted they would use EPA PAGs or guidance.[24] One state indicated that it would follow the procedures established in its radiological emergency response plan. These results are summarized in **Table 3-7**.

Table 3-7 Criteria for Drinking Water Safety

Criteria	Number of States
Safe Drinking Water Act standards	5
EPA PAGs or guidance	3
Other	1

3.5 Evacuation Beyond the 10-Mile EPZ

3.5.1 Awareness

F1. *Do you agree that it could be necessary to evacuate the public from areas beyond the 10-mile EPZ?*

In the statement of considerations for the final emergency preparedness rule published in the Federal Register (45 FR 55406) on Tuesday, August 19, 1980, the NRC explained that response bases for the EPZs are intended to facilitate the development of capabilities sufficient to respond outside the EPZ should such a response be needed:

> The Commission notes that the regulatory basis for adoption of the Emergency Planning Zone (EPZ) concept is the Commission's decision to have a conservative emergency planning policy in addition to the conservatism inherent in the defense-in-depth philosophy. This policy was endorsed by the Commission in a policy statement published on October 23, 1979 (44 FR 61123). At that time the Commission stated that two EPZs should be established around each light-water nuclear power plant. The EPZ for airborne exposure has a radius of about 10 miles; the EPZ for contaminated food and water has a radius of about 50 miles. Predetermined protective action plans are needed for the EPZs. The exact size and shape of each EPZ will be decided by emergency planning officials after they consider the specific conditions at each site. These distances are considered

[24] When the study team conducted the interviews, EPA's latest PAG Manual was the 2013 interim use draft. This draft proposed using standards developed under the Safe Drinking Water Act: the National Primary Drinking Water Regulations for Radionuclides (NPDWR). Since the interviews were conducted, EPA released a final version of the PAG Manual in January 2017, which includes a two-tier drinking water PAG for the intermediate phase: 500 mrem projected dose for the general population and 100 mrem projected dose for pregnant women, nursing women, and children age 15 and under. This PAG may not be applied for longer than one year. EPA expects that actions will be taken to return any impacted drinking water system to compliance with the NPDWR levels by the earliest feasible time.

large enough to provide a response base that would support activity outside the planning zone should this ever be needed.[25]

Table 3-8 summarizes the states' views on evacuation beyond the 10-mile EPZ. Eight states said that it could be necessary to evacuate the public from areas beyond the 10-mile EPZ. For example, State H said that it "is highly unlikely that it would be necessary to evacuate beyond the 10-mile EPZ, but it could happen." State C indicated that such evacuations have become "more of a concern since Fukushima." State E noted that it has held exercises "which have simulated a release beyond the 10-mile EPZ," and that its "procedures are flexible to address different situations." State B, the only state that did not agree, said "NRC states that a 10-mile EPZ is adequate, and that is the state's planning base."

Table 3-8 Evacuation Beyond the 10-mile EPZ

Evacuation Beyond the 10-mile EPZ	Number of States
Potentially necessary	8

3.5.2 Plans

F2. *If it were necessary to evacuate the public from areas beyond the 10-mile EPZ, what actions would be required?*

F3. *Do plans exist that may address some of these evacuation challenges?*

F4. *If plans do exist, do they include information on the availability of necessary personnel and equipment to implement the required actions?*

The states described various actions that would be necessary to evacuate the public beyond the 10-mile EPZ. Six states emphasized that communicating to the public would be necessary for evacuations. For example, States A and D would use the Emergency Alert System (EAS) and reverse dialing system but would not use sirens. State F would use route-alerting, sirens, EAS, and National Oceanic and Atmospheric Administration (NOAA) weather radios during the evacuation process but noted that it would be "difficult to get messaging to residents outside of the 10-mile EPZ." State B would also use NOAA weather radios in addition to the media and the Integrated Public Alert and Warning System to communicate evacuation information to the public. State I would communicate the information to the impacted area, define evacuation boundaries, and make recommendations to the public about evacuations and let the public know the risks of not evacuating. Meanwhile, State C noted that its evacuation actions would involve the set-up of "necessary communications."

Additionally, the states identified other actions for managing evacuation of the public beyond the 10-mile EPZ:

- NPPs would provide protective action recommendations (PARs) for the states to act upon; States E and F verified this as an expected action.
- State C said that it would set up shelters and long-term housing.

[25] Cited in NRC 2002 draft frequently asked questions, p. 21, at: https://www.nrc.gov/docs/ML0227/ML022750657.pdf (accessed February 20, 2017).

- State H indicated that its emergency operations center (EOC) would work with non-REP counties, guiding them toward using their all-hazard emergency operations plans (EOPs).
- State G noted that its state police have plans for the 10-mile EPZ, but not beyond that. The state police would "know the actions they would need to take," including setting up access control points. The state would ultimately use geopolitical boundaries to establish the evacuation area.

Four states said that their state all-hazards plans may address the challenges of evacuating beyond the 10-mile EPZ. Specifically, State G noted that its REP plan does not address evacuations beyond the 10-mile EPZ and suggested that its all-hazards plan could help address these evacuation challenges since it "addresses evacuations for events such as hazmat spills and coastal storms." State G also indicated that "state police are well versed in handling ad hoc situations." State I noted that it would assist non-REP counties "using the principles found in its REP and all-hazards plans" and that its coastal evacuation guidelines could also apply to an evacuation outside the 10-mile EPZ.

Three states indicated that county-level plans could address evacuation challenges. For example, State H said that non-REP counties would have to rely on their EOPs. States F and I provided similar responses, noting that their counties beyond the 10-mile EPZ do not have REP plans and thus those counties would rely on their all-hazard plans.

Additionally, State E expressed that its "existing plans are scalable to these evacuation challenges." State C indicated that the State Response Framework, Long-Term Recovery Working Group, and the evacuation plans for each of its state-level regions would help it to address the evacuation challenges. State B noted that it has "implied procedures, but no official plans" to address the challenges of evacuating beyond the 10-mile EPZ.

Four states indicated that their plans included information on the availability of necessary personnel and equipment to implement the required actions. State H indicated that the EOPs for non-REP counties should include this information, but likely would not include "radiological specifics." Additionally, despite indicating that its plans did not address evacuations beyond the 10-mile EPZ, State G noted that it maintains a database of assets within the state.

3.5.3 Real-World Experience

F5. *In the last 10 years, has your state supported any public evacuations for real-world incidents?*

F6. *If yes, please describe the largest such evacuation:*

All nine states have supported public evacuations for real-world incidents in the last 10 years. Threats and hazards that prompted such evacuations included floods, fires, threats of tsunami, hurricanes, and hazardous materials incidents. For example, one state conducted an evacuation which involved "accounting for people and the sheltering of pets" after a train derailment released hazardous materials. Another state experienced a hazardous materials incident when a waste plant released a plume of contaminated smoke, requiring the evacuation of over 15,000 residents from a local jurisdiction. This jurisdiction was located inside the 10-mile EPZ of an NPP, and the evacuation was "completed by local response personnel without issue." Additionally, three states experienced their largest evacuations in the last 10 years during Hurricane Sandy. Two of those states noted that tens of thousands of residents were evacuated as a result of the hurricane.

3.6 Best Practices in the Intermediate Phase

3.6.1 Alternatives to Evacuation or Relocation

G1. *Are there any alternative protective actions not mentioned previously that your jurisdiction would implement in the intermediate phase?*

G2. *If yes, please describe the conditions under which your jurisdiction would implement an alternative to evacuation and/or relocation:*

The states provided a variety of alternative protective actions in their responses, including sheltering in place, washing streets, and encouraging the public to use "time, distance, and shielding" protective actions. Two states also provided conditions under which they would implement these alternatives to evacuation and/or relocation. These conditions include a puff release, weather, population density, traffic, and time of day. State H noted it is waiting for the new EPA PAG Manual before reconsidering its protective actions and that it could add to its procedures based on the updates to the Manual.[26]

3.6.2 Radioactive Waste Management

G3. *Does your jurisdiction have any best practices or lessons learned with respect to managing radioactive waste?*

Five states did not identify any best practices or lessons learned with respect to managing radioactive waste. Those states that did respond to the question noted that there are challenges in managing radioactive waste. State B indicated that radioactive waste management is a "potential gap in capabilities." State E mentioned that on-site radioactive waste storage creates long-term problems and thus it is "necessary to have a shipping plan and funding source" with regularly scheduled shipments. State C noted that a major question surrounding radioactive waste is "how clean you want something to be." State C also noted that it is currently updating its waste management planning to include radioactive waste and that the state has some remediation experience, particularly with remediating three "greenfields."

3.6.3 Best Practices and Lessons Learned

G4. *Is there any other action you would consider a 'Best Practice and/or Lessons Learned' for intermediate phase protective actions?*

G5. *Are there any additional comments you would like to make regarding challenges in the intermediate phase?*

Five states provided best practices and/or lessons learned for intermediate phase protective actions. The states focused on technology in their responses. State D noted it has integrated technology into its field teams for live tracking of data using mobile tablets. State H indicated that it had developed its own aerial tool for detecting and mapping radioactive contamination, which

[26] In January 2017, after the study team completed the interview process, EPA issued the new PAG Manual, *Protective Action Guides and Planning Guidance for Radiological Incidents*. See https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf (accessed February 20, 2017).

would generate data to help to inform PADs. State E is developing geographic information system (GIS) map overlays to track real-time plume disposition data. The overlays will depict the locations of important facilities such as hospitals and show which crops are currently in season. State E is also working with its neighboring states to gather GIS data on food supply networks to help determine what food sources might be affected by plume events. Other best practices include:

- Developing a plan to evacuate nursing homes and assisted living facilities, which would involve nursing homes pooling together their resources to relocate patients to other facilities;
- Developing a partnership with National Guard Civil Support Teams (CSTs) for responding to radiological incidents, which would bring assets such as communication systems, medical and field teams, and decontamination units;
- Planning for use of volunteer health physicists to enhance population monitoring and contamination surveying efforts; and
- Issuing guidance on and exercising pet decontamination.

The states also provided comments regarding challenges in the intermediate phase. Two states noted the need for more discussions and guidance about how to deal with radioactive waste. Another two states said that political pressure would likely influence some decisions in the intermediate phase. The states also discussed exercises and training in their responses. State A commented that ingestion pathway exercises are not frequent enough and State C noted that frequent meetings and training opportunities would help build better relationships.

Additionally, four states commented on cooperation with some of their intermediate phase partners. State F noted the importance of support from FRMAC and the A-Team in the intermediate phase. State C indicated that both its regional mutual aid and private sector partnerships work well. State E said that it wanted to improve communication between Federal and state responders regarding aerial assets to ensure that it can obtain necessary flyover data during an incident. Additionally, State B noted that Federal lab support would be important for sampling.

Other comments from the states touched on radiation checks and sampling procedures. State G indicated that one area in which its resources would be challenged is with population monitoring and medical services, since many members of the public would want to be checked for contamination. State E noted that it would like to see more guidance on sampling and lab procedures, suggesting that more consistent procedures are necessary and that the abundance of samples might also pose a challenge and require outside resources.

4 AFTER ACTION REPORT (AAR) REVIEW

4.1 Hot Spots Beyond Initially Evacuated Areas

4.1.1 Relevant Findings

Eight AARs (from six states) contained references to hot spots:

- Browns Ferry (Alabama, 2011)
- Indian Point (New York, 1999)
- Point Beach AAR (Wisconsin, 2009)
- Palo Verde (Arizona, 1999 and 2011)
- South Texas (Texas, 2004)
- Watts Bar (Tennessee, 1993 and 2003)

Examples of the references to surveying for hot spots include:

- The Browns Ferry AAR (Alabama, 2011) noted that field teams would be used "to sample areas downwind and outside the 10-mile EPZ to determine if additional civilian personnel would have to be moved due to excessive ground deposition.";
- The Palo Verde AAR (Arizona, 2011) stated that additional sampling outside the area of the plume model "was designed to verify or discount any possible additional contamination concerns in areas outside the area defined by the plume model."; and
- The Point Beach AAR (Wisconsin, 2009) indicated that the evacuated area was "adequate unless additional aerial monitoring or ground-truthing activities identified an unknown hot spot" and that an aerial survey later identified a hot spot.

Seven of the AARs (from five states) with references to hot spots also described some of the resources, both state and Federal, that would help with hot spot identification. For example, both Palo Verde AARs (Arizona, 1999 and 2011) mentioned state assets, with Arizona utilizing its Radiological Emergency Assistance Team-Forward. The 2011 Palo Verde AAR also indicated that Arizona requested assistance from FRMAC in providing "additional ground troops to assist with monitoring" and "plume model verification." The Browns Ferry AAR (Alabama, 2011) noted how mutual aid and Federal resources, including FRMAC, the EPA, and DOE RAP teams, would help staff Alabama's field teams to identify hot spots. The Watts Bar AAR (Tennessee, 1993) explained that the Tennessee Valley Authority's field monitoring teams and Tennessee's Department of Health would assess monitoring data to help identify hot spots. The Point Beach AAR (Wisconsin, 2009) used the results of a FRMAC fixed wing flyover of the plume pathway to determine that a hot spot existed in an area beyond the evacuated area. This was the only AAR to mention a post-evacuation relocation due to a hot spot with the Wisconsin EOC issuing "a special news broadcast that ordered the relocation of all residents in the impacted area."

While only a few AARs referenced surveying for hot spots, an assessment of the total group of ingestion pathway AARs found that jurisdictions should have the capabilities to identify hot spots if needed. Of 50 AARs relating to post-plume, ingestion pathway concerns, 45 addressed evaluation of field monitoring teams. In 39 of those 45 cases, all exercise participants evaluated

on the relevant criterion "met" it, and no participant received a deficiency (or what FEMA now terms a Level 1 finding).[27]

4.1.2 Consistency with Interview Results

The findings on hot spots from the AARs are generally consistent with the interview responses, which suggested that states would conduct surveys to identify hot spots and would augment their own resources with Federal resources. The AAR review did not provide a clear answer as to whether states would utilize their own resources before requesting Federal assistance. However, in their interview responses, most states indicated that they would not rely primarily on Federal resources to perform hot spot survey functions.

4.2 Relaxation of Evacuation and Relocation Orders

4.2.1 Relevant Findings

Fourteen AARs (from eleven states and the District of Columbia) provided relevant information on relaxation of evacuation and relocation orders:

- Browns Ferry (Alabama, 2011)
- Calvert Cliffs (Maryland, 2003 and 2009)
- Columbia (Washington, 2002)
- Comanche Peak (Texas, 1999)
- Grand Gulf (Mississippi, 2011)
- Limerick (Pennsylvania, 2011)
- Millstone (Connecticut, 2010)
- North Anna (Virginia, 2008)
- Palo Verde (Arizona, 1999 and 2011)
- Point Beach (Wisconsin, 2009)
- South Texas (Texas, 2004)
- Watts Bar (Tennessee, 1993)

Ten AARs (from eight states and the District of Columbia) contained references to considerations or purposes for temporary reentry. Seven of those AARs (from six states) indicated that tending to livestock may be an acceptable purpose for reentry, and five AARs noted that reentry may be allowed for retrieval of valuables such as medicines or important documents. For example, the Browns Ferry AAR (Alabama, 2011) noted that a "plan was developed for individuals who wanted to re-enter evacuated areas to feed livestock, recover medicines or valuables." The Point Beach AAR (Wisconsin, 2009) described how three simulated requests for re-entry were received during the exercise. Two requests were for tending to farm animals and the other was to retrieve a valuable gun collection. Only the requests to tend to animals were granted. While the request to retrieve the gun collection was denied during the exercise, the AAR still noted that retrieving a "valuable commodity" may be an "appropriate justification" for reentry.

[27] From at least 1991 to 2001, the relevant criterion was 24, Post-Emergency Sampling: "Demonstrate the use of equipment and procedures for the collection and transportation of samples from areas that received deposition from the airborne plume" (FEMA-REP-14, September 1991, p. D.24-1). Following the FEMA REP strategic review, the relevant criterion was 4.b.1, Post Plume Phase Field Measurements and Sampling, "the field teams demonstrate the capability to make appropriate measurements and to collect appropriate samples (e.g., food crops, milk, water, vegetation, and soil) to support adequate assessments and protective action decision-making" (66 FR 31342, June 11, 2001). Note that the requirement is plural, so there must be at least two field teams. FEMA later made that requirement explicit in the FEMA REP Program Manual.

Three AARs (from two states and the District of Columbia) indicated that emergency workers could reenter restricted areas. For example, the Calvert Cliffs AARs (Maryland, 2003 and 2009) stated that both Maryland and the District of Columbia would allow reentry for emergency workers. Specifically, the 2009 AAR stated how the District of Columbia discussed "[a] controlled re-entry process" that would allow "designated volunteers and professional emergency workers access to re-energize critical infrastructure and emergency services" and that this would be coordinated with agencies and officials in Maryland, including the Departments of Environment and Health. Additionally, the same AAR indicated that the District of Columbia would also allow residents to re-enter the affected area with pre-approved authorization on a case-by-case basis. None of the AARs indicated any prioritization for purposes for reentry.

Four AARs referenced the use of the EPA PAGs to make decisions about temporary reentry into restricted zones. Two of those AARs indicated that reentry to the restricted zones would be based on the emergency worker dose limits stated in the EPA PAG Manual. For example, the Browns Ferry AAR (Alabama, 2011) stated that reentry for tending to livestock or retrieval of valuables "would be based upon individuals not exceeding an annual dose limit of 5 rem" and would include dosimetry requirements. Additionally, the North Anna AAR (Virginia, 2008) noted that "individuals entering the restricted zone should be controlled in accordance with dose limitations and other procedures for control of occupationally-exposed workers" and that this was in accordance with the EPA PAGs.

The remaining two AARs referencing the EPA PAGs were the Palo Verde AARs (Arizona). The 1999 Palo Verde AAR stated that "radiation exposure rates and doses corresponding to Federal relocation PAGs" were used in Arizona to develop reentry decisions. The 2011 Palo Verde AAR provided more details about the criteria for reentry, specifically stating that the general public in Arizona would be allowed reentry to restricted areas "that exceeded the 2-year and 50-year PAG"[28] under specific conditions. Individuals entering the 50-year restricted area would be limited to 12 hours per day within a seven-day period, while those entering the 2-year restricted area would be limited to six hours per day within a seven-day period. All individuals reentering the restricted area would be briefed on exposure control, and access to the 1-year restricted area would be approved on a case-by-case basis. Only one AAR mentioned criteria for temporary reentry in one state that differed from the EPA PAGs. During the Point Beach exercise (Wisconsin, 2009), individuals asking for permission for temporary reentry were "allowed a 100 mR exposure limit over an 8-hour period using a direct-reading dosimeter."

Seven AARs (from six states) included references to the use of the EPA PAGs as criteria for relocation. Four AARs specifically referenced the use of the 2 rem first year EPA relocation PAG. For example, the Columbia AAR (Washington, 2002) indicated that the state uses a computer program to identify relocation area boundaries, and the program calculates the boundaries based on the 2 rem first year dose level. During the Comanche Peak exercise (Texas, 1999), accident assessment personnel "used manual calculations to assess laboratory data to determine if the relocation PAGs had been exceeded" and specifically compared calculations to the "2 rem relocation PAG." While the Millstone AAR (Connecticut, 2011) did not reference the 2 rem first year dose limit, it noted that "[p]oints above and below the relocation PAGs will be plotted on a map."

The Palo Verde AARs from Arizona referenced the use of the EPA PAGs for relocation, but the state decided to follow more conservative criteria during the 1999 Palo Verde exercise. In this

[28] The EPA removed the 50-year relocation PAG from the 2013 interim-use PAG Manual, and the 2017 final PAG Manual does not contain a 50-year relocation PAG.

exercise, the Lead Federal Agency (LFA) provided a relocation recommendation that acknowledged that the area did not exceed the EPA PAGs for relocation. The area recommended for relocation was as much as 150 times lower than the EPA PAGs. Arizona concurred with the relocation recommendation of the LFA, even though it contradicted the EPA relocation PAG, which was included in the state plan. However, during the 2011 Palo Verde exercise, Arizona followed the EPA PAGs when it compared its sample analysis to the EPA PAGs to confirm the validity of a projected population relocation map.

Three AARs referenced criteria for return, with two of the AARs (from one state) specifically referencing the use of the EPA relocation PAG. The 1999 Palo Verde AAR (Arizona) stated that Arizona used “radiation exposure rates and doses corresponding to Federal relocation PAGs” to develop return decisions. However, the AAR also noted that “since the original relocation decision was not based on existing PAGs, it was difficult to determine how to reduce the size of the restricted area.” The 2011 Palo Verde AAR stated that “return would be appropriate outside the area designated on the map” designating relocation areas using the EPA relocation PAG. The Point Beach AAR (Wisconsin, 2009) was the sole AAR indicating that unique criteria were used in making return decisions, with Wisconsin using a "20 µR/hr (twice background)" exposure rate to determine the areas to which evacuees could return. None of the AARs provided references to relocation verification.

4.2.2 Consistency with Interview Results

The AARs generally agreed with the interview results on purposes for temporary reentry, with tending to livestock being the most frequently cited purpose in both information sources. However, unlike the interview results, the AARs provided no insight into prioritization of purposes for temporary reentry. Additionally, the AARs and interview results both emphasized the use of the EPA PAGs as criteria for reentry, return, and relocation. However, unlike the interview results, the review of the AARs produced no references to relocation verification.

4.3 Food Condemnation or Embargo

4.3.1 Relevant Findings

Twenty-seven AARs (from 22 states) contained references to food condemnation or embargo:

- Arkansas Nuclear One (Arkansas, 2008)
- Browns Ferry (Alabama, 2011)
- Brunswick (North Carolina, 2002)
- Calvert Cliffs (Maryland, 2003 and 2009)
- Columbia (Washington, 1999, 2000, 2001, and 2002)
- Edwin I. Hatch (Georgia, 2010)
- Grand Gulf (Mississippi, 2011)
- Limerick (Pennsylvania, 2011)
- Millstone (Connecticut, 2010)
- North Anna (Virginia, 2008)
- Oyster Creek (New Jersey, 2003)
- Palisades (Michigan, 2012)
- Palo Verde (Arizona, 1999 and 2011)
- Perry (Ohio, 2012)
- Point Beach (Wisconsin, 2009)

- R.E. Ginna (New York, 2005)
- River Bend (Louisiana, 2010)
- Salem/Hope Creek (New Jersey, 2010)
- South Texas (Texas, 2004)
- Watts Bar (Tennessee, 1993 and 2003)
- Wolf Creek (Kansas, 2001)

Fourteen AARs (from twelve states) referenced criteria used to determine the safety of contaminated food products, with thirteen AARs (from eleven states) specifically referencing the use of the FDA DILs. For example, the North Anna AAR (Virginia, 2008) noted that Virginia's post-plume projection procedure "cites the 1998 FDA guidelines for radioactive contamination of human food and animal feeds," which contain the DILs. The Millstone AAR (Connecticut, 2004) noted how GIS staff would "delineate the areas that show areas where DILs are exceeded." The Palisades AAR (Michigan, 2012) described how "radiological impacts on the food and water will then be compared to the appropriate ingestion PAGs or [DILs]." Additionally, the South Texas AAR (Texas, 2004) described how "after reviewing the sampling data and conferring with the Advisory Team" it was decided "that the general public should refrain from consuming leafy vegetables until otherwise notified, out to 20 miles, due to exceeding the DIL for Iodine 131." Of the 14 AARs referencing criteria to determine food safety, one cited the PAGs rather than the DILs. The Limerick AAR (Pennsylvania, 2011) described how fresh milk samples in Pennsylvania were determined to be in excess of PAGs. This is likely referring to the PAG defined in the FDA's 1998 guidelines on radioactive food contamination, which is used to compute the DILs.

Eleven AARs (from eight states) referenced food control area boundaries, with several AARs discussing the types of boundaries that would be used to determine the food control areas. Five AARs (from four states) noted the use of roads or highways as boundaries. The Limerick (Pennsylvania, 2011) and Palo Verde (Arizona, 1999 and 2011) AARs noted how roads would be used to define the food control borders, and the Wolf Creek AAR (Kansas, 2011) described embargo boundaries that included both highways and county borders. The 2000 Columbia AAR (Washington) also noted how Oregon would use both interstates and the Columbia River to define food control area boundaries. The Point Beach AAR (Wisconsin, 2009) stated how if "any portion of a County was impacted by a deposition contour, then the entire County was included in the embargo." Additionally, the Browns Ferry AAR (Alabama, 2011) discussed the "placement of TCPs [traffic control points] for both control of contaminated areas and crop embargoes."

The Columbia AARs (Washington) presented a variety of references to food control areas and boundaries, two of which also mentioned the DILs. The 1999 Columbia AAR noted how Oregon set up a food control point near Interstate Highway 82 to stop all trucks entering Oregon from Washington. The 2001 Columbia AAR described how Washington's dose assessment center used a comparison of the sampling results and the DILs to mark points on a map and draw a food control area "based on the location of the samples that were below the DILs." This was the only reference in any of the AARs to the use of the DILs specially in determining food control area boundaries. Additionally, the 2002 Columbia AAR noted how Washington would discuss the "geo-political points and boundaries for the proposed food control area" with the affected counties.

Eleven AARs (from eight states) referenced the state-level agencies responsible for establishing food control areas. In seven of those states, the Department of Agriculture played a role in establishing food control areas. For example, the Point Beach AAR (Wisconsin, 2009) noted that the "Wisconsin Department of Agriculture was responsible for any embargo notices for food or dairy and has this authority through state statute." Four states involved the Department of Health in the food control area process, three states involved the Department of Emergency

Management, and two states involved the Department of Environmental Protection. In one state, the Department of Transportation helped establish a food control point.

Additionally, in six states, the counties were involved in the food control area process. For example, the Grand Gulf AAR (Mississippi, 2011) stated how "[c]ounty directors also agreed they would rely heavily on their county agriculture agent and law enforcement assistance" to enforce "agricultural restrictions which might be imposed by the State Agriculture Department." Also, the Calvert Cliffs AAR (Maryland, 2009) described how Queen Anne County would work with the U.S. Department of Agriculture's (USDA's) Farm Service Agency and University of Maryland Extension Service to "assist in the implementation of protective actions" related to food. One AAR, the 2002 Columbia AAR, also noted how Washington sought Federal advice, discussing food control area boundaries with the A-Team and NRC Protective Measures Coordinator. For seven of the eight states with references to responsibilities for establishing food control areas, the AARs indicated that more than one of the aforementioned state-level departments participated in the establishment and/or enforcement of a food control area. Few AARs specifically mentioned responsibilities for lifting food control areas, although presumably authority to establish a food control area includes the authority to reduce or eliminate the food control area.

Fourteen AARs (from 13 states) referenced responsibilities and resources used for agricultural monitoring and surveys. In nine of those states, specific departments or agencies conducted monitoring activities. In six of those states, the Department of Agriculture participated in monitoring or sampling. Four of the states relied on the Department of Health, and one relied on its Department of Environmental Protection. In three states, field monitoring teams conducted agricultural monitoring and surveys, but the specific agencies overseeing or participating in those teams were not identified. At least one state worked with counties to conduct agricultural monitoring and sampling. The Point Beach AAR (Wisconsin, 2009) described how Wisconsin "in conjunction with the risk counties was responsible for evaluating plume deposition and formulating a sampling plan to determine if food products were contaminated above" the DILs. Additionally, three states noted how Federal resources, such as FRMAC and the A-Team, would assist with or provide advice about field monitoring efforts.

Five AARs (from four states) included references to processes for reducing or eliminating food control areas. The Browns Ferry AAR (Alabama, 2011) indicated that the Alabama Department of Health discussed "sampling requirements to release previously embargoed agricultural products" with the Advisory Team members and a FRMAC representative. The Columbia AAR (Washington, 2002) noted how "deposition mapping, monitoring and sampling by Field Monitoring Teams, and subsequent laboratory analysis" help determine refined food control area boundaries in Washington. The Palo Verde AARs (Arizona, 1999 and 2011) indicated that Arizona's embargo areas were refined using sampling data. The 2011 Palo Verde AAR described how the Arizona Department of Agriculture "developed GIS maps enhanced with data showing farms, agricultural ditches where runoff may be contaminated, crops, dairies and food processing plants" and used those maps to refine food control areas. The Point Beach AAR (Wisconsin, 2009) noted that Wisconsin would use the DILs to "define smaller areas within the Counties where food embargoes needed to be applied" and that "radiological analyses of agricultural products" helped the state decide which embargoes to remove. None of the AARs contained references to communications with the public about the safety of released crops, livestock, or farmland.

Four AARs included references to disposal of contaminated food and livestock. Only two states noted responsibilities for disposal of contaminated food. The Columbia AAR (Washington, 2002) described how "[c]ondemned food products would be impounded for disposal under the regulations set forth by the Washington State Department of Ecology" and that the Washington

Department of Agriculture would supervise the condemnation of these food products. The Point Beach AAR (Wisconsin, 2009) noted how "[c]ondemned foods are taken for disposal under authority of the Wisconsin Department of Natural Resources" but that it is "the responsibility of the farmer to dispose of condemned food or dairy products at the owner's expense." The AAR also explained how Kewaunee County in Wisconsin would work with the state's emergency management, Department of Health, and Department of Agriculture on decisions to dispose of contaminated food or animals.

Some of the states discussed potential options for disposal during their exercises. For example, the Grand Gulf AAR (Mississippi, 2011) stated that the Mississippi Emergency Management Agency requested the advice of the A-Team regarding the disposal of affected crops and livestock, with the A-Team advising that "reprocessing would decontaminate crops and/or animals enough for other uses than intended." Additionally, the Palo Verde AAR (Arizona, 1999) described discussions with Arizona's Department of Environmental Quality about options for disposal, including use of a hazardous waste incinerator or a local landfill, but no firm decision was made during the exercise.

4.3.2 Consistency with Interview Results

The results of the AAR review seem to be in agreement with the interview results on the use of the FDA DILs as the criteria used to determine the safety of food products. In regard to food control boundaries, the AARs and interview results provided similar information on the types of boundaries that would be used for food control areas. The AARs also aligned with the interview results on responsibilities for determining food control areas, with most AARs citing the same state-level agencies noted during the interviews. Additionally, the AARs, like the interview results, emphasized the need for sampling with the help of field monitoring teams and resources at both the state and Federal levels. Neither the AARs nor the interview results provided clear trends on disposal of affected livestock and their by-products, with references to this topic varying in both the AARs and interview results.

4.4 Water

4.4.1 Relevant Findings

Thirty-two AARs contained references to water contamination or monitoring and the criteria used to determine the safety of water in 22 states:

- Arkansas Nuclear One (Arkansas, 2008)
- Beaver Valley (Pennsylvania, 2004 and 2010)
- Browns Ferry (Alabama, 2011)
- Brunswick (North Carolina, 2002)
- Calvert Cliffs (Maryland, 2009)
- Columbia (Washington, 1999, 2000, and 2002)
- Comanche Peak (Texas, 1999)
- Edwin I. Hatch (Georgia, 2010)
- Grand Gulf (Mississippi, 2011)
- James A. FitzPatrick (New York, 2011)
- Limerick (Pennsylvania, 2011)
- Millstone (Connecticut, 2004 and 2010)
- Monticello (Minnesota, 2003)

- North Anna (Virginia, 2008)
- Oyster Creek (New Jersey, 2003)
- Palisades (Michigan, 2012)
- Palo Verde (Arizona, 1999 and 2011)
- Perry (Ohio, 2012)
- Point Beach (Wisconsin, 2009)
- R.E. Ginna (New York, 2005)
- River Bend (Louisiana, 2010)
- Salem/Hope Creek (New Jersey, 2010)
- South Texas (Texas, 2004)
- Susquehanna (Pennsylvania, 2004)
- Watts Bar (Tennessee, 1993 and 2003)
- Wolf Creek (Kansas, 2001)

Twenty-six of those AARs described how 22 states monitored water sources through sampling. Most of those references to water sampling were brief, with water often listed alongside food, vegetation, and milk as the types of samples taken during an exercise. Only four AARs contained references that specifically mentioned "drinking" or "potable" water rather than water in general. For example, the Limerick AAR (Pennsylvania, 2011) noted how "[s]urface drinking water inside zone A was not suitable for consumption." The Calvert Cliffs AAR (Maryland, 2009) noted how Maryland worked to ensure that "potable water supplies are controlled to prohibit public consumption." Additionally, the Point Beach AAR (Wisconsin, 2009) described how water contamination would not be a concern when it stated that the "water supply was not considered a major issue in the priority of ingestion decisions because most of the water supplies are from wells."

Three AARs referenced the criteria used to determine the safety of water, with three states using the DILs as their criteria. The Edwin I. Hatch AAR (Georgia, 2010) described how Georgia's Department of Natural Resources "effectively calculated Derived Response Levels (DRL) for a variety of environmental samples, including dairy products, eggs, fish, meat grains, water, etc.", and that the DRLs were based on the relationship between the PAGs and DILs.[29] The Palisades (Michigan, 2012) radiological impacts on water in Michigan will be compared "to the appropriate ingestion PAGs or Derived Intervention Levels (DIL)." The Watts Bar AAR (Tennessee, 2003) stated that Tennessee's dose assessment staff was able "to correlate analytical results with predetermined 1998 [FDA DILs] for agricultural products and drinking water."[30]

4.4.2 Consistency with Interview Results

Unlike the interview results, the results of the AAR review did not indicate any mention of the use of EPA's Safe Drinking Water Act standards to determine the safety of drinking water. In the interviews, most states indicated that they would use EPA's standards or guidance. On the other

[29] EPA defines a DRL as "a level of radioactivity in an environmental medium that would be expected to produce a dose equal to its corresponding PAG." See EPA, *PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents*, p. 94). Available online at: https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf (accessed February 20, 2017).

[30] These AARs predate EPA's 2017 issuance of a drinking water PAG. EPA states that its 500 mrem drinking water PAG for the general population is "consistent with PAGs currently in place for other media in the intermediate phase (i.e., the FDA's 500 mrem PAG for ingestion of food; FDA 1998, FDA 2004)" (*ibid.,* p. 53).

hand, most of the AARs contained brief references to water sampling, with three states using the FDA DILs as the criteria with which to compare sample results against.[31]

4.5 Evacuation Beyond the 10-Mile EPZ

No references were found that addressed evacuations beyond the 10-mile EPZ.

4.6 Best Practices in the Intermediate Phase

No references were found that addressed best practices in the intermediate phase. This topic area was intended primarily for the interview portion of the overall study.

[31] See previous footnote. EPA's 2017 PAG for drinking water came after these AARs, but EPA sought consistency with the dose PAGs FDA used to develop the DILs.

5 STATE RADIOLOGICAL EMERGENCY RESPONSE PLAN REVIEW

5.1 Hot Spots Beyond Initially Evacuated Areas

5.1.1 Relevant Findings

Only three state radiological emergency plans ("state plans") specifically reference hot spots:

- State of New Hampshire – Radiological Emergency Response for Nuclear Facilities Incident Annex (New Hampshire, 2016)
- The State of Florida Radiological Emergency Preparedness Plan (Florida, 2014)
- The Ohio Radiological Emergency Preparedness (REP) Operations Manual (Ohio, 2015)

Each of those three plans discusses surveying for hot spots. Florida's plan (2014) states that hot spots are to be "identified by survey teams" and "marked off and secured by local and State law enforcement personnel." Ohio's REP Operations Manual (2015) notes that, in the intermediate phase, "[d]irect continued monitoring and sample analysis to define contaminated areas and hot spots" would be assigned to the state's Ingestion Zone Recovery and Reentry Advisory Group. New Hampshire's plan (2016) explains that the state would consider "[d]etermining presence of any 'hot spots'" after initiating recovery operations.

These three plans also discuss the types of resources that may be utilized and/or requested for hot spot surveying, including resources from the Federal Government and requested through mutual aid. For example, Florida's plan (2014) explains that "[a]erial and land survey teams comprised of State agency personnel, and those additional monitors requested through mutual aid (local, State and [F]ederal)" will help screen affected areas. Ohio's REP Operations Manual (2015) notes that the state will "[e]stablish liaison with the [F]ederal monitoring and assessment teams at the FRMAC" and "request [F]ederal team radiation survey and sampling results." Additionally, New Hampshire's plan (2016) states that the National Guard Civil Support Team may assist with field monitoring and decontamination and that assistance may be requested through the New England Compact on Radiological Health Protection, DOE, or the FRMAC.

While only three plans from three states specifically mentioned hot spots, plans from the remaining 18 states do reference field-monitoring efforts that would help determine the areas affected by radiological contamination. The plans also indicate that many of these states would request additional resources from the Federal Government or through mutual aid to conduct monitoring activities.

5.1.2 Consistency with Interview Results

The results of the state plan review are consistent with the interview results. While only three plans specifically mention surveying for hot spots, all states indicate in their plans that they would conduct field-monitoring activities, which would help identify hot spots. Additionally, states note that they would augment their own resources with Federal resources or resources obtained through mutual aid. However, the state plans review did not provide a clear answer as to whether states would utilize their own resources before requesting Federal assistance.

5.2 Relaxation of Evacuation and Relocation Orders

5.2.1 Relevant Findings

Seventeen plans from 16 states contain references to the relaxation of evacuation and relocation orders:

- State of New Hampshire State Emergency Operations Plan: Radiological Emergency Response for Nuclear Facilities, Incident Annex (New Hampshire, 2016)
- Vermont Radiological Emergency Response Plan (Vermont, 2012)
- Commonwealth of Massachusetts Radiological Emergency Response Plan (Massachusetts, 2015)
- New York State Comprehensive Emergency Management Plan: Radiological Hazards Annex For Fixed Nuclear Facilities (New York, 2012)
- Commonwealth of Virginia Emergency Operations Plan Hazard-Specific Annex #1 Radiological Emergency Response (Virginia, 2012)
- West Virginia Radiological Emergency Preparedness Plan (West Virginia, 2014)
- South Carolina Operational Radiological Emergency Response Plan (South Carolina, 2014)
- The State of Florida Radiological Emergency Preparedness Plan (Florida, 2014)
- Michigan Emergency Management Plan: Disaster-Specific Procedures, Nuclear Power Plant Incidents (Michigan, 2014)
- Ohio Emergency Operations Plan: Emergency Support Function #10 Hazardous Materials and Weapons of Mass Destruction - Tab B Radiological Emergency Preparedness (REP) Incident Response Plan (Ohio, 2015)
- The Ohio Radiological Emergency Preparedness (REP) Operations Manual (Ohio, 2015)
- State of Minnesota Emergency Operations Plan (Minnesota, 2015)
- Arkansas Comprehensive Emergency Management Plan (ARCEMP) 2015: Annex N Radiological Protection System and Annex V Radiological Response System (Arkansas, 2015)
- State of Texas Emergency Management Plan: Annex D - Radiological Emergency Management (Texas, 2013)
- Louisiana Peacetime Radiological Response Plan (Louisiana, 2013)
- State of Oregon Emergency Operations Plan: IA 9- Nuclear/ Radiological (Oregon, 2014)
- Washington State Fixed Nuclear Facility Protection Plan (Washington, 2014)
- State of Oregon Emergency Operations Plan: IA 9- Nuclear/ Radiological (Oregon, 2014)

Eleven state plans mention specific considerations and purposes given for temporary reentry. One of the most common purposes for temporary reentry mentioned in the state plans is tending to farms and livestock. For example, Massachusetts's plan (2015) notes that the state "may approve re-entry on a 'need-versus-risk' basis for farm owners and/or employees with livestock and/or associated farm care responsibilities and others." Four states also indicated that they may allow reentry for retrieval of property or valuables. Other purposes mentioned in the state plans include emergency work, security patrols, maintaining utilities and critical infrastructure, providing essential services, and controlling industrial functions. While Texas's plan (2013) does not specify purposes for reentry, it explains that the Department of State Health Services, working in coordination with local jurisdictions and other agencies, "may allow some residents to reenter a restricted zone in order to conduct necessary activities for short periods of time." None of the plans prioritized any considerations or purposes for reentry.

Four plans from four states cite the EPA PAGs or EPA guidance as criteria for reentry. For example, Arkansas's plan (2015) explains how reentry "may be allowed when projected whole body doses for those members of the population who have been evacuated do not exceed EPA guidelines." Three other plans also noted specific criteria for reentry. West Virginia's plan (2014) explains how selected evacuated residents may reenter once "further radioactive release from the nuclear power plant is unlikely, and that the plant is in a stable condition." South Carolina's plan (2014) describes how the state would recommend reentry "when projected doses fall below 20% of the appropriate PAG and when surface contamination is reduced below the limits" identified in the South Carolina's Technical Radiological Emergency Response Plan. New Hampshire's plan (2016) states that "[p]ersons entering the Restricted Zone more than once will be informed of their cumulative dose readings and prohibited from entry when the cumulative dose reaches 1 Rem" but that New Hampshire's Department of Health may authorize up to the level allowed for emergency workers in accordance with Radiological Exposure Control Decision Criteria. Six other plans noted how certain departments or agencies would determine reentry criteria or how the criteria for reentry are contained in other plans or regulations.

Thirteen plans from twelve states reference criteria for relocation. Twelve plans from 11 states mention that the states will use the EPA PAGs in making relocation decisions. On the other hand, Oregon's plan (2015) states that "[i]ndividuals are relocated when the affected areas cannot be restored for unrestricted use" and that "[d]ecisions on whether to restore or relocate are based on both technological and economic considerations." In addition to citing the EPA PAGs, New Hampshire's plan (2016) notes that lack of access to food may be a consideration for relocations. The plan states there may be instances "when withdrawal of food and/or water from use may, in itself, create a hazard" and that "relocation may be an appropriate protective action in this instance."

Thirteen plans from twelve states cite the EPA PAGs as their criteria for return. For example, West Virginia's plan (2014) indicates that return for the general public will be allowed if "radiation exposure above background will not exceed established EPA Protective Action Guides." The same plan, however, notes three additional criteria for return to take place, including that further radioactive releases are unlikely, public services (e.g., water, electricity, etc.) are operable, and that the counties have reestablished their seats of government. None of the plans provided references to relocation verification.

5.2.2 Consistency with Interview Results

The state plans generally agree with the interview results for the relaxation of evacuation and relocation orders study topic. The state plans listing specific purposes for temporary reentry often list purposes similar to those mentioned during the interviews, such as tending to livestock. However, unlike the interview results, the state plans provide no insight into prioritization of those purposes for reentry. Additionally, the state plans and interview results both saw use of the EPA PAGs or EPA guidance in making reentry, relocation, and return decisions. For some states, however, these criteria are located in other supporting documents rather than in the identified plans.

5.3 Food Condemnation or Embargo

5.3.1 Relevant Findings

All 23 plans from 21 states contained information relevant to food condemnation or embargo:

- State of New Hampshire State Emergency Operations Plan: Radiological Emergency Response for Nuclear Facilities, Incident Annex (New Hampshire, 2016)
- Vermont Radiological Emergency Response Plan (Vermont, 2012)
- Commonwealth of Massachusetts Radiological Emergency Response Plan (Massachusetts, 2015)
- New York State Comprehensive Emergency Management Plan: Radiological Hazards Annex For Fixed Nuclear Facilities (New York, 2012)
- Commonwealth of Virginia Emergency Operations Plan Hazard-Specific Annex #1 Radiological Emergency Response (Virginia, 2012)
- West Virginia Radiological Emergency Preparedness Plan (West Virginia, 2014)
- North Carolina Emergency Operations Plan (NCEOP) Annex B - Appendix 8 Radiological Emergency Response Plan For Nuclear Power Facilities (NC REP) (North Carolina, 2008)
- South Carolina Operational Radiological Emergency Response Plan (South Carolina, 2014)
- The State of Florida Radiological Emergency Preparedness Plan (Florida, 2014)
- State of Alabama Emergency Operations Plan: Incident Annex E – Nuclear/Radiological Response Incident (Alabama, 2012)
- Michigan Emergency Management Plan: Disaster-Specific Procedures, Nuclear Power Plant Incidents (Michigan, 2014)
- Ohio Emergency Operations Plan: Emergency Support Function #10 Hazardous Materials and Weapons of Mass Destruction - Tab B Radiological Emergency Preparedness (REP) Incident Response Plan (Ohio, 2015)
- The Ohio Radiological Emergency Preparedness (REP) Operations Manual (Ohio, 2015)
- State of Minnesota Emergency Operations Plan (Minnesota, 2015)
- Wisconsin Emergency Response Plan: Radiological Incident Annex (Wisconsin, 2015)
- Arkansas Comprehensive Emergency Management Plan (ARCEMP) 2015: Annex N Radiological Protection System and Annex V Radiological Response System (Arkansas, 2015)
- Louisiana Peacetime Radiological Response Plan (LPRRP) (Louisiana, 2013)
- Kansas Response Plan 2014: Nuclear/ Radiological Incident Annex (Kansas, 2014)
- State of Texas Emergency Management Plan: Annex D - Radiological Emergency Management (Texas, 2013)
- Arizona Department of Health Services Radiological Emergency Response Plan (Arizona, 2012)
- State of Arizona Emergency Response and Recovery Plan: Nuclear/Radiological Incident Annex (Arizona, 2016)
- Washington State Fixed Nuclear Facility Protection Plan (Washington, 2014)
- State of Oregon Emergency Operations Plan: IA 9- Nuclear/ Radiological (Oregon, 2014)

Eleven plans from 10 states reference the FDA DILs or the FDA's guidance document ("Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies") as the criteria that would be used to determine the safety of potentially

contaminated food products. For example, Washington's plan (2014) indicates that the Department of Health will "develop protective actions recommendation on the basis of Protective Action Guides, EPA-400, and FDA derived intervention levels to minimize the impact on Public Health from a radiological emergency." Additional plans reference other criteria to determine food safety. For example, Vermont's plan (2012) states that the FDA guidance "or other method and/or Protective Action Guides deemed relevant and appropriate by the Radiological Health Advisor will be employed by the State of Vermont in the assessment of human consumables such as milk, water and other foods." Oregon's plan (2015) indicates that the state would ensure that food sources are not contaminated "above acceptable limits." Arkansas's plan (2015) notes that levels at which protective actions will be taken are found in the Department of Health's "Protective Action Guidelines." Also, according to Michigan's plan (2014), restrictions on food consumption would end when monitoring shows that projected dose is "below applicable state and [F]ederal guidance limits."

Only one plan describes specific food control boundaries. Washington's plan (2014) noted that the affected counties would propose the geopolitical boundaries of a food control area using "easily recognizable features such as roads and rivers." Other state plans, however, note how states would establish food control points. For example, Florida's plan (2014) explains how "[a]griculture control points will be established by the Department of Agriculture and Consumer Services and co-located with the access control points." South Carolina's plan (2014) notes that Food control points will be "co-located with the traffic control points" and "be used to restrict the flow of all livestock, poultry, foodstuffs and commercial products from a restricted zone." Additionally, Arizona's plan (2012) indicates that the state would establish "check points to ensure food that is being transported meets food safety standards."

Nineteen plans from 17 states discuss responsibilities for establishing food control areas or embargoes. Sixteen plans from 14 states indicate that the state-level Department of Agriculture would be involved in establishing food control areas. Other state-level agencies that may help establish food control areas include the Departments of Emergency Management, Environmental Protection, and Transportation. In six states, more than one of the aforementioned state-level departments would be involved in the establishment of a food control area. Few plans specifically described responsibilities for lifting food control areas, although presumably authority to establish a food control area includes the authority to reduce or eliminate the food control area.

Six plans from six states discuss the process for reducing or eliminating food control areas. For example, Washington's plan (2014) notes how the state will use sampling to adjust the boundaries of food control areas and that "[i]t is anticipated that the area(s) will be reduced through this process." Five of the six plans explained how food control areas would be lifted by comparing food contamination levels to food safety criteria. For example, Arkansas's plan (2015) describes how decontrol of foodstuffs and agricultural activity "will be indicated when limits fall below those in the ADH [Arkansas Department of Health] Protective Action Guides." Additionally, according to New Hampshire's plan (2016), the state's Department of Health and Human Services Radiological Health Section would lift restrictions on food once contamination levels are below the DILs.

Twenty-one plans from 20 states describe the state-level responsibilities for food and agricultural monitoring and surveys. In 17 states, the Department of Agriculture will participate in food sampling and monitoring. In 13 states, the Department of Health will be involved in the monitoring process. Other state-level departments that will participate in monitoring include the Departments of Environmental Protection and Natural Resources. Eleven states indicate that they would involve more than one agency in the monitoring process. The plans also noted how other sources, such as the Federal Government, other states, and contractors, may participate in food sampling

and monitoring. For example, Washington's plan (2014) explains how "[s]ample collection assistance is requested as needed from the local agricultural community, other states, USDOE-RL, other [F]ederal agencies, the nuclear facilities, or commercial firms under contract to conduct this function." While several of the plans describe how states would provide information to the public about food-related protective actions, none of the plans specifically addresses how states would communicate the safety of released crops and livestock to the public.

Lastly, 14 plans from 13 states reference the disposition of livestock and their byproducts. While all those plans mention destruction of livestock and food, none specifies the methods that would be used to destroy them. However, the plans often discuss how state-level agencies would coordinate or provide advice about disposal. For example, Ohio's REP Operations Manual (2015) explains that the Ingestion Zone Recovery and Reentry Advisory Group would advise local officials on "[r]emoving and disposing of materials, equipment, soils, pets, livestock, food products, farm or garden produce, and other items which cannot be decontaminated or which have spoiled or perished while the areas have been restricted." Ohio's emergency operations plan (2015) further explains that food products would be disposed of at a site approved by both the state's Environmental Protection Agency and Department of Health. Additionally, Texas's plan (2013) describes how the Animal Health Commission would "[c]oordinate the appropriate disposal of carcasses of affected livestock and pets." Vermont's plan (2012) described an alternative to disposal, explaining that canning and the storage of nonperishable crops could be used until the radioactivity has decayed.

5.3.2 Consistency with Interview Results

The findings on food condemnation or embargo in the review of state plans are generally consistent with the interview responses. Most of the state plans and interviews indicated that states would use the FDA DILs to determine the safety of food products. The plans also aligned with the interview results on responsibilities for determining food control areas, with most of the plans citing the same state-level agencies noted during the interviews. Additionally, the state plans also emphasized the need for sampling and monitoring with agencies at both the state and Federal levels participating in that process. Neither the plans nor the interview results provided clear options for disposal of affected livestock and their by-products.

5.4 Water

5.4.1 Relevant Findings

Twenty-two plans from 20 states provide references to water safety:

- Commonwealth of Massachusetts Radiological Emergency Response Plan (Massachusetts, 2015)
- State of New Hampshire State Emergency Operations Plan: Radiological Emergency Response for Nuclear Facilities, Incident Annex (New Hampshire, 2016)
- Vermont Radiological Emergency Response Plan (Vermont, 2012)
- New York State Comprehensive Emergency Management Plan: Radiological Hazards Annex For Fixed Nuclear Facilities (New York, 2012)
- Commonwealth of Virginia Emergency Operations Plan Hazard-Specific Annex #1 Radiological Emergency Response (Virginia, 2012)
- West Virginia Radiological Emergency Preparedness Plan (West Virginia, 2014)

- North Carolina Emergency Operations Plan (NCEOP) Annex B - Appendix 8 Radiological Emergency Response Plan For Nuclear Power Facilities (NC REP) (North Carolina, 2008)
- South Carolina Operational Radiological Emergency Response Plan (South Carolina, 2014)
- The State of Florida Radiological Emergency Preparedness Plan (Florida, 2014)
- Michigan Emergency Management Plan: Disaster-Specific Procedures, Nuclear Power Plant Incidents (Michigan, 2014)
- Ohio Emergency Operations Plan: Emergency Support Function #10 Hazardous Materials and Weapons of Mass Destruction - Tab B Radiological Emergency Preparedness (REP) Incident Response Plan (Ohio, 2015)
- The Ohio Radiological Emergency Preparedness (REP) Operations Manual (Ohio, 2015)
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- Wisconsin Emergency Response Plan: Radiological Incident Annex (Wisconsin, 2015)
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- Louisiana Peacetime Radiological Response Plan (LPRRP) (Louisiana, 2013)
- Kansas Response Plan 2014: Nuclear/ Radiological Incident Annex (Kansas, 2014)
- State of Texas Emergency Management Plan: Annex D - Radiological Emergency Management (Texas, 2013)
- Arizona Department of Health Services Radiological Emergency Response Plan (Arizona, 2012)
- State of Arizona Emergency Response and Recovery Plan: Nuclear/Radiological Incident Annex (Arizona, 2016)
- Washington State Fixed Nuclear Facility Protection Plan (Washington, 2014)
- State of Oregon Emergency Operations Plan: IA 9- Nuclear/Radiological (Oregon, 2014)

Twenty-two plans from 20 states contain references to contamination and/or monitoring of drinking water. The plans mostly provide brief references to water sampling and potential corrective actions to address water contamination. For example, Ohio's REP Operations Manual (2015) explains how the Ohio Environmental Protection Agency will conduct sampling, monitoring, and testing of drinking water supplies and provide advisories based on findings. New York's plan (2014) discusses how the Department of Health will provide "laboratory testing of samples to assure safe food and water supplies" and monitor potable water supplies. New Hampshire's plan (2016) explains that "[i]f sampling reveals the need, control of surface water supplies will be implemented by the department through direct contact with the water supply owner/operators." Additionally, Massachusetts's plan (2015) states that "[p]ublic surface water supplies may be temporarily condemned until testing for radioactivity levels are conducted to confirm or refute the need for control."

Nine plans from eight states referenced the criteria to determine the safety of water. Both of Ohio's plans (2015) and Louisiana's plan (2013) cited the use of the Safe Drinking Water Act standards. On the other hand, four states note in their plans that they would use the FDA DILs or FDA guidance to determine the safety of water. For example, Minnesota's plan states that modification or termination of actions related to water would be "based on guidelines established by the Food and Drug Administration" (Minnesota, 2015). While Vermont would use the DILs, the state's plan (2012) notes how another method "deemed appropriate by the Radiological Health Advisor" could be used in the evaluation of potentially contaminated drinking water. Michigan's plan (2014) does not reference specific criteria but explains how the state would "approve use of a

drinking water supply when radioactive material concentrations are below applicable state and [F]ederal guidance limits." Additionally, Arkansas's plan (2015) does not reference specific criteria but notes that, if analysis of drinking water indicates that contamination levels are "above specified limits," a protective action ordered by the Arkansas Department of Health would be to "transport uncontaminated drinking water (potable) from other locations." [32]

5.4.2 Consistency with Interview Results

While the interview results revealed that most states would use the EPA's Safe Drinking Water Act standards as guidance, review of the state plans found that use of the FDA DILs was more frequent than the use of the Safe Drinking Water Act standards. Only two states would use those standards, while four states would use the DILs as the criteria with which to compare sample results against. [33]

5.5 Evacuation Beyond the 10-Mile EPZ

No references to evacuations beyond the 10-mile EPZ were found in the state plans.

5.6 Best Practices in the Intermediate Phase

No references to best practices in the intermediate phase were found in the state plans. This topic area was intended primarily for the interview portion of the overall study.

[32] These plans predate EPA's 2017 issuance of a drinking water PAG. EPA states that its 500 mrem drinking water PAG for the general population is "consistent with PAGs currently in place for other media in the intermediate phase (i.e., the FDA's 500 mrem PAG for ingestion of food; FDA 1998, FDA 2004)." See EPA, *PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents*, p. 53. Available online at: https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf (accessed February 20, 2017).

[33] See previous footnote. EPA's 2017 PAG for drinking water came after these plans were published, but EPA sought consistency with the dose PAGs FDA used to develop the DILs.

6 AGGREGATE FINDINGS

Overall, the interview results and review of AARs and state plans provided various insights into how OROs would respond during the intermediate phase. The aggregate findings below, relying mainly on the results provided by the interview phase, suggest several key trends across the six study topics:

- **Hot Spots Beyond Initially Evacuated Areas**
  - All states said they would search for radiological hot spots, regardless of whether their plans specifically mention identifying hot spots.
  - The agencies responsible for identifying and measuring radiological contamination vary across the states.
  - Most states said they would not rely primarily on Federal assets, and would utilize their own resources first before requesting Federal assistance.
  - Exercising relocations due to hot spots has been limited to discussions during exercises.
- **Relaxation of Evacuation and Relocation Orders**
  - The purposes for temporary reentry generally varied across the states, though most states indicated that tending to agriculture and livestock and maintaining critical infrastructure and/or utilities would be valid purposes for routine reentry.
  - In general, the states emphasized life safety and maintenance of critical infrastructure, equipment, and utilities as high priority purposes for temporary reentry.
  - The majority of states interviewed said they would use the EPA PAGs as their criteria for both temporary reentry and permanent return, and all states said they would use the EPA PAGs as their relocation criteria.
  - Most states would develop guidance to the public for relocation, reentry, and/or return at the time of need.
  - All states would verify relocations, though the burden of verifying would often be on local jurisdictions.
- **Food Condemnation or Embargo**
  - All states said they would use the FDA DILs to determine the safety of food products.
  - Most states indicated they would rely on sampling to establish food control areas and initially would establish larger than necessary food control boundaries.
  - All states said they would work or consult with the Federal Government to determine the boundaries of a food control area, but none would solely defer to a Federal recommendation.
  - Most states indicated that they would release food from a food control area, depending on factors such as the concentration of contamination in food crops and livestock.
- **Water**
  - Most states expressed concern over potential radioactive contamination of drinking water.
  - All states indicated that potential drinking water contamination is addressed in their REP plans.
  - Most of the states have either addressed drinking water contamination in exercises or in real-world incidents.

    - The states identified EPA guidelines as their criteria for determining safe water consumption, though the AAR and plans reviews suggest that states may also rely on the FDA DILs or their basis.[34]
- **Evacuation Beyond the 10-Mile EPZ**
    - Most states indicated that it could potentially be necessary to evacuate the public beyond the 10-mile EPZ.
    - States presented multiple communications methods for informing the public about evacuation beyond the 10-mile EPZ.
    - States identified additional actions such as traffic control and setup of shelters and long-term housing.
    - Several states indicated that state or county-level all-hazards plans may address the challenges of evacuating beyond the 10-mile EPZ.
    - All states had dealt with real-world evacuations in the past 10 years.
- **Best Practices in the Immediate Phase**
    - States provided a number of alternative actions and related conditions for managing protective actions.
    - States offered best practices, mostly relating to technology tools and developing partnerships.
    - Other best practices focused on vulnerable populations such as the elderly and household pets.

Overall trends across the study areas included a focus on cooperation within states, regionally, and with the Federal Government; situation-dependent decision-making methods; conservative approaches to contamination and condemnation; concerns for managing radioactive waste, and the use of technology tools to enhance actions taken in the intermediate phase.

[34] Federal guidance on drinking water has evolved. As noted earlier in the report, the AARs and plans reviewed for the study predate EPA's 2017 issuance of a two-tier drinking water PAG. For the emergency tier, EPA noted that its 500 mrem drinking water PAG for the general population is "consistent with PAGs currently in place for other media in the intermediate phase (i.e., the FDA's 500 mrem PAG for ingestion of food; FDA 1998, FDA 2004)." EPA also expected action to achieve the second tier, a return to the steady-state Safe Drinking Water Act criteria, as early as possible and within no more than a year. See EPA, *PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents*, p. 53. Available online at: https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf (accessed February 20, 2017). Given the new drinking water PAG in the 2017 EPA PAG Manual, states may adjust the drinking water criteria in future updates of their plans and procedures.

7 CONCLUSIONS

Together, both phases of this study provided interesting insights into the capabilities and practices of OROs in the intermediate phase.

In particular, the interviews provided solid information and presented clear trends about the six study topics on ORO capabilities and practices. The review of the AARs and state plans augmented and tended to reinforce the interview results. There were several areas of consistency among the nine states interviewed, and reasonable conclusions may be drawn from the interview results. For example, OROs generally rely on the EPA PAGs and FDA DILs in their protective action decision-making; NRC modeling with MACCS can continue to use these values with confidence. Additional statistical value may be obtainable in the future should the interview questions ever be refined and adapted for a broader, more comprehensive survey to support NRC modeling assumptions on ORO practices and capabilities for PADs in the intermediate phase.

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APPENDIX A READ-AHEAD: INTERVIEWS FOR NUCLEAR REGULATORY COMMISSION STUDY

A.1 Study Purpose

The United States Nuclear Regulatory Commission (NRC) models consequences of incidents at nuclear power plants to understand potential benefits of regulations and safety measures. In its models, the NRC makes assumptions about the protective action decisions (PADs) and capabilities of offsite response organizations (OROs). The NRC is conducting a study to help ensure NRC assumptions about OROs' likely intermediate-phase PADs and associated capabilities in a General Emergency situation are as accurate as possible. A key part of the study is to interview ORO decision-makers and their staffs in various states, on a voluntary basis. Your willingness to take part in an interview for this study is greatly appreciated.

The study is expressly not meant to drive new regulations, seek changes to offsite oversight, or evaluate any ORO. The study is strictly a research project to improve modeling assumptions where possible. The study may also identify good practices that can be shared.

A.2 Interview Format

The information-gathering interview will last approximately 90 minutes. The study team will be represented by a facilitator/interviewer and a note-taker; ideally the state will be represented by several key agencies and positions involved in protective action decision-making for nuclear power plant incidents. Interview topics include:

1. Surveying for radiological hot spots beyond initially evacuated areas,
2. Relaxation of evacuation and relocation orders,
3. Food condemnation or embargo,
4. Safety of drinking water,
5. Evacuation beyond the 10-mile Emergency Planning Zone (EPZ), and
6. Potential best practices in intermediate-phase protective actions.

The study team will rely on an interview guide. This is *not* a survey, but a tool to ensure key questions are covered and that any nuance and explanation are captured. The interview is intended to be a stress-free, facilitated conversation. Results will be non-attributional: the final report will not identify any specific individual or state in association with a particular response. (For example, states may be referred to as State A, State B, State C, etc.)

A.3 Interview Preparation

The study team will provide the interview guide in advance. Interview participants are encouraged to read the interview guide in advance and come prepared with responses. Ideally interview participants can agree in advance on a consensus state response for the questions, but this is not necessary; facilitated discussion will help to collectively determine responses.

A.4 After the Interview: Analysis and Reporting

The interview group may contact the study team by email to request a summary of their particular interview session; please give roughly two weeks. The study team will use the interview data to determine trends or areas of strong agreement across OROs and to identify any best practices.

The final report, expected no earlier than May 2017, should advance NRC understanding of ORO practices and capabilities, as well as improve the technical basis for NRC modeling assumptions.

APPENDIX B INTERVIEW QUESTIONNAIRE

Note: This appendix reproduces the questions and, as applicable, multiple choice response options from the interview questionnaire in an accessible format compliant with Section 508 of the Rehabilitation Act (29 U.S.C. 794d).

This interview is part of an applied research project to improve the Nuclear Regulatory Commission's (NRC's) understanding and modeling of certain protective measures taken by offsite response organizations. Results will not be used to inform regulations or conduct evaluations.

Table B-1 Interview Questionnaire

Question	Response
A. Interview Participants *Please provide the name(s), title(s), organization(s), phone number(s), and email(s) of the interviewee(s) below. Continue at the end of the document if necessary. Identifying information is collected only for internal use in managing data; the final report will not attribute comments or data to any particular state or individual (e.g., participating States will be identified as State A, State B, etc.)*	
B. Hot Spots Beyond Initially Evacuated Areas *Intent* B1. Do your State's/jurisdiction's plans address conducting radiological surveys outside of initially evacuated areas in order to identify "hot spots"* and determine if others should evacuate? **Note: NRC defines a "hot spot" as a region in a radiation/contamination area where the level of radiation/contamination is significantly greater than in neighboring regions in the area.*	☐ Yes (Cite: _____) ☐ No
B2. Regardless of your plans, would your State/jurisdiction seek to identify "hot spots" requiring additional evacuations?	☐ Yes ☐ No
Resources B3. What State agency is responsible for identifying and measuring radiological contamination? (Note all that apply and identify responsible sub-organization, if applicable, e.g., Bureau of Radiation Protection.)	☐ Department of Environmental Protection ☐ Department of Health ☐ Other. Identify: _____

Question	Response
B4. Would the State rely primarily on Federal assets to perform "hot spot" survey functions? Note that this may involve a wait of 24-36 hours.	☐ Yes ☐ No, State would rely primarily on its own assets ☐ No, State would rely primarily on contracted assets ☐ No, State would rely primarily on mutual aid assets ☐ N/A. State will not seek identification of hot spots.
B5. Have your jurisdictions exercised requirements for additional evacuations due to hot spots?	☐ No, scenarios have not required such evacuations ☐ Yes, but only the decision-making (Describe: _____) ☐ Yes, both decision-making and implementation of additional evacuations (Describe: _____)
C. Relaxation of Evacuation and Relocation Orders *Priorities* C1. For what purposes would the State (or local authorities) allow temporary reentry?	☐ Recover possessions or business records ☐ Maintain equipment or utilities ☐ Tend pets or farm animals ☐ Other (identify: _____)
C2. Which of these purposes has the highest priority?	

Question	Response
Criteria C3. What are the criteria for temporary reentry?	☐ Reentry time is limited to ensure no one receives a dose exceeding the EPA relocation PAG of 2 rem first year, 0.5 rem in subsequent years ☐ Reentry time is subject to the Department of Energy's (DOE's) Preliminary Report on Operational Guidelines (developed for a radiological dispersal device [RDD] incident) ☐ Reentry time is subject to other criteria (describe: _____) ☐ State has not developed or identified criteria for temporary reentry
C4. What are the criteria for relocation after initial evacuation?	☐ 2 rem (20 mSv) projected dose first year, 0.5 rem (5 mSv)/year in subsequent years [current EPA protective action guide (PAG)] ☐ 5 rem (50 mSv) over 50 years [former EPA PAG] ☐ Other (explain: _____)
C5. For areas initially evacuated but found to be contaminated at levels below the EPA relocation PAG, what are the criteria for the public to permanently return?	☐ There are no criteria other than the EPA relocation PAG; public may return when it is operationally feasible ☐ Return is subject to other criteria (describe: _____) ☐ State has not developed or identified criteria for return ☐ State will not allow return to a contaminated area

Question	Response
Public Information C6. Has the State developed guidance to the public for relocation, reentry, and/or return? (Check all that apply.)	☐ Yes, State has guidance on relocation (list/cite: _____) ☐ Yes, State has guidance on reentry (list/cite: _____) ☐ Yes, State has guidance on return (list/cite: _____) ☐ No, State will develop guidance at time of need
Verification C7. Does the State verify that relocations are completed?	☐ Yes ☐ No
D. Food Condemnation and Embargo *Criteria* D1. What criteria would be used to determine the safety of contaminated or potentially contaminated food products (crops, livestock, milk, etc.)?	☐ Food and Drug Administration (FDA) derived intervention levels (DILs)* ☐ Other (explain) _____ **Note: FDA estimates the committed effective dose equivalent associated with its guidance (5 mSv or 500 mrem) would yield excess cancer mortality of 1 in 4,400.*
D2. If criteria other than FDA's would be used, they are:	☐ More conservative (i.e., involve lower concentrations of radioactive material) ☐ Less conservative (i.e., involve higher concentrations of radioactive material) ☐ N/A: FDA DILs are used
Extent. D3. How would the boundaries of a food control area be set?	☐ Strictly in accordance with the criteria. ☐ More widely then the criteria would indicate (i.e., with a buffer)
D4. If more widely, why?	

Question	Response
D5. What agency or organization is responsible for determining the boundaries of a food control area? Identify all that apply, and explain their roles in the determination.	☐ Office of the Governor ☐ State Department of Agriculture ☐ State Department of Public Health ☐ State Department of Environmental Quality ☐ Other: _____
D6. Will the responsible agency or organization defer to a Federal recommendation? If so, from which organization?	☐ No, State will rely primarily on its own experts ☐ Yes, from the A-Team (Advisory Team) [Advisory group with representatives from the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), the Centers for Disease Control and Prevention (CDC), and the U.S. Department of Agriculture (USDA)] ☐ Yes, from the NRC ☐ Yes, from the USDA ☐ Yes, from HHS ☐ Yes, from another Federal agency:
Disposition. D7. Will food crops and livestock be released from the food control area?	☐ Yes, if shown to be contaminated at a level below the criteria. ☐ Yes, if shown not to be contaminated at any detectable level. ☐ No, all crops in the initial food control area will be condemned and destroyed to ensure public confidence in the State's agricultural industry.

Question	Response
D8. If yes, what determines the areas and the crops or livestock within them that may be safely introduced into commerce? Note all that apply. Discuss any limitations.	**Radiological monitoring** ☐ Nuclear power plant personnel ☐ State monitoring teams ☐ Mutual aid monitoring teams (e.g., via EMAC) ☐ Federal monitoring teams ☐ Contract monitoring teams ☐ Other _____ **Sampling** ☐ State agriculture/radiation protection teams ☐ Mutual aid sampling teams ☐ Federal agriculture/radiation protection teams ☐ Contract sampling teams ☐ Other _____ **Laboratory testing** ☐ State laboratory resources ☐ Mutual aid laboratory resources ☐ Federal laboratory resources ☐ Contract laboratory resources ☐ Other _____
D9. What is the process for reducing or eliminating the food control area?	
D10. Is that process documented in a plan or procedure?	☐ Yes (Cite: _____) ☐ No
D11. How will the safety of released crops, livestock, and farmland be communicated to the media and the public?	

Question	Response
D12. What will be done with affected livestock and their by-products?	
E. Water *Applicability.* E1. Is potential radioactive contamination of drinking water a concern for your jurisdiction?	☐ Yes ☐ No
Plans/Exercises/Incidents. E2. Is potential drinking water contamination addressed in your radiological emergency preparedness plan?	☐ Yes (Cite: _____) ☐ No
E3. How have you dealt with drinking water contamination in exercises or real-world (non-radiological) incidents?	
Criteria. E4. After a radiological incident, what criteria would your jurisdiction use to determine that water is safe to drink?	☐ The Environmental Protection Agency's (EPA's) day-to-day maximum contaminant level for radionuclides under the Safe Drinking Water Act (4 mrem/yr)* ☐ A less conservative standard (i.e., involving higher concentrations of radioactive material) ☐ A more conservative standard (i.e., involving lower concentrations of radioactive material) **Note that EPA's 4 mrem/yr in water is less than FDA's 500 mrem for food, but the EPA limit assumes chronic, lifetime exposure.*
F. Evacuation Beyond the 10-Mile Emergency Planning Zone (EPZ) *Awareness.* F1. Do you agree that it could be necessary to evacuate the public from areas beyond the 10-mile EPZ?	☐ Yes ☐ No

Question	Response
Plans. F2. If it were necessary to evacuate the public from areas beyond the 10-mile EPZ, what actions would be required?	
F3. Do plans exist that may address some of these evacuation challenges?	☐ Yes, in our REP planning even though it is not required (Cite: _____) ☐ Yes, in our all-hazard plans and procedures (Cite: _____) ☐ No, but the following may address some of these challenges_____ ____.
F4. If plans do exist, do they include information on the availability of necessary personnel and equipment to implement the required actions?	
Real-World Experience. F5. In the last 10 years, has your State supported any public evacuations for real-world incidents?	☐ No ☐ Yes, 1-5 times ☐ Yes, 5-10 times ☐ Yes, more than 10 times
F6. If yes, please describe the largest such evacuation:	a. Year: _____ b. Hazard: _____ c. Approximate number of people evacuated: _____ d. Duration of evacuation: _____ e. Any issues encountered: _____ f. Was there a written plan that was used to support the evacuation? _____

Question	Response
G. Best Practices in the Intermediate Phase *Alternatives to Evacuation or Relocation* G1. Are there any alternative protective actions not mentioned previously that your jurisdiction would implement in the intermediate phase?	☐ Yes ☐ No
G2. If yes, please describe the conditions under which your jurisdiction would implement an alternative to evacuation and/or relocation:	
Radioactive Waste Management G3. Does your jurisdiction have any best practices or lessons learned with respect to managing radioactive waste?	
Best Practices and Lessons Learned G4. Is there any other action you would consider a 'Best Practice and/or Lessons Learned' for intermediate phase protective actions?	
G5. Are there any additional comments you would like to make regarding challenges in the intermediate phase?	

APPENDIX C DOCUMENT REVIEW GUIDE

Table C-1 Review Guide for AARs and State Radiological Emergency Plans

Topics for Review	Document Details
A. Documentation Type Indicate the title, site, local jurisdiction (if applicable), state, FEMA Region, and date of plan; also the Uniform Resource Locator (URL) and/or Agency wide Documents and Management System (ADAMS) accession number, if applicable.	Title: Site: Jurisdiction: State: FEMA Region: Date of Report/Plan: URL: ADAMS number:
B. Hot Spots Beyond Initially Evacuated Areas *Awareness* B1. Document references to jurisdiction's addressing surveying for "hot spots" and resources utilized in the after-action report (AAR)/plan.	Section: Page #: REP Standards/Criteria: Language:
Resources B2. Document references to what type of resources would be requested for 'hot spot' surveying.	Section: Page #: REP Standards/Criteria: Language:
B3. Document references to any additional evacuations taking place based on additional needs.	Section: Page #: REP Standards/Criteria: Language:
C. Relaxation of Evacuation and Relocation Orders *Priorities* C1. Document references to specific considerations given for temporary reentry in the AAR/plan.	Section: Page #: REP Standards/Criteria: Language:
C2. Document if these temporary reentry considerations are prioritized.	Section: Page #: REP Standards/Criteria: Language:
Criteria C3. Document references to the criteria for temporary reentry in the AAR/plan.	Section: Page #: REP Standards/Criteria: Language:

Topics for Review	Document Details
C4. Document references to the criteria for relocation after initial evacuation in the AAR/ plan.	Section: Page #: REP Standards/Criteria: Language:
C5. Document references to return criteria in the AAR/ plan.	Section: Page #: REP Standards/Criteria: Language:
Verification C6. Document references to relocation verification in the AAR/ plan.	Section: Page #: REP Standards/Criteria: Language:
D. Food Condemnation or Embargo *Criteria* D1. Document references to the criteria used to determine the safety of contaminated or potentially contaminated food products (crops, livestock, milk, etc.).	Section: Page #: REP Standards/Criteria: Language:
Extent D2. Document references to food control area boundaries in the AAR/ plan.	Section: Page #: REP Standards/Criteria: Language:
Disposition D3. Document responsibilities for establishing a food control area or embargo in the AAR/ plan.	Section: Page #: REP Standards/Criteria: Language:
D4. Document responsibilities for lifting a food control area or embargo in the AAR/ plan.	Section: Page #: REP Standards/Criteria: Language:
D5. Document responsibilities for crop/agricultural monitoring and surveys in the AAR/ plan.	Section: Page #: REP Standards/Criteria: Language:
D6. Document the process for reducing or eliminating the food control area	Section: Page #: REP Standards/Criteria: Language:

Topics for Review	Document Details
D7. Document references to communicating to the public the safety of released crops, livestock, and farmland	Section: Page #: REP Standards/Criteria: Language:
D8. Document references to what will be done with affected livestock and their by-products.	Section: Page #: REP Standards/Criteria: Language:
E. Water *Plans/Exercises/Incidents* E1. Document references to drinking water contamination or monitoring in the AAR/ plan.	Section: Page #: REP Standards/Criteria: Language:
Criteria E2. Document references to the criteria used to determine the safety of water.	Section: Page #: REP Standards/Criteria: Language:
F. Evacuation Beyond the 10-Mile Emergency Planning Zone (EPZ) *Intent* F1. Document references to evacuating the public from areas beyond the 10-mile EPZ and the actions required.	Section: Page #: REP Standards/Criteria: Language:
Resources. F2. Document references to the resources needed to evacuate beyond the 10-mile EPZ.	Section: Page #: REP Standards/Criteria: Language:
G. Best Practices in the Intermediate Phase *Alternatives to Evacuation or Relocation.* G1. Document references to alternative protective actions not mentioned previously.	Section: Page #: REP Standards/Criteria: Language:

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11. ABSTRACT (200 words or less)

This report documents the results of a study conducted to better understand the capabilities and practices of offsite response organizations (OROs) for protective actions in the intermediate phase of a radiological emergency response. The research consisted of:

- Interviews with state OROs regarding protective action decisions (PADs) and capabilities.
- Review of Federal Emergency Management Agency (FEMA) after action reports (AARs) from the Radiological Emergency Preparedness Program ingestion pathway exercises.
- Review of a sample of state radiological emergency response plans.

Nine states voluntarily participated in the interview process, including at least one state from eight of the nine FEMA regions with nuclear power plants. State practices were largely consistent in several areas, including using Federal guidelines and scientific procedures to inform protective action decision-making; working within and across various levels of government to develop and implement PADs; and utilizing resources from the Federal Government or mutual aid sources as needed.

The review of AARs yielded 35 with relevant information from 25 states. This review, combined with the review of 23 state radiological emergency response plans from 21 states, augmented the interview results. Results from the interviews and the documentary reviews may be used by the Nuclear Regulatory Commission to inform modeling assumptions.

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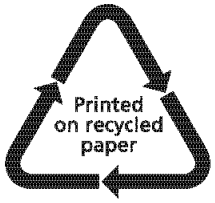

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