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Next Generation Nuclear Plant -

Emergency Planning Zone Definition at 400 Meters

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EXECUTIVE SUMMARY

Regulatory requirements for the establishment of exclusion area and low population zones around nuclear plants were initially established within the reactor siting criteria in the 1962 rule 10 CFR Part 100. Emergency planning requirements later expanded upon the Part 100 requirements, adding (in 1980) the requirement that two Emergency Planning Zones (EPZs), a plume exposure pathway EPZ and an ingestion pathway EPZ, be required. The size of these EPZs was stated as "about" 10 miles and 50 miles, respectively, and reflected a focus on large Light Water Reactors (LWRs). However, the fact that small LWRs and gas-cooled reactors presented less risk and thus could justify smaller EPZs was recognized and reflected in the emergency planning requirements. Specifically, the supplementary information accompanying the rulemaking included NRC's "Position on Planning Basis for Small Light-Water Reactors and Ft. St. Vrain":

> "The Commission has concluded that the operators of small light-water-cooled power reactors (less than 250 MWt) and the Ft. St. Vrain gas-cooled reactor may establish smaller planning zones which will be evaluated on a case-by-case basis. This conclusion is based on the lower potential hazard from these facilities (lower radionuclide inventory and longer times to release significant amounts of activity in many scenarios)."

Preapplication reviews of the Modular High Temperature Gas-cooled Reactor (MHTGR) and other small DOE sponsored designs, conducted in the mid- to late-1980's with the NRC, followed-up on this acknowledgement. The preapplication reviews considered DOE proposals for reducing the EPZ sizes to that of the Exclusion Area Boundary (EAB) and, in the process, provided justification for simplifying emergency planning requirements for such advanced reactor designs. The NRC concluded that a reduction of the EPZs could be achieved, adding that the approach to further simplification of emergency planning requirements represented a policy issue to be closed as part of a formal application review.

The purpose of this EPZ task is to better define the specific regulatory criteria that apply to the definition of the plume exposure pathway and ingestion pathway EPZ footprints and to then establish an initial licensing strategy to address and resolve issues that would currently appear to preclude implementation of the following criteria:

- For accident conditions, the dose limits for plume exposure and ingestion are assumed to apply at the exclusion area boundary (EAB) of the plant, which is expected to be in the range of 400 meters from the centerline of the reactor modules, and

- The expected (mean) offsite doses for accidents shall meet the Environmental Protection Agency (EPA) Protective Action Guides (PAGs).

The task objective is to establish a licensing strategy to simplify emergency planning requirements for the Next Generation Nuclear Plant (NGNP) that, when implemented, would:

- Permit distances for the plume exposure pathway EPZ and ingestion pathway EPZ that are less than the 10-mile and 50-mile zones currently used for large LWRs with the objective of significantly reducing the EPZs to distances more appropriate to HTGRs,
- Prepare arguments for sizing the exclusion area at a distance that allows for practical co-location of the nuclear (i.e., heat generation) and non-nuclear (i.e., heat application) facilities that comprise the NGNP (i.e., establish the EAB at about 400 meters from the reactor centerline),
- Demonstrate that radiological releases during normal and accident conditions (required for plant siting and emergency planning purposes) are less than the EPA Protective Action Guides (PAGs),
- Demonstrate appropriate siting and design features as defined by the NRC policy issue on emergency planning as an essential element in providing defense-in-depth, and
- Identify regulatory agencies beyond the NRC (e.g., Federal Emergency Management Agency (FEMA), Department of Homeland Security (DHS)) and public interfaces that must be engaged in order to properly integrate NGNP emergency preparedness into the nation's National Response Framework.

The recommendation is to pursue reduction of the most onerous emergency planning requirements, including (1) a reduction of the plume exposure pathway EPZ to the EAB or the area encompassing industrial plant workers, whichever is larger, and (2) a reduction of the ingestion pathway EPZ (i.e., that for which action may be required to protect the food chain) to a smaller size appropriate to the accident source terms from an HTGR.

Based on the review of regulations and guidance summarized in Section 2 of this report and on our current understanding of the NGNP design, the approach to licensing basis events and their corresponding radioactivity release source terms, simplification of emergency planning requirements can be pursued within the current regulations. However, additional NRC staff guidance with Commission review and approval may be required before reduced emergency planning requirements including reduced EPZs can be implemented for the NGNP.

The strategy and schedule described in Sections 3 and 4 address the above objectives by proposing strategy elements and specific tasks aimed at (1) making the plume exposure and ingestion pathway EPZ sizes as small as reasonable given the local site conditions and the PAG analysis results, with 400 meters radius as a target, and (2) simplifying emergency planning requirements.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

APPENDICES

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

Abbreviation or Acronym	Definition
ACRS	Advisory Committee on Reactor Safeguards
AEC	Atomic Energy Commission
ALAB	Atomic Licensing Appeals Board
ALARA	As Low As Reasonably Achievable
ALWR	Advanced Light Water Reactor
ANPR	Advanced Notice of Proposed Rulemaking
BL	Bulletin
BNL	Brookhaven National Laboratory
BWR	Boiling Water Reactor
CANDU	Canadian Deuterium Uranium Reactor
CFR	Code of Federal Regulations
COL	Construction and Operating License
DBA	Design Basis Accident
DG	Draft Guide
DHS	Department of Homeland Security
DOE	Department of Energy
EAB	Exclusion Area Boundary
EAL	Emergency Action Level
EPA	Environmental Protection Agency
EP	Emergency Planning
EPRI	Electric Power Research Institute
EPZ	Emergency Planning Zone
ESP	Early Site Permit
ESF	Engineered Safety Feature
ETE	Evacuation Time Estimate

LIST OF ACRONYMS (continued)

Abbreviation or Acronym	Definition
FDA	Final Design Approval
FEMA	Federal Emergency Management Agency
FR	Federal Register
FRC	Federal Radiation Council
FSAR	Final Safety Analysis Report
FSV	Fort St. Vrain
GSA	General Services Administration
HTGR	High Temperature Gas-cooled Reactor
IAEA	International Atomic Energy Agency
IN	Information Notice
INL	Idaho National Laboratory
ISG	Interim Staff Guidance
ITAAC	Inspections, Tests, Analyses and Acceptance Criteria
LBE	Licensing Basis Event
LCF	Latent Cancer Fatality
LLC	Limited Liability Company
LOCA	Loss of Coolant Accident
MCA	Maximum Credible Accident
MHTGR	Modular High Temperature Gas-cooled Reactor
MWt	Megawatts Thermal
NBS	National Bureau of Standards
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act
NGNP	Next Generation Nuclear Plant
NISAC	National Infrastructure Simulation and Analysis Center

LIST OF ACRONYMS (continued)

Abbreviation or Acronym	Definition
NRC	Nuclear Regulatory Commission
NRF	National Response Framework
NRIA	Nuclear/Radiological Incident Annex (to the NRF)
NUREG	Nuclear Regulatory Commission report
NUREG/CR	Nuclear Regulatory Commission Consultant Report
ORNL	Oak Ridge National Laboratory
PAG	Protective Action Guide
PB	Peach Bottom
PBMR	Pebble Bed Modular Reactor
PIUS	Process Inherent Ultimate Safety
PRA	Probabilistic Risk Assessment
PRISM	Power Reactor Innovative Small Module
PSER	Preapplication Safety Evaluation Report
PWR	Pressurized Water Reactor
QHO	Quantitative Health Objective
RI/PB	Risk-Informed, /Performance-Based
RIS	Regulatory Issue Summary
SECY	NRC Commissioner's Document (acronym)
SOARCA	State-of-the-Art Reactor Consequence Analysis
SRM	Staff Requirements Memorandum
STCP	Source Term Code Package
TEDE	Total Effective Dose Equivalent
TID	Technical Information Document
TMI	Three Mile Island
WIPP	Waste Isolation Pilot Plant

1 INTRODUCTION

1.1 Task Description

1.1.1 Element Description

The site layout for the Next Generation Nuclear Plant (NGNP) is being developed with a target configuration that is expected to offer a "footprint" that is acceptable and manageable for the end-users and/or owner-operators. There is a desire to reduce the plume exposure emergency planning zone (EPZ) of 10 miles and ingestion pathway EPZ of 50 miles that is required of current light water reactors to an area that approaches the exclusion area boundary (EAB) of the plant. [ref. 1]

Existing regulations include 10 CFR §50.47(c)(2), which states, in part: "The size of the EPZs also may be determined on a case-by-case basis for gas-cooled reactors …."

The purpose of this task is to better define the specific regulatory criteria that apply to the definition of the footprint and to then establish an initial licensing strategy to address and resolve issues that would currently appear to preclude implementation of the following criteria:

- For accident conditions, the dose limits for exposure and ingestion are assumed to apply at the EAB of the plant, which is expected to be in the range of 400 meters from the centerline of the reactor modules.
- The expected (mean) offsite doses for accidents shall meet the Environmental Protection Agency (EPA) Protective Action Guides (PAGs).[1]

1.1.2 Scope and Activities To Be Performed

Task 1: Identify and catalogue existing regulatory requirements and regulatory guidance documents that apply to the establishment of the footprint and are associated with the criteria stated in section 1.1.1.

Task 2: Provide a recommended strategy, with identification of proposed NGNP project activities and deliverables, to achieve the desired footprint.

[1] The values of initially defective fuel and particle failures (e.g., failure fraction) during normal operation and accident conditions are such that worker dose limits can be met with acceptable margin and the PAGs can be met at the EAB, thereby eliminating any technical need for offsite evacuation and sheltering plans.

Task 3: Based on Task 2, identify areas where regulatory guidance or requirements must be modified or revised.

Task 4: Provide a summary that describes the recommended strategy and a proposed schedule addressing and resolving the identified issues. This schedule should include logic ties to key project licensing activities.

The deliverables shall be a report containing the evaluations and analyses discussed in Tasks 1 through 4 above. The final report will summarize the strategy, implementation schedule and identify any regulatory requirements or proposed revisions that require special attention.

1.2 Background

Requirements on plant siting, areas of owner control, and offsite planning zones have evolved over a period of time with the majority of the focus on light-water reactor (LWR) power plants. Today's regulatory framework reflects decisions made for large LWRs, but also includes allowances for small LWRs and for non-LWRs. These allowances –noted in the requirements – have generally remained unfulfilled pending industry deployment of such reactors. One such requirement involves the determination of the appropriate sizes for emergency planning zones for High Temperature Gas-cooled Reactors (HTGRs).

The original plant siting regulation (10 CFR Part 100) required an exclusion area and a low population zone (LPZ) be established around each power reactor. In the 1970's, a joint Nuclear Regulatory Commission (NRC) – Environmental Protection Agency (EPA) task force studied the requirements for offsite emergency planning and recommended that two emergency planning zones (EPZs) be established in addition to the 10 CFR Part 100 required zones. The recommended EPZs included a plume exposure pathway EPZ "of about 10 miles" and an ingestion pathway EPZ "of about 50 miles". The task force recommendation on EPZ distances was based on the then existing experience with large LWR designs. In 1980, the NRC added a new section 10 CFR §50.47 that made mandatory the task force recommendations on EPZs, stating in the rule itself:

> "The exact size and configuration of the EPZs surrounding a particular nuclear power reactor shall be determined in relation to local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries."

Notably, for gas-cooled reactors, the rule added:

> "The size of the EPZs also may be determined on a case-by-case basis for gas-cooled reactors."

During the 1980's and 1990's, siting and emergency planning requirements were reviewed as part of efforts to incorporate realistic source terms and plant performance into NRC's regulations. Reactor siting requirements in 10 CFR Part 100 were revised and a new section 10 CFR §50.67 allowing the use of alternate source terms for LWRs on a backfit basis was added. Concurrently, the NRC prepared a policy paper, SECY 1997-0020, *Results of Evaluation of Emergency Planning for Evolutionary and Advanced Reactors* [ref. 2], which outlined a "roadmap" for establishing the size of EPZs for evolutionary and advanced LWRs. SECY 1997-0020 stated that EPZs for future reactors could be reduced significantly, but allowed that defense-in-depth considerations would weigh heavily in any licensing action undertaken in pursuit of the approach. While advanced reactor designs, such as HTGRs, were not specifically addressed, the SECY did consider the roadmap suitable for such reactors:

> "However, the same process used for evaluating EP for the evolutionary and advanced LWRs, as described in this paper, would be appropriate for evaluating EP for the more-advanced reactor designs. Changes to EP requirements may be warranted for advanced reactor designs for which the consequences from potential accidents are reduced or the timing or composition of potential releases are different from that for current reactor designs."

The role of emergency planning and its relationship to other requirements for advanced reactors was evaluated during preapplication reviews of non-LWRs (e.g., MHTGR, PRISM, etc.). In NUREG-1338, *Draft Preapplication Safety Evaluation Report for the Modular High-Temperature Gas-Cooled Reactor* [ref. 3], the NRC staff generally agreed with DOE's proposal for significantly reducing emergency planning requirements for advanced reactors. The staff noted the implications of reducing or eliminating the EPZs as tied to NRC's overall policy on maintaining emergency planning as an essential element of defense-in-depth. The cessation of the MHTGR preapplication review in 1994, however, resulted in the issue remaining open.

NRC's current position on emergency planning is described in SECY 2003-0047, *Policy Issues Related to Licensing Non-Light-Water Reactor Designs* [ref. 4]:

> "The Commission, in its staff requirements memorandum (SRM) of July 30, 1993, stated that it was premature to reach a conclusion on emergency planning for advanced reactors and that for ongoing review purposes, the staff should use existing regulatory requirements. The SRM went on to say that the staff should remain open to suggestions to simplify the emergency planning requirements for reactors that are designed with greater safety margins, and that the work on EP should be closely correlated with work on accident evaluation and source term, in order to avoid unnecessary conservatism."

Phrasing the EPZ sizing policy question as: "Under what conditions can the emergency planning zone (EPZ) be reduced, including a reduction to the site exclusion area boundary?" the NRC staff stated:

> "The staff recommends that no change to emergency preparedness requirements be made at this time. This recommendation is consistent with the guidance contained in the Commission's July 30, 1993, SRM and is based upon the following two considerations:
>
> - Provision already exists in 10 CFR 50.47 for accommodating the unique aspects of high-temperature gas reactors.
> - In the near term, new plants are likely to be built on an existing site which conforms to current requirements.
>
> If approved by the Commission, the role of emergency preparedness in defense-in-depth would be addressed as part of the development of a policy or description of defense-in-depth as recommended under Issue 2 above. In the longer term, if and when a need for change in emergency preparedness requirements is identified, that policy or description would serve as guidance in assessing the proposed change."

In its SRM, the Commission approved the staff's recommendation.

1.3 Outline of This Report

This paper addresses the considerations contained in the NRC staff recommendation. Section 2 provides a historic perspective on the development of the existing emergency preparedness requirements, defines the zones around a nuclear power plant, identifies the regulatory requirements and guidance related to the zones, and adds background information on how the EPZ sizing issue has been considered during prior reviews of non-LWR designs.

Section 3 identifies the elements of a strategy for simplifying emergency planning requirements for the NGNP. Detailed discussion is provided for each of seven strategy elements that, when taken together, establish a licensing approach to lessen the emergency planning burden for the NGNP.

Section 4 summarizes the tasks derived from the recommended strategy elements and provides a proposed schedule to be implemented in the NGNP work plan.

Three appendices are included that detail the historical background behind emergency planning requirements (Appendix A), provide a bibliography of related documents (Appendix B), and summarize prior NRC review of the issues as documented in the preapplication review for the MHTGR (Appendix C).

1.4 Strategy Elements

The objective of the EPZ task is to establish a licensing strategy to simplify emergency planning requirements for the NGNP that, when implemented, would:

- Permit distances for the plume exposure pathway EPZ and ingestion pathway EPZ that are less than the 10-mile and 50-mile zones currently used for large LWRs with the objective of significantly reducing the EPZs to distances more appropriate to HTGRs,
- Prepare arguments for sizing the exclusion area at a distance that allows for practical co-location of the nuclear (i.e., heat generation) and non-nuclear (i.e., heat application) facilities that comprise the NGNP (i.e., establish the EAB at about 400 meters from the reactor centerline),
- Demonstrate that radiological releases during normal and accident conditions (required for plant siting and emergency planning purposes) are less than the EPA Protective Action Guides (PAGs),
- Demonstrate appropriate siting and design features as defined by the NRC policy issue on emergency planning as an essential element in providing defense-in-depth, and
- Identify regulatory agencies beyond the NRC (e.g., Federal Emergency Management Agency (FEMA), Department of Homeland Security (DHS)) and public interfaces that must be engaged in order to properly integrate NGNP emergency preparedness into the nation’s National Response Framework.

The proposed approach includes the following strategy elements:

Strategy Element 1 − Establish the technical basis for compliance with the PAGs. Perform a technical analysis of the NGNP to establish the mechanistic source term and doses needed to achieve the smallest possible plume exposure and ingestion pathway EPZs that meet the PAG criteria. The bases for conclusions should be clearly stated with justifications and explanations as appropriate. This technical assessment includes development of the methods, assumptions, and acceptance criteria for a gas-cooled reactor, with results expected comparable to those described in the historical literature.

Strategy Element 2 − Develop regulatory position statement(s) for simplifying emergency planning requirements for the NGNP. Given demonstration of compliance with the PAGs, proactively take a position that the design of and risk for a gas-cooled reactor is significantly different from that for an LWR (for which existing emergency planning requirements were developed) that any emergency can be addressed using a type of emergency response planning normally used for industrial facilities (e.g., refineries, chemical processing plants). NRC's roadmap, SECY 1997-0020, allowed that changes to emergency planning requirements may be warranted for advanced reactor designs for which the consequences from potential accidents are reduced or the timing or composition of potential releases are different from that for current reactor designs.

Strategy Element 3 − Address the other factors as identified in the SECY 1997-0020 "roadmap". NRC's roadmap also included discussion of factors other than dose analyses needed to meet the PAGs. These factors include consideration of the 10 CFR Part 100 siting factors and identification of accident progression sequences more appropriate to the design (e.g., consideration of timing or radionuclide composition of potential releases). This strategy element also needs to address NRC Commission direction for retention of emergency planning as an essential element of defense-in-depth in providing adequate assurance of plant safety.

Strategy Element 4 – Establish the EAB for the NGNP at a distance commensurate with meeting the PAGs for each of the candidate site(s). The distance to the EAB needs to allow for sites having different emergency planning considerations, e.g., siting the NGNP at the INL versus at an existing nuclear site (other than the INL), or at an industrial site not having an existing nuclear plant. Integration of a new emergency plan (for the NGNP) with an existing plan (existing nuclear plant or industrial facility) will need to be examined.

Strategy Element 5 − Assess ongoing emergency planning and security rulemakings to assure continued viability of the NGNP approach. NRC initiatives in the areas of enhanced emergency planning, security, risk-informed requirements development, and interagency coordination need to be followed and impacts potentially affecting the NGNP strategy need to be identified. This may require proactive engagement with the NRC to shape emergent regulatory requirements favorably for modular gas reactors. Based on the results of Strategy Elements 2 and 3, re-confirm the adequacy of current regulations and identify any necessary new guidance or policy statements or revisions to existing guidance and policies.

Strategy Element 6 – Prepare and implement communications plan(s) for engaging with Federal, state, and local agencies (e.g., NRC/FEMA/et al) having cognizance over emergency planning efforts. The emergency planning approach taken for the NGNP needs to be communicated with the affected governmental agencies to assure continuity in direction and in requirements.

Strategy Element 7 − Develop an NGNP white paper for submittal to the NRC describing the NGNP emergency planning approach. The paper needs to convey the NGNP project's understanding of the regulatory background, requirements and guidance, state the strategy approach, identify outcome objectives from the NRC, and detail a series of preapplication engagement activities to serve as a means of communicating with NRC staff. It is recognized that some related issues (e.g., mechanistic source term and dose assessment) will not be resolved in the near term, but the paper should be written contingent on completion of the related activities. This paper should present the overall EPZ reduction program and its supporting activities, including those activities that should be led by the Alliance.

1.5 Summary and Recommendations

Based on the review of regulations and guidance summarized in Section 2 of this report and on our current understanding of the NGNP design, the approach to licensing basis events and their corresponding radioactivity release source terms, simplification of emergency planning requirements can be pursued within the current regulations. However, additional NRC staff guidance with Commission review and approval may be required before reduced emergency planning requirements including reduced EPZs can be implemented for the NGNP.

The strategy and schedule described in Sections 3 and 4 address the above objectives by proposing strategy elements and specific tasks aimed at (1) making the plume exposure and ingestion pathway EPZ sizes as small as reasonable given the local site conditions and the PAG analysis results, with 400 meters radius as a target, and (2) simplifying emergency planning requirements.

2 REGULATORY FRAMEWORK

Per NRC regulations, multiple zones are required around nuclear power plants in which onsite and offsite actions are specified. This section identifies these zones and states the requirements for each in terms of sizing and activities permitted or prescribed. Regulatory guidance that amplifies or clarifies the guidance is provided as well as examples of how the requirements have been interpreted in past gas-cooled reactor applications.

2.1 Historical Perspective

Regulatory requirements for the establishment of zones around nuclear plants were initially proposed in the late 1950's when the Atomic Energy Commission (AEC) solicited public comment on proposed siting criteria for power and test reactors. Following significant comment, the AEC published a new rule (10 CFR Part 100) requiring that specific zones be established: an exclusion area and a low population zone.[2] The determination of what constituted sufficient size for each zone was included in a technical information (guidance) document TID-14844, *Calculation of Distance Factors for Power and Test Reactor Sites*. [ref. 5] TID-14844 described a multiplicity of factors and introduced an example calculation that used conservative assumptions in attempting to define a "maximum credible accident" (MCA) for light-water reactors. One of the acknowledgements of the report was:

> "Thus, even in the postulated maximum credible accident should occur, the resulting exposure doses would probably be many times lower than those calculated by the indicated method."

In the Federal Register Notice for the new 10 CFR Part 100 [ref. 6], the AEC stated:

> "(b) Insufficient experience has been accumulated to permit the writing of detailed standards that would provide a quantitative correlation of all factors significant to the question of suitability of reactor sites. This part is intended as an interim guide to identify a number of factors considered by the Commission in the evaluation of reactor sites and the general criteria used at this time as guides in approving or disapproving proposed sites. Any applicant who believes that factors other than those set forth in the guide should be considered by the Commission will be expected to demonstrate the applicability and significance of such factors."

[2] The new rule also included a requirement that power reactors be sited away from population centers and specified a "population center distance" siting factor of one and one-third times the outer boundary of the low population zone. This is a factor for consideration during plant siting and is not a specific zone.

Notwithstanding this statement, the purpose section of the new 10 CFR Part 100, the example calculation method described in TID-14844 became a *de facto* standard that is retained in many Regulatory Guides in existence today.

A new Appendix E to 10 CFR Part 50 was added in 1970 [ref. 7] that required that an emergency plan be prepared by each power reactor applicant. Not included at the time was the identification of formal emergency planning zones; nor was the reactor applicant required to coordinate emergency planning activities with offsite (local) governmental agencies.

In the 1970's, increased federal agency coordination in emergency planning was directed. Using joint task forces, the NRC and the EPA reviewed plant siting and emergency planning requirements, arriving at a number of recommendations. Included was the recommendation that EPA PAGs be used in conjunction with the expanding review of LWR accident analyses to help establish a set of emergency response actions.[3] Another recommendation was that formal EPZs be established. The addition of a new section 10 CFR §50.47 in 1980 [ref. 8] included the requirement for two zones: a plume exposure pathway EPZ "of about 10 miles" and an ingestion pathway EPZ "of about 50 miles". As with 10 CFR Part 100, these new EPZs were stated in terms of approximations with allowance for design and site factors.

In the supplementary information accompanying the 10 CFR §50.47 rule, the NRC described its "Emergency Planning Zone Concept" as:

> "…a conservative emergency planning policy in addition to the conservatism inherent in the defense-in-depth philosophy. ... [T]wo Emergency Planning Zones (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 large enough to provide a response base that would support activity outside the planning zone should this ever be needed."

This description of the EPZ concept was followed in the supplementary information by NRC's "Position on Planning Basis for Small Light-Water Reactors and Ft. St. Vrain" in which:

> "The Commission has concluded that the operators of small light-water-cooled power reactors (less than 250 MWt) and the Ft. St. Vrain gas-cooled reactor may

3 Radiation incident PAGs were initially used in the late 1950's and early 1960's to establish a set of guidance actions to take in response to the fallout from atomic weapons testing. The NRC/EPA Task Force on Emergency Planning recommended that the PAGs be updated and used to structure a framework for offsite emergency response actions tied to a spectrum of postulated accidents from minor through severe (Class 9).

> establish smaller planning zones which will be evaluated on a case-by-case basis. This conclusion is based on the lower potential hazard from these facilities (lower radionuclide inventory and longer times to release significant amounts of activity in many scenarios)."

During the 1980's and 1990's, siting and emergency planning requirements were reviewed as part of efforts to incorporate realistic source terms and plant performance into NRC's regulations. Reactor siting requirements in 10 CFR Part 100 were revised and a new section 10 CFR §50.67 allowing the use of alternate source terms for LWRs on a backfit basis was added. A "roadmap" for evaluating proposed reductions in EPZ sizes for future reactors was outlined in a policy paper, SECY 1997-0020, *Results of Evaluation of Emergency Planning for Evolutionary and Advanced Reactors* [ref. 9].

Appendix A includes a more detailed description of the historical development of siting and emergency planning requirements for power reactors. Appendix B includes a bibliography of related documentation.

2.2 Glossary of Planning Zones Around a Nuclear Power Plant

Multiple planning areas or zones are required around a nuclear power plant. Reactor siting regulations in 10 CFR Part 100 specify two zones[4], defining these as:

> ***Exclusion area*** means that area surrounding the reactor, in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area. This area may be traversed by a highway, railroad, or waterway, provided these are not so close to the facility as to interfere with normal operations of the facility and provided appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway, in case of emergency, to protect the public health and safety. Residence within the exclusion area shall normally be prohibited. In any event, residents shall be subject to ready removal in case of necessity. Activities unrelated to operation of the reactor may be permitted in an exclusion area under appropriate limitations, provided that no significant hazards to the public health and safety will result.
>
> ***Low population zone*** means the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be

[4] 10 CFR §100.3 also includes a definition for *population center distance*, defining it as the distance from the reactor to the nearest boundary of a densely populated center containing more than about 25,000 residents. As this is a factor for consideration during plant siting and is not a specific zone, it is not included in the glossary of zones above.

taken in their behalf in the event of a serious accident. These guides do not specify a permissible population density or total population within this zone because the situation may vary from case to case. Whether a specific number of people can, for example, be evacuated from a specific area, or instructed to take shelter, on a timely basis will depend on many factors such as location, number and size of highways, scope and extent of advance planning, and actual distribution of residents within the area.

Emergency planning regulations in 10 CFR Part 50 specify two zones. Unlike the siting zones, the definition of the EPZs is not specified exactly in the regulations but must be summarized from guidance documents, notably NUREG-0396 [ref. 10].

> ***Plume exposure pathway EPZ*** for nuclear power reactors shall consist of an area about 10 miles (16 km) in radius. The principal exposure sources from this pathway are (a) whole body external exposure to gamma radiation from the plume and from deposited material and (b) inhalation exposure from the passing radioactive plume. The time of potential exposure could range from hours to days.
>
> ***Ingestion pathway EPZ*** shall consist of an area about 50 miles (80 km) in radius. The plans for the ingestion pathway shall focus on such actions as are appropriate to protect the food ingestion pathway. The principal exposure from this pathway would be from ingestion of contaminated water or foods such as milk or fresh vegetables. The time of potential exposure could range in length from hours to months.

Physical protection (e.g., security) regulations in 10 CFR Part 73 specify multiple inter-related areas and zones, defining them as:

> ***Controlled access area*** means any temporarily or permanently established area which is clearly demarcated, access to which is controlled and which affords isolation of the material or persons within it.
>
> ***Isolation zone*** means any area adjacent to a physical barrier, clear of all objects which could conceal or shield an individual.
>
> ***Material access area*** means any location which contains special nuclear material, within a vault or a building, the roof, walls, and floor of which each constitute a physical barrier.
>
> ***Protected area*** means an area encompassed by physical barriers and to which access is controlled. An isolation zone shall be maintained around the physical barrier at the perimeter of the protected area and any part of the building used as part of that physical barrier. The isolation zone shall be monitored to detect the presence of individuals or vehicles within the zone so as to allow response by

armed members of the license security organization to be initiated at the time of penetration of the protected area. Parking facilities, both for employees and visitors, shall be located outside the isolation zone.

Vital area means any area which contains vital equipment. Vital equipment means any equipment, system, device, or material, the failure, destruction, or release of which could directly or indirectly endanger the public health and safety by exposure to radiation. Equipment or systems which would be required to function to protect public health and safety following such failure, destruction, or release are also considered to be vital. A vital area shall be located within a protected area such that access to vital equipment requires passage through at least two physical barriers. More than one vital area may be within a single protected area.

Used, but not defined in the security regulations, is the term "owner controlled area". This term is interpreted generally to be equivalent to the exclusion area required by 10 CFR Part 100.

Figure 2-1 depicts these various zones.

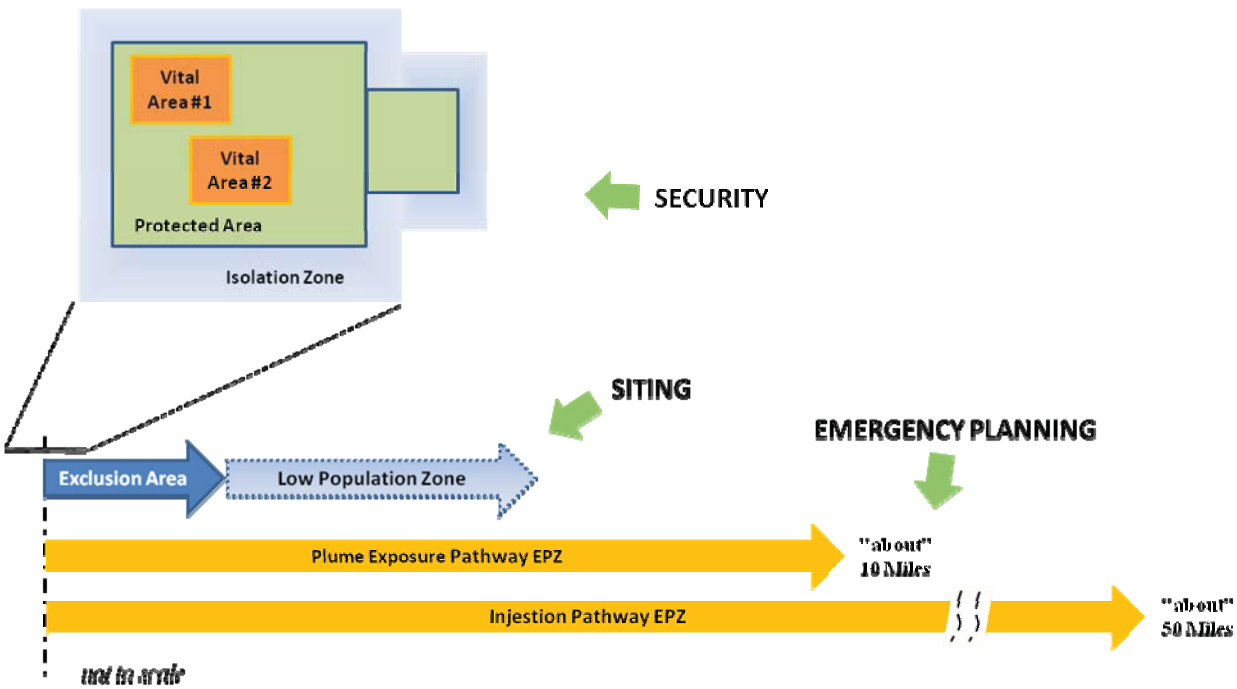
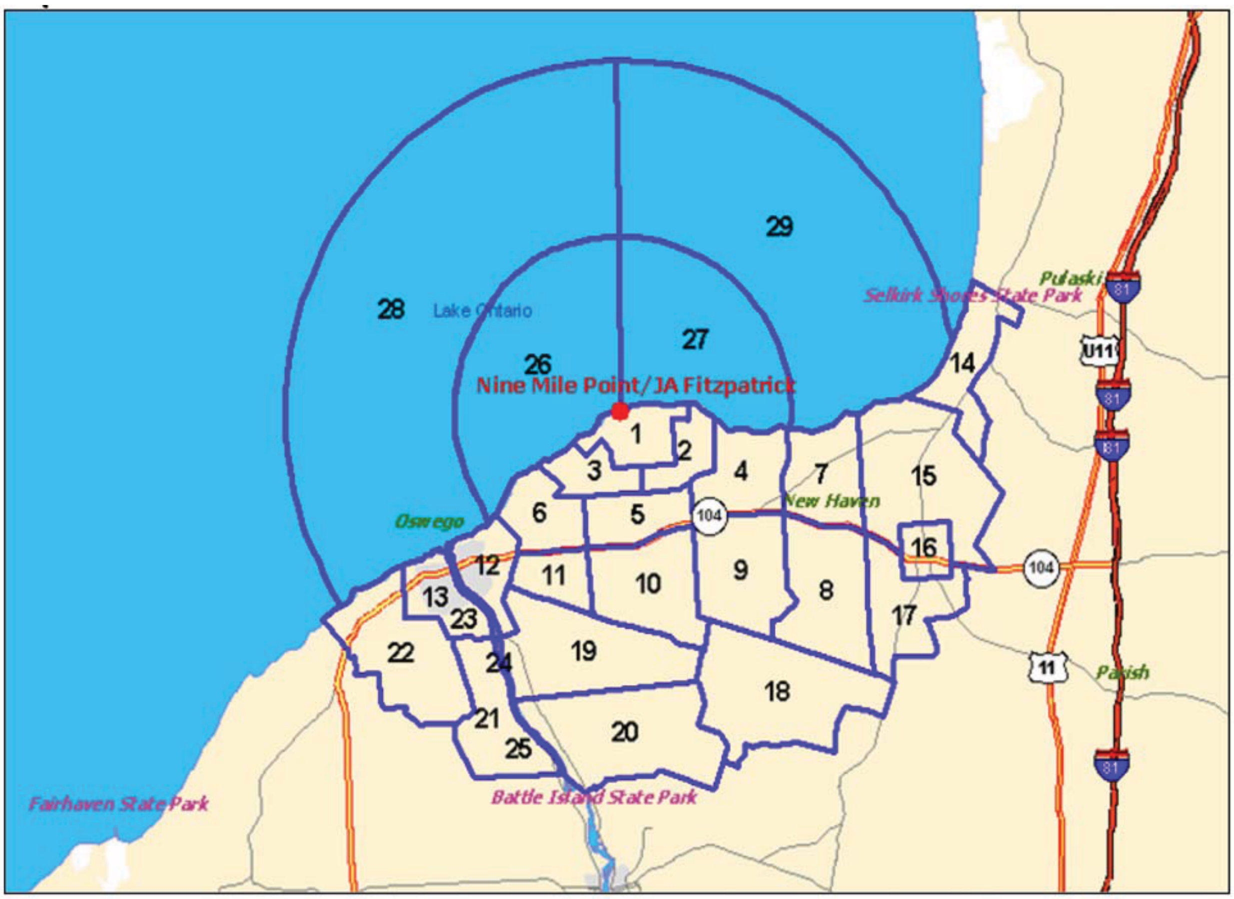


Figure 2-1: Depiction of Zones Around a Nuclear Power Plant

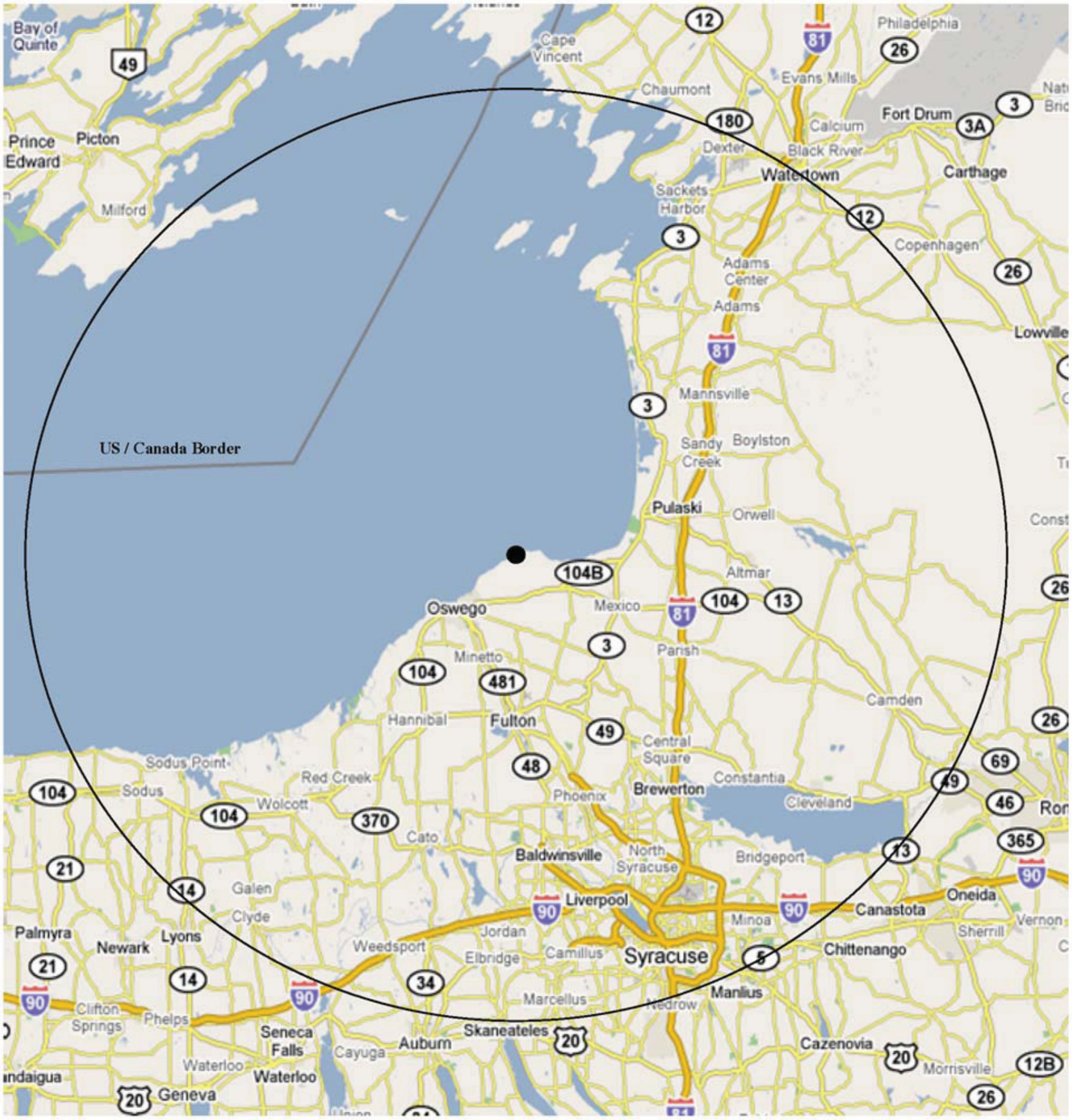
Figure 2-2 depicts a typical 10-mile plume exposure pathway, shown here for the Nine Mile Point nuclear plant. Noticeable is that the EPZ selected by the plant owner is not an exact circle but allows for considerations of local conditions such as demography, topography, land characteristics, access routes, and local jurisdictional boundaries. Figure 2-3 depicts the corresponding 50-mile ingestion pathway EPZ for the Nine Mile Point nuclear plant.

In siting a new nuclear plant adjacent to an existing unit(s), the plume exposure pathway is selected based upon the midpoint between the units. The Bell Bend Nuclear Power Plant introduces a slightly different consideration as the new unit will be located on the same property as that of the existing Susquehanna Steam Electrical Station but at a distance approximately 0.6 mile away from the existing plant. The intent is that initially there will be two emergency plans for the site. Combining the two emergency plans is an option for later consideration. Figure 2-4 depicts the two plume exposure pathway EPZs for these co-located plants.



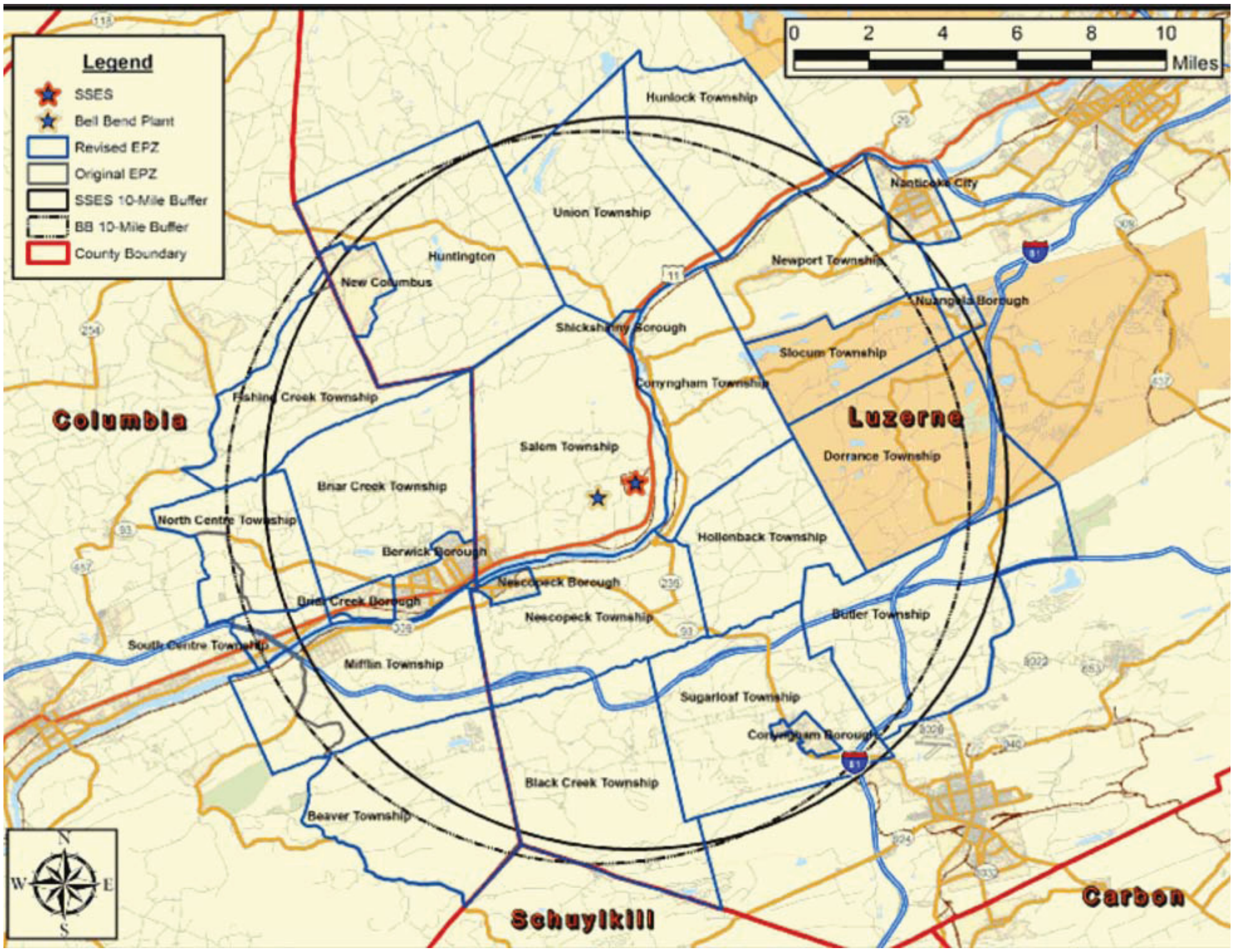
Source: Ref.11, Figure 1-2

Figure 2-2: Example of 10 Mile Plume Exposure Pathway EPZ (Nine Mile Point)



Source: Ref.11, Figure 1-3

Figure 2-3: Example of 50 Mile Ingestion Pathway EPZ (Nine Mile Point)



Source: Ref.,12 Page 11C-17

**Figure 2-4: Example of Co-located Plume Exposure Pathway EPZs
(Bell Bend Nuclear Power Plant and Susquehanna Steam Electric Station)**

2.3 Regulatory Requirements

2.3.1 Plant Siting Requirements

Existing regulation 10 CFR §100.21(a) states that "Every site must have an exclusion area and a low population zone." §100.21 then lists the non-seismic siting factors as:

> "(b) The population center distance, as defined in § 100.3, must be at least one and one-third times the distance from the reactor to the outer boundary of the low population zone. In applying this guide, the boundary of the population center shall be determined upon consideration of population distribution. Political boundaries are not controlling in the application of this guide;

> (c) Site atmospheric dispersion characteristics must be evaluated and dispersion parameters established such that:
>
> (1) Radiological effluent release limits associated with normal operation from the type of facility proposed to be located at the site can be met for any individual located offsite; and
>
> (2) Radiological dose consequences of postulated accidents shall meet the criteria set forth in § 50.34(a)(1) of this chapter for the type of facility proposed to be located at the site;
>
> (d) The physical characteristics of the site, including meteorology, geology, seismology, and hydrology must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site;
>
> (e) Potential hazards associated with nearby transportation routes, industrial and military facilities must be evaluated and site parameters established such that potential hazards from such routes and facilities will pose no undue risk to the type of facility proposed to be located at the site;
>
> (f) Site characteristics must be such that adequate security plans and measures can be developed;
>
> (g) Physical characteristics unique to the proposed site that could pose a significant impediment to the development of emergency plans must be identified;
>
> (h) Reactor sites should be located away from very densely populated centers. Areas of low population density are, generally, preferred. However, in determining the acceptability of a particular site located away from a very densely populated center but not in an area of low density, consideration will be given to safety, environmental, economic, or other factors, which may result in the site being found acceptable."

Criterion (h) does not mandate that power reactors be sited in areas of low population density, but states a preference. The footnote to criterion (h) describes factors for consideration when siting in more densely populated areas.

> "Examples of these factors include, but are not limited to, such factors as the higher population density site having superior seismic characteristics, better access to skilled labor for construction, better rail and highway access, shorter transmission line requirements, or less environmental impact on undeveloped areas, wetlands or endangered species, etc. Some of these factors are included in, or impact, the other criteria included in this section."

2.3.2 Emergency Planning Requirements

General

Emergency planning requirements and the need to consider emergency planning zones (EPZs) beyond the exclusion area and LPZ requirements of 10 CFR Part 100 came into existence in the 1970's. The emergency planning regulation, 10 CFR §50.47(c)(2), issued as a final rule in 1980, specifies that EPZs are to be considered and defines the size of the EPZs as:

> "Generally, the plume exposure pathway EPZ for nuclear power plants shall consist of an area about 10 miles (16 km) in radius and the ingestion pathway EPZ shall consist of an area about 50 miles (80 km) in radius. The exact size and configuration of the EPZs surrounding a particular nuclear power reactor shall be determined in relation to local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries."

10 CFR §50.47(c)(2) also allows that: "The size of the EPZs also may be determined on a case-by-case basis for gas-cooled reactors."

Footnote 1 in Appendix E to 10 CFR Part 50 states:

> "EPZs for power reactors are discussed in NUREG–0396; EPA 520/1–78–016, ''Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants,'' December 1978. The size of the EPZs for a nuclear power plant shall be determined in relation to local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries. The size of the EPZs also may be determined on a case-by-case basis for gas cooled nuclear reactors and for reactors with an authorized power level less than 250 MW thermal. Generally, the plume exposure pathway EPZ for nuclear power plants with an authorized power level greater than 250 MW thermal shall consist of an area about 10 miles (16 km) in radius and the ingestion pathway EPZ shall consist of an area about 50 miles (80 km) in radius."

This approach to stating the size requirements for EPZs is included in other sections of the CFR that address applications for construction permits, operating licenses, Early Site Permits (ESPs) and combined Construction and Operating Licenses (COLs). For example, 10 CFR §52.77, *Contents of applications; general information*, states that the information requirements in 10 CFR §50.33 must be contained in a COL application. 10 CFR §50.33 states:

"(g) If the application is for an operating license or combined license for a nuclear power reactor, or if the application is for an early site permit and contains plans for coping with emergencies under § 52.17(b)(2)(ii) of this chapter, the applicant shall submit radiological emergency response plans of State and local governmental entities in the United States that are wholly or partially within the plume exposure pathway emergency planning zone (EPZ),[4] as well as the plans of State governments wholly or partially within the ingestion pathway EPZ.[5] If the application is for an early site permit that, under 10 CFR 52.17(b)(2)(i), proposes major features of the emergency plans describing the EPZs, then the descriptions of the EPZs must meet the requirements of this paragraph. Generally, the plume exposure pathway EPZ for nuclear power reactors shall consist of an area about 10 miles (16 km) in radius and the ingestion pathway EPZ shall consist of an area about 50 miles (80 km) in radius. The exact size and configuration of the EPZs surrounding a particular nuclear power reactor shall be determined in relation to the local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries. The size of the EPZs also may be determined on a case-by-case basis for gas-cooled reactors and for reactors with an authorized power level less than 250 MW thermal. The plans for the ingestion pathway shall focus on such actions as are appropriate to protect the food ingestion pathway.

Footnotes:

[4] Emergency planning zones (EPZs) are discussed in NUREG–0396, EPA 520/1–78–016, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light-Water Nuclear Power Plants," December 1978.

[5] If the State and local emergency response plans have been previously provided to the NRC for inclusion in the facility docket, the applicant need only provide the appropriate reference to meet this requirement."

In referring to the report of the Joint NRC/EPA Task Force on Emergency Planning (NUREG-0396) [ref. 10], the requirement above (in §50.33) states the size threshold for small reactors as *less than* 250 MW thermal. This differs slightly from the report text which describes the size threshold for reactors *greater than* 250 MWt. The Task Force report was described further in NUREG-0654/FEMA-REP-1 [ref. 13], which included guidance on:

"The choice of the size of the Emergency Planning Zones represents a judgment on the extent of detailed planning which must be performed to assure an adequate response base. In a particular emergency, protective actions might well be restricted to a small part of the planning zones. On the other hand, for the worst possible accidents, protective actions would need to be taken outside the planning zones.

The Task Force selected a radius of about 10 miles for the plume exposure pathway and a radius of about 50 miles for the ingestion exposure pathway, as shown in Figure 1 and in Table 1[6]. Although the radius for the EPZ implies a circular area, the actual shape would depend upon the characteristics of a particular site.

Footnote:

[6] These radii are applicable to light water nuclear power plants, rated at 250 MWt or greater. The FEMA/NRC Steering Committee has concluded that small water cooled power reactors (less than 250 MWt) and the Fort St. Vrain gas cooled reactor may use a plume exposure emergency planning zone of about 5 miles in radius and an ingestion pathway emergency planning zone of about 30 miles in radius. In addition, the requirements for the alerting and notification system (Appendix 3) will be scaled on a case-by-case basis. This conclusion is based on the lower potential hazard from these facilities (lower radionuclide inventory and longer times to release significant amounts of activity for many accident scenarios). The radionuclides considered in planning should be the same as recommended in NUREG-0396/EPA-520/1-78-016."

Table 1 and Figure 1 from NUREG-0654/FEMA-REP-1 are repeated below as Table 2-1 and Figure 2-5, respectively. Table 2-2, a reprint of Table 2 from the NUREG, then describes the timing and duration of accident releases.

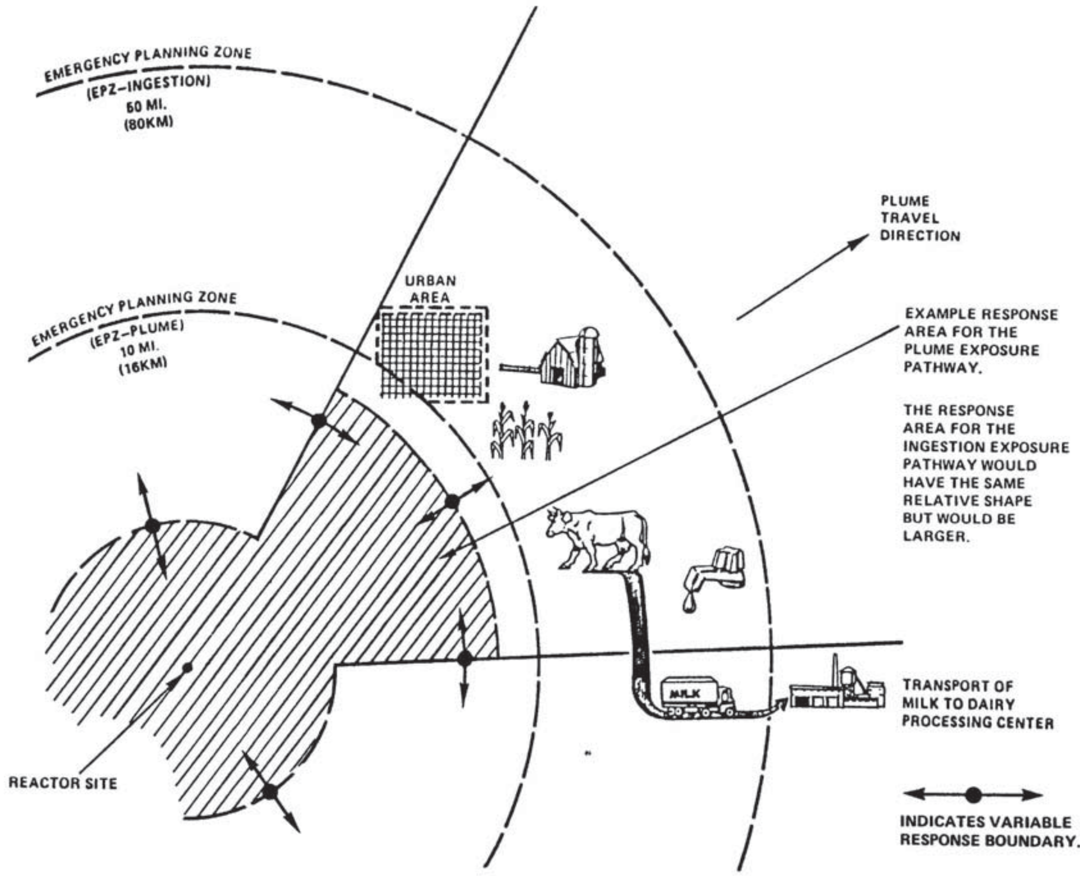
Table 2-1: Guidance on Size of the Emergency Planning Zone

Accident Phase	Critical Organ and Exposure Pathway	EPZ Radius
Plume Exposure Pathway	Whole Body (external)	about 10 mile radius*
	Thyroid (inhalation)	
	Other organs (inhalation)	
Ingestion Pathway	Thyroid. whole body, bone marrow (ingestion)	about 50 mile radius**

* Judgment should be used in adopting this distance based upon considerations of local conditions such as demography, topography, land characteristics, access routes, and local jurisdictional boundaries.

**Processing plants for milk produced within the EPZ should be included in emergency response plans regardless of their location.

Source: NUREG-0654/FEMA-REP-1 [Ref. 13] (Table 1)



Source: NUREG-0654 [Ref. 13] (Figure 1)

Figure 2-5: Concept of Emergency Planning Zones

Table 2-2: Guidance on Initiation and Duration of Release

Time from the initiating event to start of atmospheric release	0.5 hours to one day
Time period over which radioactive material may be continuously released	0.5 hours to several days
Time at which major portion of release may occur	0.5 hours to 1 day after start of release
Travel time for release to exposure point (time after release)	5 miles – 0.5 to 2 hours 10 miles – 1 to 4 hours

Source: NUREG-0654 [Ref. 13] (Table 2)

Requirements for the Accident Source Terms to be Used in EPZ Analyses

In the final rule adding 10 CFR §50.67 allowing for use of alternate source terms, the NRC described how accident source terms are to be included in the FSAR. [ref. 14]

> "The regulations of Part 50 are supplemented by those in other parts of Chapter I of Title 10, including 10 CFR Part 100, *Reactor Site Criteria*. Part 100 contains language that qualitatively defines a required accident source term and contains a note that discusses the availability of TID-14844. With the exception of 10 CFR §50.34(f), there are no explicit requirements to use the TID-14844 accident source term. Section 50.34(f), which addresses additional TMI-related requirements, is only applicable to a limited number of construction permit applications pending on February 16, 1982, and to applications under Part 52.
>
> * * *
>
> Fundamental assumptions that are design inputs, including the source term, were required to be included in the FSAR and became part of the design basis[1] of the facility. From a regulatory standpoint, the requirement to use the TID-14844 source term is expressed as a licensee commitment (typically to Regulatory Guide 1.3 or 1.4) documented in the facility FSAR, and is subject to the requirements of Sec. 50.59.
>
> --------------------------
>
> Footnote 1. As defined in Sec. 50.2, design bases means that information which identifies the specific functions to be performed by a structure, system, or component of a facility, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be (1) restraints derived from generally accepted "state of the art" practices for achieving functional goals, or (2) requirements derived from analysis (based on calculation and/or experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals. The NRC considers the accident source term to be an integral part of the design basis because it sets forth specific values (or range of values) for controlling parameters that constitute reference bounds for design.
>
> * * *
>
> In relocating the source term and dose requirements for future reactors to Sec. 50.34, the NRC retained the requirements for the exclusion area and the low population zone, but revised the associated numerical dose criteria to replace the two different doses for the whole body and the thyroid gland with a single, total effective dose equivalent (TEDE) value. The dose criteria for the whole body and the thyroid, and the immediate 2-hour exposure period were largely predicated by the assumed source term being predominantly noble gases and radioiodines instantaneously released to the containment and the assumed "single critical organ" method of modeling the internal dose used at the time that Part 100 was originally published. However, the current dose criteria, by focusing on doses to

> the thyroid and the whole body, assume that the major contributor to doses will be radioiodine. Although this may be appropriate with the TID-14844 source term, as implemented by Regulatory Guides 1.3 and 1.4, it may not be true for a source term based on a more complete understanding of accident sequences and phenomenology."

In addition to this design basis accident source term, emergency planning requirements in 10 CFR §50.47 require an applicant to evaluate a severe accident source term:

Requirement for Use of EPA Protective Action Guides

Protective Action Guides (PAGs) for radiological incidents were first initially used in the late 1950's and early 1960's to establish a set of guidance actions to take in response to the fallout from atomic weapons testing.[5] In a Memorandum for the President [ref. 15], the Federal Radiation Council '*adopted the term "Protective Action Guide" (PAG, defined as the projected absorbed dose to individuals in the general population which warrants protective action following a contaminating event*.'

In the 1970's, the Joint NRC/EPA Task Force on Emergency Planning recommended that the PAGs be updated and used to structure a framework for offsite emergency response actions tied to a spectrum of postulated accidents from minor through severe (Class 9). In their report, NUREG 0396 [ref. 10], the Task Force described their recommendation for use of PAGs:

> "The concept of Protective Action Guides was introduced to radiological emergency response planning to assist public health and other governmental authorities in deciding how much of a radiation hazard in the environment constitutes a basis for initiating emergency protective actions. These guides (PAGs) are expressed in units of radiation dose (rem) and represent trigger or initiation levels, which warrant pre-selected protective actions for the public if the projected (future) dose received by an individual in the absence of a protective action exceeds the PAG. PAGs are defined or definable for all pathways of radiation exposure to man and are proposed as guidance to be used as a basis for taking action to minimize the impact on individuals.
>
> The nature of PAGs is such that they cannot be used to assure that a given level of exposure to individuals in the population is prevented. In any particular response situation, a range of doses may be experienced, principally depending on the distance from the point of release. Some*of these doses may be well in excess of the PAG levels and clearly warrant the initiation of any feasible protective actions. This does not mean, however, that doses above PAG levels can be

[5] Initially used by the Federal Radiation Council, the responsibility for radiological incident PAGs was transferred to the EPA following its formation in 1970.

prevented or that emergency response plans should have as their objective preventing doses above PAG levels. Furthermore, PAGs represent only trigger levels and are not intended to represent acceptable dose levels. PAGs are tools to be used as a decision aid in the actual response situation. Methods for the implementation of Protective Action Guides are an essential element of emergency planning. These include the predetermination of emergency conditions for which planned protective actions such as shelter and/or evacuation would be implemented offsite.

* * *

[T]he objective of emergency response plans should be to provide dose savings for a spectrum of accidents that could produce offsite doses in excess of the PAGs."

2.3.3 Security Requirements

In SECY 2009-0007, *Proposed Rule Related to Enhancements to Emergency Preparedness Regulations (10 CFR Part 50) (RIN 3150-AI10)*, the NRC staff discussed their comprehensive review of requirements and proposed a number of revisions to emergency planning requirements for security based events. This effort was directed by the Commission following a December 2004 briefing on the topic as well as in an SRM to SECY 2005-0010, *Recommended Enhancements of Emergency Preparedness and Response at Nuclear Power Plants in the Post 9/11 Environment*. While both SECY 2005-0010 and its SRM were not released publicly, subsequent Commission policy papers are available. Notably, SECY 2006-0200 describes the NRC staff's proposal for proceeding with rulemaking. In the SRM to SECY 2006-0200, the NRC Commissioners directed that the staff prepare a rulemaking plan (which was subsequently provided to the Commission in SECY 2009-0007).

SECY 2009-0007 outlined a series of NRC orders and policy papers issued since 9/11 that addressed coordination measures between emergency planning and security areas. The proposed rule changes, while not specific to the topic of EPZ sizing, did address aspects related to the adequacy of onsite emergency response capabilities (as well as offsite coordination).

In March 2009, the NRC published a final rule in the Federal Register [ref. 16] adding a new section 73.58 on safety/security integration requirements. The new rule includes a requirement that:

"(b) The licensee shall assess and manage the potential for adverse effects on safety and security, including the site emergency plan, before implementing changes to plant configurations, facility conditions, or security."

2.3.4 Other Requirements

Essential Onsite Personnel

10 CFR §50.47(b)(11) requires:

> "Means for controlling radiological exposures, in an emergency, are established for emergency workers. The means for controlling radiological exposures shall include exposure guidelines consistent with EPA Emergency Worker and Lifesaving Activity Protective Action Guides."

NRC requirements generally focus on the control room operators. In a recent Federal Register (FR) Notice denying a petition for rulemaking concerning design basis dose requirements for control room operators [ref. 17], the NRC described the requirements:

> "Design-basis dose consequence analyses are intentionally based upon conservative assumptions and are intended to model the potential hazards that would result from any credible accident, not necessarily the most probable accident. As stated in footnotes to 10 CFR 100.11, "Determination of exclusion area, low population zone, and population center distance," and 10 CFR 50.67, "Accident source term," "[t]he fission product release assumed for these calculations should be based upon a major accident, hypothesized for purposes of site analysis or postulated from considerations of possible accidental events, that would result in potential hazards not exceeded by those from any accident considered credible. Such accidents have generally been assumed to result in substantial meltdown of the core with subsequent release of appreciable quantities of fission products."
>
> The performance-based control room dose criterion is designed to maintain an acceptable level of control room habitability even under the maximum credible accident scenario. The NRC has determined that providing an acceptable level of control room habitability for design-basis events is necessary to provide reasonable assurance that the control room will continue to be effectively manned and operated to mitigate the effects of the accident and protect public health and safety. Meeting or exceeding the design-basis control room dose limit would not impose an immediate evacuation requirement on the control room operators. Moreover, by removing the 5 rem acceptance criterion, a regulatory basis for the acceptance of the radiological protection aspects of control room designs would no longer exist and would not support the Commission's policy regarding performance-based regulations.
>
> The conservative assumptions used in design-basis dose consequence analyses need not and should not form the basis for restricting actions described in emergency operating procedures. These procedures are designed to ensure that during an accident all available means are used to assess actual radiological conditions and to maintain emergency worker doses As Low As Reasonably

Achievable (ALARA), as required by 10 CFR Part 20, "Standards For Protection Against Radiation." Additionally, no NRC regulations, including 10 CFR Part 20, "Standards for Protection Against Radiation," require evacuation of the control room when the design-basis control room dose limit is exceeded. Emergency operating procedures include guidance for controlling doses to workers under emergency conditions. This guidance would be applicable in the unlikely event that control room doses were projected to exceed the design-basis dose limit during an actual emergency."

Requirements for on-site emergency personnel other than in the control room are generally described in a recent Federal Register Notice [ref.18] on emergency planning as:

"5. Protection for Onsite Personnel

NRC regulations at Sec. 50.47(b)(10) and Appendix E to Part 50 do not currently require specific emergency plan provisions to protect onsite emergency responders, and other onsite personnel, in emergencies resulting from hostile action events at nuclear power plants. Licensees are required to provide radiological protection for emergency workers and the public in the plume exposure pathway emergency planning zone (EPZ), including actions such as warning of an emergency, providing for evacuation and accountability of individuals, and providing for protective clothing and/or radio-protective drugs. Many of these personnel are required by the site emergency plan that the licensee must follow and maintain. The emergency plan requires responders with specific assignments to be available on-shift 24 hours a day to minimize the impact of radiological emergencies and provide for the protection of public health and safety. However, in analyses performed after the terrorist attacks of September 11, 2001, the NRC staff determined that a lack of protection for emergency responders who are expected to implement the emergency plan could result in the loss of those responders and thus an inability to effectively implement the emergency plan.

The normal response actions for personnel protection, such as site evacuation, site assembly and accountability, and activation of onsite emergency response facilities, may not be appropriate in this instance because these actions may place at risk the response personnel necessary to mitigate plant damage resulting from the hostile action. BL-05-02 pointed out that actions different than those normally prescribed may be more appropriate during a hostile action, particularly an aircraft attack. This may include actions such as evacuation of personnel from potential target buildings and accountability of personnel after the attack has concluded. Precise actions would depend on site-specific arrangements, such as the location of personnel in relation to potential targets. Procedures would need to be revised to ensure plant page announcements are timely and convey the onsite protective measures deemed appropriate.

The NRC considered other options to attempt to resolve this issue. The NRC considered taking no additional regulatory action and relying upon continuation of the voluntary initiatives currently being implemented by licensees

> as a result of BL-05-02. The NRC believes that taking no action could result in the vulnerability of onsite personnel during a hostile action event. Action is necessary to ensure effective coordination to enable licensees to more effectively implement their pre-planned actions. Voluntary programs do not provide a consistent, NRC-approved means for addressing needed enhancements. Further, the implementation of voluntary actions does not ensure that these measures would be incorporated into emergency plans at new sites.

The NRC is proposing to revise Appendix E by creating a new Section IV.I. to address this issue, as discussed in Section V of this document."

Additional consideration as to the number of onsite emergency personnel is provided NUREG/CR-2723 [ref. 19]:

> "An examination of NRC regulations concerning reactor operating procedures during emergencies, as well as procedures of the utilities, indicated that during a major emergency in which a significant release is imminent there would be approximately 40 persons on the site in either the control room or the technical support center, both of which are required to provide a degree of protection from a radiological release."

Nonessential Onsite Personnel

Nonessential onsite personnel are presumed to follow the actions identified for offsite personnel (e.g., evacuate, shelter). NRC's procedure for protective action decision making [ref. 20] states:

> "The procedures should specify protective actions for onsite nonessential personnel, including evacuation for Site Area Emergencies and General Emergencies. This information is also normally included in the licensee's General Employee Training Program."

Requirement for Co-located Licensees to Coordinate Emergency Plan Activities

10 CFR §50.54(q) requires that a "*holder of a nuclear power reactor operating license under [part 50], or a combined license under part 52… shall follow and maintain in effect emergency plans which meet the standards in § 50.47(b) and the requirements in appendix E [of part 50].*' Under §50.54(q), the addition of a new reactor at an existing site requires a review of the proposed extension of the existing site's emergency plan to ensure that the addition of the new reactor(s) would not decrease the effectiveness of the existing plans and the plans, as changed, would continue to meet the requirements of §50.47 and Appendix E.

Appendix E to 10 CFR Part 50 defines co-located licensees as:

> "two different licensees whose licensed facilities are located either on the same site or on adjacent, contiguous sites, and that share most of the following emergency planning and siting elements:
>
> a. plume exposure and ingestion emergency planning zones,
> b. offsite governmental authorities,
> c. offsite emergency response organizations,
> d. public notification system, and/or
> e. emergency facilities"

Each of these elements would need to be reviewed to ensure the continued adequacy of the existing (approved) emergency plan.

Section C.I.13.3.2 of Regulatory Guide 1.206, *Combined License Applications for Nuclear Power Plants (LWR Edition)*, states:

> "If the new reactor is located on, or near, an operating reactor site with an existing emergency plan (i.e., multi-unit site), and the emergency plan for the new reactor includes various elements of the existing plan, the application should do the following:
>
> (1) Address the extent to which the existing site's emergency plan is credited for the new unit(s), including how the existing plan would be able to adequately accommodate an expansion to include one or more additional reactors and include any required modification of the existing emergency plan for staffing, training, emergency action levels, and the like.
> (2) Include a review of the proposed extension of the existing site's emergency plan pursuant to 10 CFR 50.54(q), to ensure that the addition of a new reactor(s) would not decrease the effectiveness of the existing plans and the plans, as changed, would continue to meet the standards of 10 CFR 50.47(b) and the requirements of Appendix E to 10 CFR Part 50.
> (3) Describe any required updates to existing emergency facilities and equipment, including the alert notification system.
> (4) Incorporate any required changes to the existing onsite and offsite emergency response arrangements and capabilities with state and local authorities or private organizations.
> (5) Justify the applicability of the existing 10-mile plume exposure EPZ and 50-mile ingestion control EPZ.
> (6) Address the applicability of the existing ETE or provide a revised ETE, if appropriate.
> (7) If applicable, address the exercise requirements for co-located licensees, in accordance with Section IV.F.2.c of Appendix E to 10 CFR Part 50, and the conduct of EP activities and interactions discussed in RG 1.101.

(8) If applicable, include ITAAC which will address any changes to the existing emergency plans, facilities and equipment, and programs that are to be implemented, along with a proposed schedule.
(9) Describe how emergency plans, to include security, are integrated and coordinated with emergency plans of adjacent sites."

Regulatory Guide 1.101, *Emergency Planning and Preparedness for Nuclear Power Reactors*, also states:

> "This regulatory guide provides guidance to co-located licensees and collocated applicants on methods that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for complying with the agency's regulations for emergency response plans and preparedness relative to conducting emergency response planning activities and interactions (A&I) in the years between participation in the offsite full or partial participation exercises with offsite authorities. This regulatory guide does not impose any new positions or requirements. Licensees and applicants are not required to use the methods specified in the regulatory position set forth in this guide, and are free to propose other means to achieve compliance with the applicable regulations."

SECY 2001-0131, *Rulemaking Plan: Revision of Appendix E, Section IV.F.2, to 10 CFR Part 50, Concerning Clarification of Emergency Preparation Exercise Participation Requirements for Co-located Licensees*, provides clarification of requirements for coordinating the exercise of emergency plans between co-located licenses.

2.4 Regulatory Guidance

2.4.1 General

In SECY 1993-0087, *Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advance Light-Water Reactor (ALWR) Designs*, the NRC staff requested Commission approval on 42 technical and policy issues pertaining to either evolutionary LWRs, passive LWRs, or both. During this same timeframe, the staff evaluated issues pertaining to advanced non-LWR designs.

In SECY 1993-0092, *Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, and PIUS) and Canadian Deuterium Uranium Reactor (CANDU) 3 Designs and Their Relationship to Current Regulatory Requirements*, the NRC staff discussed the status of their preapplication reviews of advanced reactor designs, and provided additional comment on the set of issues described in SECY 1990-0016. On the topic of applying existing regulations to advanced designs, Commission direction was provided for the circumstances where new requirements are determined to be necessary. This direction was to move away from prescriptive regulations:

> "Staff reviews of these advanced reactor designs should utilize existing regulations to the maximum extent practicable. When new requirements are necessary, the staff should move toward performance standard regulations and away from prescriptive regulations."

In conjunction with (and following) the preapplication discussion with Exelon Generation Company on a potential COL application for a multi-module Pebble Bed Modular Reactor (PBMR) plant, the NRC considered the implications of use of a mechanistic source term in licensing gas reactor designs. Issues on the use of a mechanistic source term and its implications on the size of EPZs were discussed extensively in SECY 2002-0139, *Plan for Resolving Policy Issues Related to Licensing Non-Light Water Reactor Designs*. Here, the NRC staff described the issues as:

> "The four policy issues of a more specific technical nature are as follows:
>
> - To what extent should a probabilistic approach be used to establish the plant licensing basis?
> - Under what conditions, if any, should scenario-specific accident source terms be used for licensing decisions regarding containment and site suitability?
> - Under what conditions, if any, can a plant be licensed without a pressure-retaining containment building?
> - Under what conditions, if any, can emergency planning zones be reduced, including a reduction to the site exclusion area boundary?"

Further NRC staff discussion was provided in SECY 2003-0047, *Policy Issues Related to Licensing Non-Light-Water Reactor Designs*. In their SRM on SECY 2003-0047, the NRC Commissioners stated their approval of the staff's recommendations on the use of a probabilistic approach in licensing, use of scenario-specific accident source terms (in establishing site suitability), and considering under what conditions EPZs might be reduced. The Commissioners disapproved the staff's recommended approach on containment, directing:

> "The staff should develop performance requirements and criteria working closely with industry experts (e.g., designers, EPRI, etc.) and other stakeholders regarding options in this area, taking into account such features as core, fuel, and cooling systems design. The staff should pursue the development of functional performance standards and then submit options and recommendations to the Commission on this important policy decision."

In follow-on SECY 2004-0103, *Status of Response to the June 26, 2003, Staff Requirements Memorandum on Policy Issues Related to Licensing Non-Light Water Reactor Designs*, the staff noted:

> "The approved issues are being implemented through the development of a technology-neutral, risk-informed and performance-based framework for new plant licensing."

SECY 2004-0103 also updated the Commission on activities related to integrated risk and containment functional requirements, but did not seek Commission feedback on the staff's activities.

SECY 2004-0157, *Status of Staff's Proposed Regulatory Structure for New Plant Licensing and Potentially New Policy Issues*, and SECY 2005-0006, *Second Status Paper on the Staff's Proposed Regulatory Structure for New Plant Licensing and Update on Policy Issues Related to New Plant Licensing*, provided status updates on the development of the risk-informed, performance-based (RI/PB) framework for new reactor licensing. Attachment 1 to SECY 2005-0006 provided insights on the staff's thinking relative to the use of scenario specific source terms in accident analyses:

> "Scenario specific source terms may be used for licensing purposes (e.g., siting) providing the following are met:
>
> - the scenarios to be used for the source term evaluation should be selected from a design specific probabilistic risk assessment, with due consideration of uncertainties.
> - the source term calculation, using the selected scenarios, should be based upon analytical tools that have been verified with sufficient experimental data to cover the range of conditions expected and to determine uncertainties.
> - the source terms used for licensing decisions should reflect the scenario specific timing, form and magnitude of radioactive material released from the fuel and coolant. Credit may be taken for natural and/or engineered attenuation mechanisms in estimating the release to the environment, provided there is adequate technical basis to support their use.
> - The source terms used for assessing compliance with dose related siting requirements should be 95% confidence level values based upon best estimate calculations with quantified uncertainties. Where uncertainties cannot be quantified, engineering judgment shall be used.
> - the source terms used in assessing emergency preparedness should be mean values based upon best estimate calculations with quantified uncertainties.

> The above guidance is intended to provide a flexible, performance-based approach for establishing scenario specific licensing source terms. However, it puts the burden on the applicant to develop the technical bases (including experimental data) to support their proposed source terms. Applicants could, however, propose to use a conservative source term for licensing purposes (in order to reduce research and development costs and schedule), provided the use of such a source term does not result in design features or operational limits that could detract from safety. Finally, it should be noted that the use of scenario specific source terms may result in smaller source terms being used for siting purposes then traditionally used for LWR siting.
>
> In developing technology-specific regulatory guides, the staff may propose acceptable conservative source terms(s), if it is feasible to do so."

In SECY 2005-0130, *Policy Issues Related to New Plant Licensing and Status of the Technology-Neutral Framework for New Plant Licensing*, the staff provided additional information related to the issue on integrated risk and on the containment functional performance requirements issue relative to the Commissions' safety goals and Quantitative Health Objectives (QHOs). In its SRM, the Commission disapproved the staff's recommendations on specifying a minimum level of safety for advanced designs, instead directing the staff:

> "The staff should develop expeditiously an Advanced Notice of Proposed Rulemaking (ANPR) to consider the spectrum of issues relating to risk-informing the reactor requirements. The formal program to risk-inform Part 50, as well as other related risk-informed efforts, should be incorporated into this ANPR. Safety, security and preparedness should be integrated throughout this effort."

The Commission approved the staff's proposed rulemaking plan in its SRM on SECY 2006-0007, *Staff Plan to Make a Risk-Informed and Performance-Based Revision to 10 CFR Part 50*. The ANPR was published in the Federal Register in May 2006 [ref. 21]. Several questions related to emergency planning matters for which the NRC requested comment included:

> "12. Should emergency preparedness requirements be risk-informed? Why or why not? How should emergency preparedness requirements be modified to be better integrated with safety and security?
>
> 35. What role should the following factors play in integrating emergency preparedness requirements (as contained in 10 CFR 50.47) in the overall framework for future plants:
>
> - The range of accidents that should be considered?
> - The extent of defense-in-depth?
> - Operating experience?
> - Federal, state, and local authority input and acceptance?

- Public acceptance?
- Security-related events?

36. What should the emergency preparedness requirements for future plants be? Should they be technology specific or generic regardless of the reactor type?

46. Is it reasonable to use a 95% confidence value for the mechanistic source term for both the PRA sequences and the sequences designated as LBEs to provide margin for uncertainty? If not, why not? Is it reasonable to use a conservative approach for dispersion to calculate doses? If not, why not?

64. Should the NRC continue with the ongoing current rulemaking efforts and not undertake any effort to risk-inform other regulations in 10 CFR Part 50, or should the NRC undertake new risk-informed rulemaking on a case-by-case priority basis? Why?

65. If the NRC were to undertake new risk-informed rulemakings, which regulations would be the most beneficial to revise? What would be the anticipated safety benefits?"

The staff included with the ANPR considerable discussion on the approach for use of QHOs in licensing new reactor designs, including differing opinions provided by members of the Advisory Committee on Reactor Safeguards (ACRS). The staff reported on the comments received from the ANPR in SECY 2007-0101, *Staff Recommendations Regarding a Risk-Informed and Performance-Based Revision to 10 CFR Part 50 (RIN 3150-AH81)*. As for risk-informing 10 CFR Part 50 technical requirements, the staff noted:

> "The staff agrees [with the public comments] that the NRC should not undertake new RI/PB revisions of 10 CFR Part 50 until specific rules are identified, which will allow industry and NRC to focus resources on maintaining the safety of existing reactors and on the expedient licensing of new reactors to existing requirements. The staff will propose candidate rulemakings after time allows the staff and industry to identify any requirements appropriate for revision."

In its SRM, the Commission approved the staff recommendation to defer rulemaking pending identification of specific rule enhancements, noting:

> "The Commission has approved the staff's recommendation to defer rulemaking for risk-informed and performance-based 10 CFR Part 50 reactor requirements for advanced reactors until after the development of the licensing strategy for the Next Generation Nuclear Plant (NGNP), or receipt of an application for a Pebble Bed Modulator Reactor (PBMR) design certification or combined license."

2.4.2 Guidance on the Sizing of Emergency Planning Zones (EPZs)

SECY 1997-0020, *Results of Evaluation of Emergency Planning for Evolutionary and Advanced Reactors*, described the rationale employed by the Joint NRC/EPA Task Force on Emergency Planning in arriving at the 10- and 50-mile EPZs.

> "Review of the Basis for the Size of the Emergency Planning Zone (EPZ)
>
> The most important element to be considered in establishing requirements for EP is the distance from the nuclear power plant over which emergency actions need to be planned. Two areas were identified: (1) a plume exposure pathway EPZ for planning for prompt actions to protect the public and (2) an ingestion pathway zone for planning for actions to prevent radioactive material from entering the food chain. Several rationales were considered for establishing the size of the EPZ. These included risk, probability, cost effectiveness, and accident consequence spectrum. The task force chose to base the rationale on a full spectrum of accidents and corresponding consequences tempered by probability considerations. It was the consensus of the task force that emergency plans could be based upon a generic distance within which predetermined actions would provide a dose saving for any such accidents.
>
> The following criteria were used to determine the generic distance for the plume exposure pathway EPZ:
>
> - The EPZ should encompass those areas in which projected dose from design-basis accidents could exceed the EPA PAGs.
> - The EPZ should encompass those areas in which consequences of less severe Class 9 (core melt) accidents could exceed the EPA PAGs.
> - The EPZ should be of sufficient size to provide for substantial reduction in early severe health effects in the event of the more severe Class 9 accidents.
>
> Detailed planning within the EPZ was expected to provide a substantial base for expanding response efforts should expansion be necessary for those low-probability, high-consequence events whose effects extend beyond the EPZ.
>
> To determine the areas in which these criteria were met, the task force evaluated design-basis accident data from licensees' final safety analysis reports and accident sequence and source term data from NRC document WASH-1400, "Reactor Safety Study" (1975). Specifically, the task force calculated (1) the fraction of plants that exceeded PAG doses beyond 10 miles for design-basis

> accidents, (2) the probability of exceeding various dose thresholds as a function of distance from the reactor, and (3) the benefit of various protective action strategies.
>
> On the bases of these analyses, the task force recommended that emergency plans should be developed for an area within a radius of about 10 miles of the reactor for the plume exposure pathway. Using a similar rationale and considering the expected dispersal and deposition of the radioactive material and the conversion of atmospheric iodine to chemical forms that do not readily enter the ingestion pathway, an area within a radius of about 50 miles of the reactor was selected for the ingestion pathway."

The Task Force recommendations were accepted and included in 10 CFR §50.47. During the 1980's, challenges were raised as to the adequacy of these EPZ sizes. In response to a petition for increasing the plume exposure EPZ size [ref. 22], the NRC summarized the legal basis as:

> "Regarding the Petitioner's comment that an evacuation zone limited to only 10 miles is "sorely inadequate," the size of the EPZs for commercial nuclear power plants in the United States is established by NRC regulations, and the NRC has consistently found that a plume exposure EPZ of about 10 miles in radius provides an adequate planning basis for radiological emergency planning. See NUREG-1251, Vol. 1, "Implications of the Accident at Chernobyl for Safety Regulation of Commercial Nuclear Power Plants in the United States," April 1989, and see Long Island Lighting Company (Shoreham Nuclear Power Station, Unit 1), CLI-87-12, 26 NRC 383, 395 (1987) where the Commission ruled that 10 CFR 50.47(c)(2) precludes adjustments on safety grounds to the size of an EPZ that is "about 10 miles in radius."

The public petition at question sought to increase the plume exposure EPZ size for LWRs. Not questioned was decreasing the size for non-LWRs (as allowed in the footnotes to the rule).

In SECY 2003-0047, *Policy Issues Related to Licensing Non-Light-Water Reactor Designs* [ref. 23], the NRC staff reviewed the history:

> "The Commission, in its staff requirements memorandum (SRM) of July 30, 1993, stated that it was premature to reach a conclusion on emergency planning for advanced reactors and that for ongoing review purposes, the staff should use existing regulatory requirements. The SRM went on to say that the staff should remain open to suggestions to simplify the emergency planning requirements for reactors that are designed with greater safety margins, and that the work on EP should be closely correlated with work on accident evaluation and source term, in order to avoid unnecessary conservatism."

Phrasing the EPZ sizing policy question as: *Under what conditions can the emergency planning zone (EPZ) be reduced, including a reduction to the site exclusion area boundary?* the NRC staff stated:

> "The staff recommends that no change to emergency preparedness requirements be made at this time. This recommendation is consistent with the guidance contained in the Commission's July 30, 1993, SRM and is based upon the following two considerations:
>
> - Provision already exists in 10 CFR 50.47 for accommodating the unique aspects of high-temperature gas reactors.
> - In the near term, new plants are likely to be built on an existing site which conforms to current requirements.
>
> If approved by the Commission, the role of emergency preparedness in defense-in-depth would be addressed as part of the development of a policy or description of defense-in-depth as recommended under Issue 2 above. In the longer term, if and when a need for change in emergency preparedness requirements is identified, that policy or description would serve as guidance in assessing the proposed change."

In its SRM, the Commission approved the staff's recommendation. The Commission dated:

> "[A]t this time it is premature to reach a conclusion on emergency planning for advanced reactors. For ongoing review purposes, the staff should use existing regulatory requirements. However, the staff should remain open to suggestions to simplify the emergency planning requirements for reactors that are designed with greater safety margins. To that end, the staff should submit to the Commission recommendations for proposed technical criteria and methods to use to justify simplification of existing emergency planning requirements.
>
> The Commission agrees with the ACRS recommendation and the staff's agreement that the work on EP should be closely correlated with work on Accident Evaluation and Source Term, in order to avoid unnecessary conservatism. Also, the work on EP for advanced reactors should be coordinated with the approach for evolutionary and passive reactors."

2.4.3 Guidance on the Sizing of the Exclusion Area

Requirements that a power reactor have an exclusion area and a low population zone were included in the 1962 rulemaking that added 10 CFR Part 100. At the time, the sizing of the exclusion area was left to guidance in TID-14844.

In the 1980 rulemaking that added 10 CFR §50.47 to Part 50, the NRC described the rationale for coordination of plant siting and emergency planning requirements. The *Supplementary Information* to the proposed rule adding 10 CFR §50.47 [ref. 24] described this interplay as:

> "The principal aspects of the NRC staff review for emergency planning includes (sic) the protections of persons within the exclusion area, the onsite emergency response organization, the protection of the public beyond the exclusion area and the connection between the facilities plan and that of the offsite emergency response organization consisting of local, State and Federal agencies. These reviews are part of the safety review of each application. These matters may also be considered In identifying any potential emergency planning advantages or disadvantages of particular sites as part of the NEPA cost/benefit analysis of alternate sites.
>
> There are two elements of the NRC staff review required by the Commission's regulations as stated in 10 CFR Part 100, "Reactor Site Criteria," and 10 CFR Part 50, "'Licensing of Production and Utilization Facilities." The first review element is to determine compliance with the seting (sic) criteria of 10 CPR Part 100. Rector site criteria are established in part 100 which, in conjunction with postulated accident calculations performed by the applicant for the proposed facility design, establish boundaries for an exclusion area and a low population zone (LPZ). In this connection, the Commission has, from the earliest days of licensing reactors, required the use of conservative assumptions and calculation methods in assessing consequences of a hypothetical release from the nuclear facility. The review conducted in conformance with 10 CFR Part 100 requirements establishes, for an acceptable site, that certain numerical exposure guidelines are met and in addition that the number and density of people within the LPZ are such that appropriate protective measures could be taken on their behalf in the event of an accident.
>
> Beyond the siting criteria and the question of site suitability is the second review element which is to determine compliance with the licensing requirements in I0 CFR Part 50 and appendix E thereto for emergency plans. This review element focuses on the question of organizational and operational preparedness to cope with emergencies. A principal aspect of this review is to determine whether the applicant has made or will make appropriate arrangements with appropriate Federal, State and local officials to assure that, in the event of an actual

> emergency, necessary evacuation or other protective actions will be taken to protect offsite members of the public. Although these arrangements include the protective measures contemplated by 10 CFR Part 100, in connection with the LPZ, they need not be limited to application within the LPZ, nor to measures intended to cope primarily with the airborne pathway (cloud passage) covered by sections 100.3 and 100.11 of part 100. Such arrangements are expected to be guided by emergency action criteria, arrived at through a coordinated effort among local, State, and Federal authorities. Such criteria are believed to be a sound and prudent approach to the management of the small residual risk involved in the operation of nuclear facilities."

NRC policy papers in the 1980's described studies to revise TID-14844 to introduce realistic source terms into licensing and to "decouple" siting from design. SECY 1990-0341, *Staff Study on Source-Term Update and Decoupling Siting from Design* [ref. 25], summarized the background for the existing regulations and provided comment on an integrated approach for using realistic source terms in establishing the exclusion area and low population zone. The NRC staff noted:

> "Although Part 100 requires an exclusion area and a LPZ, it is important to recognize that it does not provide any numerical criteria for site parameters (other than that they must not result in the calculated dose consequences being exceeded). With regard to the dose calculation method, Part 100 states (via a note at the end) that TID-14844 contains a procedural method and a sample calculation that "result in distances roughly representing current siting practices. * * * Based on a survey of the 75 U.S. sites where reactors are presently operating or under construction, the distance to the exclusion area boundary varies from 277 meters to 2130 meters, with a typical value of about 800 meters (0.5 mile). LPZ distances range from 1100 to 11,000 meters with a typical value of about 4800 meters (3 miles)."

Figure 2-6 provides a depiction of the EAB distances for the 15 reactor sites (blue color) that were listed in TID-14844 and the 75 reactor sites (red color) summarized in SECY 1990-0341. The EAB distances are shown in comparison to reactor thermal power levels. The values for Fort St Vrain (FSV) and Peach Bottom (PB) gas-cooled reactors were identified as 590 meters and 912 meters, respectively.

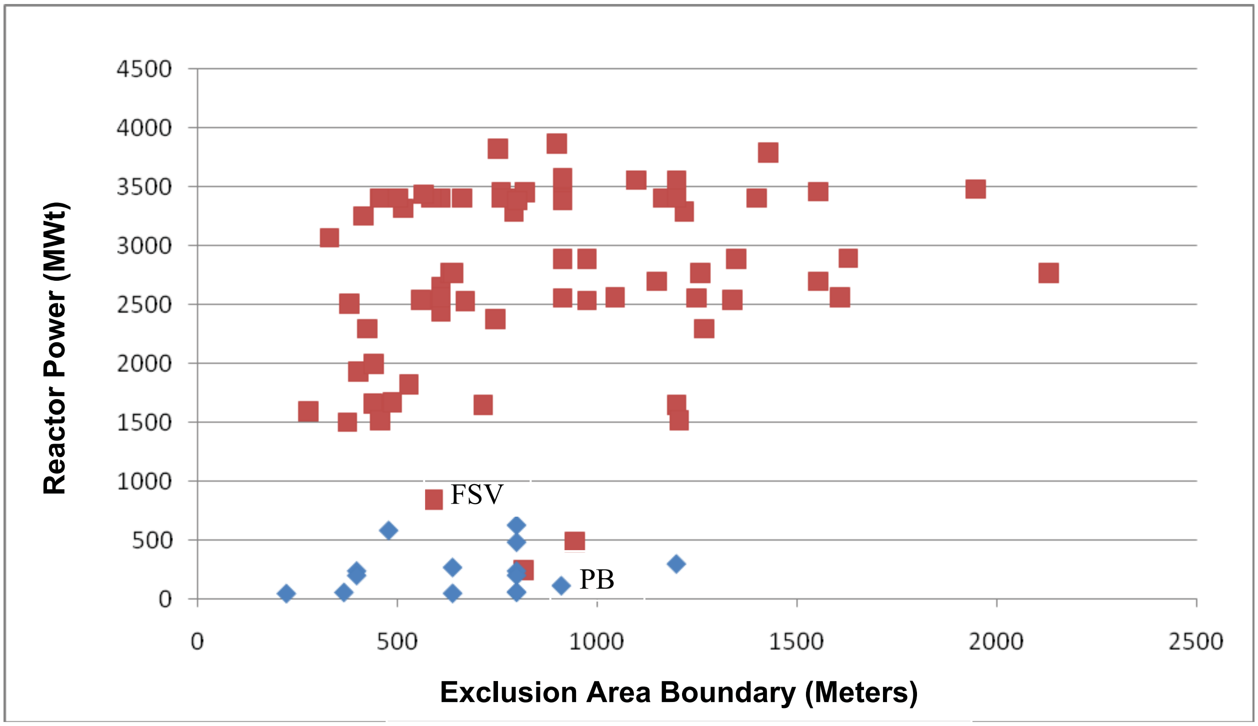


Figure 2-6: Exclusion Area Boundary Distances for 90 Power Reactor Sites

In a proposed rulemaking on the 10 CFR Part 100 reactor siting criteria (denying a petition on reactor siting) [ref. 26], the NRC requested comment on a proposal for establishing a minimum value for the exclusion area distance:

> "An exclusion area surrounding the immediate vicinity of the plant has a requirement for siting power reactors from the very beginning. This area provides a high degree of protection to the public from a variety of potential plant accidents and also affords protection to the plant from potential man-related hazards.
>
> The present regulation has no numerical size requirement, in terms of distance, for the exclusion area. The present regulations assesses (sic) the consequences of a postulated radioactive fission product release within containment, coupled with assumptions regarding containment leakage, performance of certain fission product mitigation systems, and atmospheric dispersion factors for a hypothetical individual located at any point on the exclusion area boundary. The plant and site combination is considered to be acceptable if the calculated consequences do not exceed the dose values given in the present regulation. Regulatory Guide 4.7 suggests an exclusion area distance of 0.4 miles (640 meters). This distance has been found, in conjunction with typical engineered safety features, to meet the dose values in the existing regulation. Future reactors would be expected to be as good or better in meeting the dose criteria at this distance.

> The Commission considers an exclusion area to be an essential feature of a reactor site and is retaining this requirement for future reactors. However, in keeping with the recommendation of the Siting Policy Task Force to decouple site requirements from reactor design, the proposed regulation would eliminate the use of a postulated source term, assumptions regarding mitigation systems and dispersion factors, and the calculation of radiological consequences to determine the sizes of the exclusion area and low population zone. It would instead require a minimum exclusion area distance of 0.4 miles (640 meters) for power reactors.
>
> This distance, together with typical engineered safety features previously reviewed by the staff, has been found to satisfy the dose guidelines in the present regulation. An exclusion area of this size or larger is fairly common for most power reactors in the U.S. It has not been unduly difficult for most prospective applicants to find and obtain a suitable site.
>
> Finally, this distance has also been found to readily satisfy the prompt fatality quantitative health objective of the Commission's Safety Boards Policy, when coupled with plant designs as reflected by those in NUREG-1150, and for a reactor power level of 3800 Megawatts (thermal). Therefore, the minimum exclusion area distance proposed would assure a very low level of risk to individuals, even for those located very close to the plant.
>
> Although an exclusion area size of about 0.4 miles is considered appropriate for reactor power levels of current design, the Commission is also considering whether or not this size unduly penalizes potential reactors that have significantly lower power levels and is therefore requesting comments on this subject."

A second proposed rulemaking (in 1994) on revising 10 CFR Part 100 reactor siting requirements [ref. 27] provided a detailed discussion on how the dose calculations are to be performed. The final rulemaking (in 1996) [ref. 28] described the decoupling of the dose calculations from siting:

> "The Commission is retaining source term and dose calculations to verify the adequacy of a site for a specific plant, but source term and dose calculations are relocated to Part 50, since experience has shown that these calculations have tended to influence plant design aspects such as containment leak rate or filter performance rather than siting. No specific source term is referenced in Part 50. Rather, the source term is required to be one that is "* * * assumed to result in substantial meltdown of the core with subsequent release into the containment of appreciable quantities of fission products." Hence, this guidance can be utilized with the source term currently used for light-water reactors, or used in conjunction with revised accident source terms.

> The relocation of source term and dose calculations to Part 50 represent (sic) a partial decoupling of siting from accident source term and dose calculations. The siting criteria are envisioned to be utilized together with standardized plant designs whose features will be certified in a separate design certification rulemaking procedure. Each of the standardized designs will specify an atmospheric dilution factor that would be required to be met, in order to meet the dose criteria at the exclusion area boundary. For a given standardized design, a site having relatively poor dispersion characteristics would require a larger exclusion area distance than one having good dispersion characteristics. Additional design features would be discouraged in a standardized design to compensate for otherwise poor site conditions.

In response to comments received on the proposed rule, the NRC decided not to include a requirement specifying a minimum distance for the EAB, but to continue to rely on the guidance in Regulatory Guide 4.7.

2.4.4 Guidance on the Sizing of the Low Population Zone (LPZ)

The 1992 proposed rulemaking and notice denying the petition on sizing of the EAB also included a request for comment on the elimination of the LPZ, based on an understanding that the functions assigned the LPZ are not codified in 10 CFR §50.47 for EPZs.

> "The present regulation requires that a low population zone (LPZ) be defined immediately beyond the exclusion area. Residents are permitted in this area, but the number and density must be such that there is a reasonable probability that appropriate protective measures could be taken in their belief in the event of a serious accident. In addition, the nearest densely populated center containing more than about 25,000 residents must be located no closer than one and one-third times the outer radius of the LPZ. Finally, the dose to a hypothetical individual located at the outer radius of the LPZ over the entire course of the accident must not be in excess of the dose values given in the regulation. Regulatory Guide 4.7 suggests that an outer radius of about 3 miles (4.8 km) for the LPZ has been found to satisfy the dose values in the present regulation.
>
> Several practical problems have arisen in connection with the LPZ. Before 1980, the LPZ generally defined the distance over which public protective actions were contemplated in the event of a serious accident. The regulations in 10 CFR 50.47 now requires (sic) plume exposure Emergency Planning Zones (EPZ) of about 10 miles for each plant.
>
> The LPZ also places restrictions on the proximity of the nearest densely populated center of 25,000 or more residents. However, without numerical requirements for the outer radius of the LPZ, this requirement has little practical effect. Typical LPZs for existing power reactors have several thousand residents. If Regulatory

> Guide 4.7 were (sic) followed and a distance of 3 miles were selected as the LPZ outer radius, a maximum population within the LPZ at the time of site approval would be about 14,000 residents. Finally, the staff has sometimes experienced difficulty in defining a "densely populated center."
>
> The Commission considers that the functions intended for the LPZ, namely, a low density of residents and the feasibility of taking protective actions, have been accomplished by other regulations or can be accomplished by other means. Protective action requirements are defined via the use of the EPZ, while restrictions on population close to the plant can be assured via proposed population density criteria. For these reasons, the Commission is proposing to eliminate the requirement of an LPZ for future power reactor sites for purposes of determining site suitability."

The 1994 proposed rulemaking on revising reactor siting requirements [ref. 27] reversed direction, with the NRC explaining why a requirement for an LPZ should be retained:

> "Before 1980, the LPZ generally defined the distance over which public protective actions were contemplated in the event of a serious accident. The regulations in 10 CFR 50.47 now requires (sic) plume exposure Emergency Planning Zones (EPZ) of about 10 miles for each plant.
>
> While the Commission considers that the siting functions intended for the LPZ, namely, a low density of residents and the feasibility of taking protective actions, have been accomplished by other regulations or can be accomplished by other guidance, the Commission continues to believe that a requirement that limits the radiological consequences over the course of the accident provides a useful evaluation of the plant's long-term capability to mitigate postulated accidents. For this reason, the Commission is proposing to retain the requirement that the dose consequences be evaluated at the outer boundary of the LPZ over the course of the postulated accident and that these not be in excess of 25 rem TEDE."

This proposal was then codified in the 1996 final rule amending 10 CFR Parts 50 and 100.

2.5 NRC Precedents Involving Gas-Cooled Reactors

2.5.1 Fort St. Vrain

Licensing of the Fort St. Vrain (FSV) plant occurred in the late 1960's and early 1970's, well prior to the final rulemaking adding 10 CFR §50.47. Nevertheless, postulated accidents involving radiological releases were evaluated as part of the FSV license application. Due to the timing of the FSV licensing and the promulgation of emergency planning and National

Environmental Policy Act (NEPA) regulations (i.e., 40 CFR 1500-1508), the accident classification scheme then used in Appendix D to 10 CFR Part 50 had to be modified for FSV. Table 2-3 provides a summary of this modification for the nine classes of accidents and Table 2-4 summarizes the radiological consequences. Of note is that FSV did not indicate a Class 9 accident. FSV had an exclusion area of 590 meters. NUREG-0654 notes that a 5-mile plume exposure pathway and a 30-mile ingestion pathway EPZ were considered acceptable for FSV.

The 1980 rulemaking that added 10 CFR §50.47 included NRC's '*Position on Planning Basis for Small Light-Water Reactors and Ft. St. Vrain*' in which it was stated:

> "The Commission has concluded that the operators of small light-water-cooled power reactors (less than 250 MWt) and the Ft. St. Vrain gas-cooled reactor may establish smaller planning zones which will be evaluated on a case-by-case basis. This conclusion is based on the lower potential hazard from these facilities (lower radionuclide inventory and longer times to release significant amounts of activity in many scenarios). Guidance regarding the radionuclides to be considered in planning is set forth in NUREG-0396; EPA 520/1-78-016, "Planning Basis for the Development of State and Local Government Radiological Response Plans in Support of Light-Water Nuclear Power Plants," December 1978."

Table 2-3: Comparison of Classification of Postulated Accidents and Occurrences for the Fort St. Vrain Nuclear Power Plant

Classification as in the Annex to Appendix D of 10 CFR Part 50		Modification for Fort St. Vrain Nuclear Generating Station	
Class	Description	Class	Description
1.	Trivial incidents	1.	Trivial incidents (small spills)
2.	Miscellaneous small releases outside containment	2.	Miscellaneous small releases outside containment (spills or leaks)
3.	Radwaste system failure	3.	Radwaste system failures (leakage and gas or liquid storage tank failure
4.	Fission products to primary system (BWR)	4.	Not applicable
5.	Fission products to primary and secondary systems (PWR)	5.	Fission products to secondary systems (reheater tube break)
6.	Refueling accidents	6.	Not applicable
7.	Spent fuel handling accidents	7.	Spent fuel handling accident (fuel cask drop)
8.	Accident initiation events considered in design basis evaluation in the safety analysis report	8.	Accident initiation events considered in design basis evaluation in the safety analysis report (instrumentation line break and helium purification system regeneration line accident; rapid depressurization accident and permanent loss-of-forced circulation)
9.	Hypothetical sequence of failures more severe than Class 8	9.	None

Source: Ref. 29 (Table VI-1)

Table 2-4: Summary of Radiological Consequences of Postulated Accidents for the Fort St. Vrain Nuclear Power Plant

Class	Event	Estimated Fraction of 10 CFR Part 20 Limit at Site Boundary	Estimated Dose to Population in 50 Mile Radius, man-rem
1.0	Trivial incidents	*b*	*b*
2.0	Miscellaneous small releases outside containment	*b*	*b*
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	<< 0.001	< 0.001
3.2.	Release of waste gas storage tank contents	<< 0.001	0.001
3.3.	Release of liquid waste storage tank contents	<< 0.001	< 0.001
4.	NOT APPLICABLE		
5.	Fission products to secondary system		
5.1	Reheater tube break	<< 0.001	< 0.001
6.0	NOT APPLICABLE		
7.0	Spent fuel handling accident		
7.1	Fuel cask drop	<< 0.001	< 0.001
8.0	Accident initiation events considered in design basis evaluation in the safety analysis report		
8.1	Instrumentation line break	0.001	0.01
8.2	Helium purification system regeneration line accident	0.041	5.1
8.3	Rapid depressurization accident	0.24	30
8.4	Permanent loss-of-forced circulation accident	< 0.001	< 0.001

α Represents the calculated fraction of a whole body dose of 500 millirem, or the equivalent dose to an organ.
b These releases are expected to be a small fraction of 10 CFR Part 20 limits.

Source: Ref. 29 (Table VI-2)

2.5.2 Modular High-Temperature Gas-Cooled Reactor

At the request of the Department of Energy (DOE), the NRC in 1986 undertook a preapplication review of the MHTGR design. Included was a review of emergency planning requirements for advanced reactor designs. The NRC staff defined the proposed reduction in EPZ size as a policy issue in SECY 1988-0203, *Key Licensing Issues Associated with DOE Sponsored Advanced Reactor Designs*. The policy issue and NRC staff conclusions are discussed in sections 3.2.2.4 and 13.1 of NUREG-1338, *Draft Preapplication Safety Evaluation Report for the Modular High-Temperature Gas-Cooled Reactor*' [ref. 3]. Appendix C includes these excerpted sections from NUREG-1338.

The NRC staff viewed DOE's proposal as essentially leading toward the elimination of emergency planning requirements for advanced reactors. While allowing that the plume exposure pathway could be eliminated (due to the long period of time before onset of significant releases of radioactive material), the NRC staff was reluctant to do away fully with emergency planning requirements. Section 3.2.2.4 of NUREG-1338 described this as:

> "The staff believes that emergency-planning requirements for advanced reactors should be based on the characteristics of the designs. This principle is similar to that in the emergency planning rule (10 CFR 50.47), which states that the size of the emergency planning zone for HTGRs can be determined on a case-by-case basis. In addition, the power level of each advanced-reactor module is much smaller than that of a conventional LWR and, based on size alone, some reduction in the radius of the emergency planning zone may be warranted similar to what has been done for the existing small-size LWRs. In addition to these considerations, it is the staff's judgment that a plant's ability to prevent significant releases of radioactive material (particularly the prevention of release by core melt) and to provide long times before releases for all but the most remotely probable events should also be reflected in any emergency-planning requirements. Accordingly, the staff proposes criteria that consider such ability, consistent with evaluating a range of events similar to those evaluated for LWRs.
>
> Specifically, the staff proposes the following criteria as guidelines for the advanced-reactor designs in order for NRC to accept the DOE proposal of no traditional offsite emergency planning (other than simple notification). While an offsite emergency plan would still be required, such a plan would not have to include early notification, detailed evacuation planning, and provisions for exercising the plan if
>
> (1) the lower-level PAGs were not predicted to be exceeded at the site boundary within the first 36 hours following any event in categories EC-I, -II, and –III

(2) a PRA for the plant, which included at least all events in categories EC-I through EC-IV, indicated that the cumulative mean value for the frequency of exceeding the lower-level PAGs at the site boundary within the first 36 hours did not exceed approximately 10^{-6} per year.

These criteria give credit for designs that provide long times before significant radiation release. For designs such as these, the staff believes that because sufficient time is available, prompt notification of offsite authorities will permit effective evacuation on an ad hoc basis."

In the final draft of NUREG-1338, the NRC identified Section 13.1 of NUREG-1368, *Preapplication Safety Evaluation Report for the Power Reactor Innovative Small Module (PRISM) Liquid-Metal Reactor* [ref. 30], for additional guidance on emergency planning for the MHTGR design. NUREG-1368 notes that the PRISM plume exposure pathway EPZ would be "within the plant site exclusion area boundary (EAB). Additionally, NUREG-1368 details proposed commitments for inclusion within the PRISM emergency plan.

2.6 Summary of Requirements and Guidance

Regulatory requirements for the establishment of exclusion area and low population zones around nuclear plants were initially required within the reactor siting criteria in the 1962 rule that added 10 CFR Part 100. Emergency planning requirements later expanded upon the 10 CFR Part 100 requirements, adding (in 1980) the requirement that two EPZs, a plume exposure pathway EPZ and an ingestion pathway EPZ, be required. The size of these EPZs was stated as "about" 10 miles and 50 miles, respectively, and reflected NRC focus on large LWRs. The fact that small LWRs and gas-cooled reactors presented less of a risk and thus could justify smaller EPZs was recognized and reflected in the emergency planning requirements. Specifically, the supplementary information accompanying the rulemaking included NRC's "Position on Planning Basis for Small Light-Water Reactors and Ft. St. Vrain":

"The Commission has concluded that the operators of small light-water-cooled power reactors (less than 250 MWt) and the Ft. St. Vrain gas-cooled reactor may establish smaller planning zones which will be evaluated on a case-by-case basis. This conclusion is based on the lower potential hazard from these facilities (lower radionuclide inventory and longer times to release significant amounts of activity in many scenarios)."

Preapplication reviews of the MHTGR and other small DOE sponsored designs, conducted in the mid- to late-1980's with the NRC, followed-up on this acknowledgement. The preapplication reviews considered DOE proposals for reducing the EPZ sizes to that of the EAB and, in the process, providing justification for simplifying emergency planning requirements for these advanced reactor designs. The NRC concluded that a reduction of the EPZs could be achieved, adding that the approach to further simplification of emergency planning requirements represented a policy issue to be closed as part of a formal application review.

In parallel with the reviews of the small, advanced reactor designs, siting and emergency planning requirements were reviewed as part of efforts to incorporate realistic source terms and plant performance into NRC's regulations. Reactor siting requirements in 10 CFR Part 100 were revised and a new section (10 CFR §50.67) was added that allowed the use of alternate source terms for LWRs on a backfit basis. A "roadmap" for evaluating proposed reductions in EPZ sizes for future reactors was outlined in a policy paper, SECY 1997-0020, *Results of Evaluation of Emergency Planning for Evolutionary and Advanced Reactors*. While the focus of the policy paper was on evolutionary and advanced LWRs, the roadmap approach was considered suitable for use with reactor designs other than LWRs.

Based on the review of regulations and guidance summarized in this section and on our current understanding of the NGNP design, the approach to licensing basis events and their corresponding radioactivity release source terms, simplification of emergency planning requirements can be pursued within the current regulations. However, additional NRC staff guidance with Commission review and approval may be required before reduced emergency planning requirements including reduced EPZs can be implemented for the NGNP.

3 APPROACH

3.1 Strategy Objective and Elements

The objective of the EPZ task is to establish a licensing strategy to simplify emergency planning requirements for the NGNP that, when implemented, would:

- Permit distances for the plume exposure pathway EPZ and ingestion pathway EPZ that are less than the 10-mile and 50-mile zones currently used for large LWRs with the objective to significantly reduce the EPZs to distances more appropriate to HTGRs (i.e., essentially equal to the EAB distance);
- Prepare arguments for sizing the exclusion area at a distance that allows for practical co-location of the nuclear (heat generation) and non-nuclear (heat application) facilities that comprise the NGNP (that is, establish the EAB at about 400 meters from the reactor centerline);
- Demonstrate that radiological releases during normal and accident conditions (required for plant siting and emergency planning purposes) are less than the Environmental Protection Agency's Protective Action Guides (PAGs);
- Demonstrate appropriate siting and design features as defined by NRC's policy issue on emergency planning as an essential element in providing defense-in depth; and
- Identify regulatory and public interfaces, beyond the NRC, that must be engaged in order to properly integrate NGNP emergency preparedness into the nation's National Response Framework.

The purpose of the strategy described below is to address the above objectives by proposing strategy elements aimed at (1) making the appropriate plume and ingestion pathway EPZ sizes as small as reasonable given the local site conditions and the PAG analysis results, with 400 meters radius as a target, and (2) identifying appropriate simplifications within the defined EPZs. The basic elements of the strategy are described in the following subsections and include:

Strategy Element 1 − Establish the technical basis for compliance with the PAGs. Perform a technical analysis of the NGNP to establish the mechanistic source term and doses needed to achieve the smallest possible plume exposure and ingestion pathway EPZs that meet the PAG criteria. The bases for conclusions should be clearly stated with justifications and explanations as appropriate. This technical assessment includes development of the methods, assumptions, and acceptance criteria for a gas-cooled reactor, with results expected comparable to those described in the historical literature.

Strategy Element 2 − Develop regulatory position statement(s) for simplifying emergency planning requirements for the NGNP. Given demonstration of compliance with the PAGs, proactively take a position that the design of and risk for a gas-cooled reactor is significantly different from that for an LWR (for which existing emergency planning requirements were developed) that any emergency can be addressed using a type of emergency response planning normally used for industrial facilities (e.g., refineries, chemical processing plants). NRC's roadmap, SECY 1997-0020, allowed that changes to emergency planning requirements may be warranted for advanced reactor designs for which the consequences from potential accidents are reduced or the timing or composition of potential releases are different from that for current reactor designs.

Strategy Element 3 − Address the other factors as identified in the SECY 1997-0020 "roadmap". NRC's roadmap also included discussion of factors other than dose analyses needed to meet the PAGs. These factors include consideration of the 10 CFR Part 100 siting factors and identification of accident progression sequences more appropriate to the design (e.g., consideration of timing or radionuclide composition of potential releases). This strategy element also needs to address NRC Commission direction for retention of emergency planning as an essential element of defense-in-depth in providing adequate assurance of plant safety.

Strategy Element 4 – Establish the EAB for the NGNP at a distance commensurate with meeting the PAGs for each of the candidate site(s). The distance to the EAB needs to allow for sites having different emergency planning considerations, e.g., siting the NGNP at the INL versus at an existing nuclear site (other than the INL), or at an industrial site not having an existing nuclear plant. Integration of a new emergency plan (for the NGNP) with an existing plan (existing nuclear plant or industrial facility) will need to be examined.

Strategy Element 5 − Assess ongoing emergency planning and security rulemakings to assure continued viability of the NGNP approach. NRC initiatives in the areas of enhanced emergency planning, security, risk-informed requirements development, and interagency coordination need to be followed and impacts potentially affecting the NGNP strategy need to be identified. This may require proactive engagement with the NRC to shape emergent regulatory requirements favorably for modular gas reactors. Based on the results of Strategy Elements 2 and 3, re-confirm the adequacy of current regulations and identify any necessary new guidance or policy statements or revisions to existing guidance and policies[6].

Strategy Element 6 – Prepare and implement communications plan(s) for engaging with Federal, state, and local agencies (e.g., NRC/FEMA/et al) having cognizance over emergency

[6] Per Federal Register notices 74 FR 23198 dated May 18, 2009 and 74 FR 27557 dated June 10, 2009 the Federal Emergency Management Agency is accepting comments on Supplement 4 to NUREG-0654, Revision 1, and Radiological Emergency Preparedness Program Manual through October 19, 2009.

planning efforts. The emergency planning approach taken for the NGNP needs to be communicated with the affected governmental agencies to assure continuity in direction and in requirements.

Strategy Element 7 − Develop an NGNP white paper for submittal to the NRC describing the NGNP emergency planning approach. The paper needs to convey the NGNP project's understanding of the regulatory background, requirements and guidance, state the strategy approach, identify outcome objectives from the NRC, and detail a series of pre-application engagement activities to serve as a means of communicating with NRC staff. It is recognized that some related issues (e.g., mechanistic source term and dose assessment) will not be resolved in the near term, but the paper should be written contingent on completion of the related activities. This paper should present the overall EPZ reduction program and its supporting activities, including those activities that should be led by the Alliance.

3.2 Strategy Elements

The following subsections discuss in detail each of the strategy elements described above.

3.2.1 Element 1 − Establish the Technical Basis for Compliance with the PAGs

This subsection addresses the input needs and methods for analysis of PAG doses and related health effects. The protective action dose analysis is done as a supplement to, but consistent with, the design, safety analysis and Probabilistic Risk Assessment (PRA) performed as part of the Final Safety Analysis Report (FSAR) that is submitted in support of the license application (COL or DC application). The basic elements of the protective action dose analysis are:

- Protective action criteria to be addressed;
- Major plant radioactivity source terms (e.g., reactor core, transport and plate-out inside the helium pressure boundary and reactor building);
- Methods for frequency and consequences of mechanistic best-estimate analyses including quantity and timing of radioactivity releases to the environment;
- Site meteorological data;
- Demographics, land use, and personnel movement during an accident for the site and surrounding area potentially considered for emergency planning (e.g., the approximate 10-mile radius plume exposure zone and the 50-mile radius ingestion exposure zone); and
- Method of analysis of offsite doses, personnel exposure and land contamination as a function of meteorological conditions and personnel movement.

It is recommended that the emergency planning assessment elements including criteria, methods and assumptions, and the results be viewed and managed as a package. That is, firm commitments should not be made to the NRC staff on any particular element until the NGNP project including designers, analysts and licensing managers are satisfied that results are satisfactory and can be defended during the NRC staff review.

The elements of the analysis approach listed above are summarized in the following subsections.

3.2.1.1 Protective Action Criteria to be Addressed

As summarized in the NRC' roadmap, SECY 1997-0020, three criteria were used to determine the generic distance for the plume exposure pathway EPZ. These criteria are:

- The EPZ should encompass those areas in which the projected dose from design-basis accidents could exceed the EPA PAGs,
- The EPZ should encompass those areas in which consequences of less severe Class 9 (i.e., core melt) accidents could exceed the EPA PAGs, and
- The EPZ should be of sufficient size to provide for substantial reduction in early severe health effects in the event of the more severe Class 9 accidents.

The EPA *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents* [ref. 31] recommends PAGs and corresponding protective actions for both the early and intermediate phases of an atmospheric release of radioactivity. The PAGs are recommended criteria against which projected[7] doses to members of the public are compared in determining whether corresponding protective actions should be taken.

From Table 2-1 of the Manual, the PAGs for the early phase[8] of an incident (e.g., hours to days) are:

- Evacuation[9]: 1 – 5 rem[10] and
- Administration of stable iodine: 25 rem[11]

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[7] Actual doses to the population may be either higher or lower than the projected doses.

[8] In the Manual of Protective Action Guides it is assumed that the early phase can last up to four days. Exposure pathways may include direct exposure from the facility or a passing plume, contamination of skin and clothing, and exposure to deposited material.

[9] Although evacuation is the preferred action in most cases (within 5 miles of the reactor, page I-51 of NUREG-0396), it is recognized that sheltering may be more appropriate in some circumstances considering particular issues such as local weather and mobility concerns (e.g., re-locating nursing home residents). Such actions would normally be initiated when the dose is projected to reach 1 rem, but could be initiated at 5 rem for groups that are less mobile. Moreover, for unusually hazardous environmental conditions, sheltering may be justified for projected doses up to 5 rem for the general population and up to 10 rem for special groups.

[10] This PAG is the sum of the "effective dose equivalent" resulting from exposure to external sources and the "committed effective dose equivalent" incurred from all significant inhalation pathways..

[11] This is the committed dose equivalent to the thyroid from radioiodine.

For the intermediate phase (e.g., days up to about one year beyond the early phase), PAGs for protection of food and water and exposure of the population are provided in Chapter 3 of the Manual.

- Whole body: 0.5 rem and
- Thyroid: 1.5 rem.

In situations where the only feasible protective actions have high dietary or social costs, Chapter 3 of the Manual describes "emergency" PAGs as:

- Whole body: 5 rem and
- Thyroid: 15 rem.

The PAGs for exposure to deposited radioactivity (Manual Chapter 4, Table 4-1) are:

- Relocation of the general population: ≥ 2 rem[12] and
- Application of simple dose reduction techniques: < 2 rem[13].

From a different source (Table 1 of NUREG-0396), an additional ingestion pathway PAG is stated as:

- Placing dairy cows on stored feed = 1.5 rem to the infant thyroid

The established threshold for early severe health effects is a 200 rem whole body dose (re: page 8 of SECY 1997-0020 and page I-51 of NUREG-0396)[14]. Per SECY 1997-0020, analyses of LWRs have shown that there is a significant drop in early severe health effects at about a 10-mile distance from the reactor.

In addition, it is recommended that the NGNP project perform the following supplementary analyses

- A PRA evaluation to demonstrate a cumulative mean frequency for sequences resulting in greater than 1 rem total effective dose equivalent (TEDE) over 36 hours at the site boundary, consistent with NRC's review of the MHTGR (see section 2.5.2),

[12] This is the projected sum of effective dose equivalent from external gamma radiation and committed effective dose equivalent from inhalation of re-suspended materials from exposure or intake during the first year.
[13] Simple dose reduction techniques include, for example: scrubbing of hard surfaces, plowing of soil, minor removal of soil where radioactive materials have concentrated, and spending more time indoors.
[14] The 200 rem threshold for early severe health effects is associated with a 15% fatality rate per 2-12 of the EPA PAG Manual. Supportive medical treatment would decrease this fatality rate.

- An evaluation to demonstrate that the plant design is consistent with the prompt accident quantitative health objective of the 1986 NRC Safety Goal Policy,[15] and

- An evaluation to demonstrate that the plant design is consistent with the latent cancer fatality health objective of the Safety Goal Policy.[16]

It is recommended that for the NGNP EPZ reduction program, compliance with all of the above listed criteria (i.e., probabilistic dose analysis and health effect criteria as well as the listed PAGs) be addressed so that the full spectrum of issues (i.e., health effects, food and water protection, meteorology-directional protection planning, etc.) can be addressed when evaluating the feasibility of eliminating or reducing the plume exposure pathway and ingestion pathway EPZs.

3.2.1.2 Identification of the Accident Source Term

The foundation for today's emergency planning basis (e.g., the EPA Manual of Protective Action Guides and Protective Actions, NUREG-0396, NUREG-1150) includes an assumed LWR core-melt accident. This is consistent with the "maximum credible accident" requirement for LWR siting and accident analysis[17]. Therefore, LWR PAG dose analyses are a function of a core melt occurrence and the related containment performance (i.e., usually resulting in early releases within 30 minutes to a few hours of accident initiation), site meteorological conditions and the time limit selected for the analysis. The containment analyses include consideration of the source term itself and the timing, magnitude, and characteristics of releases. For HTGRs such as NGNP, the approach to the mechanistic source term and containment function performance needs to be re-evaluated so that the approach to emergency planning can be comprehensively addressed. The NGNP mechanistic source term necessarily will need to include not only releases from the core, but also the expected low probability of a significant release given the design and performance of

[15] From Section C of the policy statement (51 FR 28044, published August 4, 1986): The risk to an average individual in the vicinity of a nuclear power plant of prompt fatalities that might result from reactor accidents should not exceed one-tenth of one percent (0.1 percent) of the sum of prompt fatality risks resulting from other accidents to which members of the U. S. population are generally exposed.

[16] From Section C of the policy statement (51 FR 28044, published August 4, 1986): The risk to the population in the area near a nuclear power plant of cancer fatalities that might result from nuclear power plant operation should not exceed one-tenth of one percent (0.1 percent) of the sum of cancer fatality risks resulting from all other causes. The Policy defines the population considered to be at significant risk as the population living within 10 miles of the plant site.

[17] As stated in footnotes to 10 CFR §100.11, "Determination of exclusion area, low population zone, and population center distance," and 10 CFR §50.67, "Accident source term," "[t]he fission product release assumed for these calculations should be based upon a major accident, hypothesized for purposes of site analysis or postulated from considerations of possible accidental events, that would result in potential hazards not exceeded by those from any accident considered credible. Such accidents have generally been assumed to result in substantial meltdown of the core with subsequent release of appreciable quantities of fission products.

the fuel particles, inherent reactor system safety features, releases from dust in the reactor system and attenuation as the radioactivity passes through the reactor building (e.g., plate-out and filtering). Hence it is recommended that, when addressing the source term for NGNP, the underlying premises of today's emergency planning basis, especially the underlying assumption of a severe core melt accident, be addressed directly and compared to the increased safety features of HTGR designs that would justify different assumptions.

While the NGNP plant design and safety analysis must define various source terms throughout the plant (e.g., reactor core, stored fuel), the PAG analysis only requires the identification of those source terms contributing to releases during an accident. Predictions of radioactivity release during the specific LBEs analyzed are a necessary part of the PAG analysis. In addition, the dust plated-out on the inside of the reactor system boundary may also contribute to the radioactivity released from the plant during an accident.

The timing of radionuclide releases is also important to emergency planning considerations. Generally, the more severe LWR accident releases occur within a "few hours." For HTGRs similar to those being considered for NGNP it is expected that releases (which are much smaller in magnitude relative to those for LWRs) will occur over a duration that is measured in "days" into the accident.

The frequency of a severe accident has not been a dominant factor in establishing the need for emergency planning (SECY 1997-0020 and Appendix I of NUREG-0396). The reason is that the public generally has seen the risk from a nuclear plant accident as less acceptable than the corresponding risk from non-nuclear accidents. Hence, emergency planning for at least LWRs has been seen as a matter of prudence (defense-in-depth), not as a matter of specific frequencies and consequences. For the NGNP EPZ reduction initiative, it is recommended that this task determine whether there is an adequate basis for challenging and changing the current nuclear power plant paradigm and replacing it with the reality that an NGNP accident is no more risky than industrial accidents. While emergency planning would still be necessary, there would be no special treatments simply because NGNP is a nuclear power plant. The underlying principle here is that the NGNP is so fundamentally different from current LWRs that a whole new logic in regards to emergency planning needs to be developed and implemented.

In summary, the magnitude, timing and frequency of the maximum credible releases (maximum credible source terms) should be assessed for the NGNP in establishing the emergency planning basis. These results will then provide needed support and direction to the effort to reduce the NGNP EPZs.

3.2.1.3 Reactor Building Functional Performance Requirements

In addition to establishing the NGNP accident source terms, the related containment functional performance requirements and event sequences (i.e., spectrum of accidents) need to be defined. The corresponding radionuclide release time frame requirements have a critical impact on the successful definition and implementation of the NGNP safety case including deterministic safety analysis, risk-informed performance-based design, emergency planning assessments, and specification of the EPZs.

For the NGNP, a clear set of containment function design and performance requirements should be developed and documented in a manner such that (1) there exists a very clear understanding of the underlying design reasons as to why the NGNP source terms and radioactivity releases are so low and (2) the design and safety analysis guidance related to the containment function is clearly documented for future HTGR designs and NGNP follow-on commercial plant design variations.

3.2.1.4 Spectrum of Accidents to be Analyzed

A set of LBEs must be identified and analyzed using "best-estimate" methods[18]. This set of LBEs should include event sequences that lead to a full range of design basis and beyond design basis accidents.

When considering beyond design basis accidents, it will be necessary to decide how to address the extremely low frequency events and whether their elimination from emergency planning assessments can be justified. According to SECY 1997-0020, issues which would have to be addressed in the consideration of reduced EPZs for LWRs and which should be addressed in the evaluation of reduced EPZs for NGNP are:

- The frequency level, if any, below which accidents will not be considered for emergency planning,
- The use of increased safety in one level of the defense-in-depth framework (e.g., fuel integrity) to justify reducing requirements in another level, and
- The acceptance of such changes by Federal, State, and local emergency response agencies.

A frequency cutoff level of 10^{-7}/year has been used in NRC documentation including NUREG-1420, *Special Committee Review of the Nuclear Regulatory Commission's Severe Accident Risks Report (NUREG-1150)* [ref. 32], and NUREG-1338, *Draft Pre-application Safety Evaluation*

[18] Best-estimate and/or 50th percentile analyses are performed for emergency planning analyses so that realistic results are obtained and evacuation and other emergency actions, which themselves involve risk to the population, are not initiated unnecessarily.

Report for the Modular High-Temperature Gas-Cooled Reactor [ref. 3]. The NGNP project should address this issue and adopt a value appropriate for NGNP.

The output of these analyses must include at least the source term input needed for the probabilistic consequences analysis described in the following subsection.

Another result must be a clear understanding of the dominant accident sequences in regards to impact on radioactivity releases along with a confirmation that all cost-effective design features that could reduce these consequences have been adopted.

3.2.1.5 Demonstration of Compliance with Protective Action Criteria

Compliance with the protective action criteria in subsection 3.2.1.1 should be demonstrated with a model that can perform an assessment of dose and health effects consequences including time-dependent meteorology.

The modeling of meteorology for NGNP needs to be determined. Possibilities include (1) use of the atmospheric conditions summarized in NRC Regulatory Guides 1.3 and 1.4 and (2) use of the meteorology database which is published in NUREG/CR-2239 [ref. 33] for sites in the United States.[19] NRC guidance on meteorological monitoring programs is provided in Regulatory Guide 1.23, Revision 1.

It is recommended that the emergency planning analysis be performed at the same time as the usual best-estimate safety analysis and PRA are performed even though the emergency planning results might not be required until a later point in time. The basis for this recommendation is experience wherein conservative modeling and analysis assumptions were made for expediency in completing the PRA. These assumptions were acceptable for the PRA because results were weighted by their probability of occurrence, but became “unacceptably conservative” when attempts were made to perform the PAG analysis for each specific LBE.

3.2.2 Element 2 − Develop Regulatory Position Statement(s) for Simplifying Emergency Planning Requirements for the NGNP

This strategy element follows the logic that the design of a gas-cooled reactor is different from that for an LWR and its “risk” is so small that any emergency can be addressed using the same type of response planning normally used for industrial facilities (e.g., oil refineries, chemical processing plants). This strategy will require coordination with various governmental agencies (Strategy Element 6), and a public relations and education campaign, especially near the site selected for the NGNP. It may be expedient for the site owner to coordinate such an effort in

[19] This database can also be seen in Annex B to Appendix A of Chapter 1 of the EPRI Advanced Light Water Reactor Utility Requirements Document.

conjunction with the Nuclear Energy Institute (NEI). An approach might be similar to that taken for the Waste Isolation Pilot Plant (WIPP) which included probabilistic assessments and sound reasoning to address the concerns of skeptics and the public ("Power to Save the World," Gwyneth Cravens, 2007, pages 143, 331, etc.).

3.2.3 Element 3 − Address the Other Factors as Identified in the SECY 1997-0020 "Roadmap"

While dose analyses form a major part of the justification for reducing the EPZ size, other areas of regulatory review must be considered. The objective of this strategy element would be to identify the various regulatory areas of review that also influence the final decision on appropriate EPZ sizes. Factors such as security needs and defense-in-depth will need to be considered and project activities needed to assure a full understanding of each identified.

The NRC indicated in the SECY 1997-0020 "roadmap" that if a reduction in EPZ size is to be considered, several issues need to be addressed (see subsection 3.2.1.1):

- The frequency level, if any, below which accidents will not be considered for emergency planning,
- The use of increased safety in one level of the defense-in-depth framework (e.g., fuel integrity) to justify reducing requirements in another level, and
- The acceptance of such changes by Federal, State, and local emergency response agencies.

For the NGNP, this would entail establishing the frequency level for beyond design basis events (e.g., 10^{-7}/year as indicated in subsection 3.2.1.3) below which emergency planning need not be considered and providing the corresponding justification. Also, the various levels of defense-in-depth implemented in the NGNP design would need to be defined, with emphasis on fuel particle integrity and the corresponding increase in accident prevention relative to accident mitigation. This strategy element should also include identification of issues and NGNP positions that will then need to be discussed with Federal, State and local officials.

Other non-technical (i.e., qualitative) factors are also considered in the establishment of the size of the EPZs. EPA's PAG Manual (Section 1.3) indicates that in addition to the local demographic, terrain and other considerations mentioned in 10 CFR §50.47(c)(2), the local emergency planning impacts and organizations responsible for implementation of plans need to be considered.

> "The size and shape of the recommended EPZs were only partially based on consideration of the numerical values of the PAGs. A principle additional basis was that the planning zone for evacuation and sheltering should be large enough

to accommodate any urban and rural areas affected and involve the various organizations needed for emergency response. This consideration is appropriate for any facility requiring an emergency response plan involving offsite areas. Experience gained through emergency response exercises is then expected to provide an adequate basis for expanding the response to an actual incident to larger areas, if needed. It is also noted that the 10-mile radius EPZ for the early phase is large enough to avoid exceeding the PAGs for the early phase at its boundary for low consequence, nuclear reactor, core-melt accidents and to avoid early fatalities for high-consequence, nuclear reactor core-melt accidents. The 50-mile EPZ for ingestion pathways was selected to account for the proportionately higher doses via ingestion compared to inhalation and whole body external exposure pathways."

3.2.4 Element 4 – Establish the EAB for the NGNP at a Distance Commensurate with Meeting the PAGs for Each of the Candidate Site(s)

An appropriate distance for the EAB (and commensurate limiting distance for each PAG) will need to be determined. The EAB sizing needs to take into consideration not only compliance with the PAGs but the unique characteristics of each type of site selected for evaluation, including meteorological data and demographic information. The strategy needs to outline for each of the candidate sites, a program to identify and address the non-technical issues that would need to be addressed, including consideration of current emergency plans at the particular site and discussions with Federal, State and local officials. Examples of the site types to be considered are:

- Existing DOE site such as Idaho National Laboratory (INL),
- Existing commercial nuclear plant (e.g., Waterford Unit 3), and
- Industrial site (e.g., refinery, chemical processing).

It is noted that the EPZ footprint is expected to be different for each site type. The development of licensing arguments for sizing the exclusion area at a distance that allows for practical co-location of the nuclear (heat generation) and non-nuclear (heat application) facilities that comprise the NGNP is needed. In addition, appropriate simplifications of emergency planning requirements within the EPZ will need to be identified.

The 1996 rulemaking that amended 10 CFR Part 100 [ref. 28, as summarized in Section A.7 of Appendix A] provides a detailed discussion of the siting factors and NRC's guidance related to each. Factors to be assessed include:

- Exclusion area,
- Site dispersion factors (e.g., Chi/Qs),

- Low population zone,
- Physical characteristics of the site,
- Nearby transportation routes, industrial and military facilities,
- Adequacy of security plans,
- Emergency planning,[20] and
- Siting away from densely populated centers.

3.2.5 Element 5 − Assess Ongoing Emergency Planning and Security Rulemakings to Assure Continued Viability of the NGNP Approach

Plant design safeguards and security experts should confer with site owner counterparts to identify common issues with emergency planning and establish actions, schedule time frames and input requirements for addressing each issue. The recently issued final rule on security requirements [ref. 16] and the proposed rule on enhancements to emergency preparedness requirements [ref. 18] are included in these evaluations. Other regulatory initiatives, such as the pilot program on State-of-the-Art Reactor Consequence Analysis (SOARCA) and the EPA initiative to revise the PAG manual[21], need to be considered.[22] Based on the results of Strategy Elements 2 and 3, re-confirm the adequacy of current regulations and identify any necessary new guidance documentation or policy statements or revisions to existing guidance and policies based on more detailed review and road-mapping of requirements in related NRC documentation.

3.2.6 Element 6 – Prepare and Implement Communications Plan(s) for Engaging with Federal, State, and Local Agencies (e.g., NRC/FEMA/et al) Having Cognizance over Emergency Planning Efforts

The NRC is the coordinating agency for federal review of emergency planning activities for nuclear power plants. However, a license applicant must interface with other Federal, State and local agencies in preparation and exercise of the emergency plan.

[20] The emergency planning factor is included here for completeness in describing the list of site factors included in the rulemaking.

[21] See: http://www.epa.gov/rpdweb00/rert/pags.html#status.

[22] The NRC recently completed the preliminary analysis of a boiling water reactor (Peach Bottom Atomic Power Station) and a pressurized water reactor (Surry Power Station), the first two pilot plants of the SOARCA project. The NRC is using the improved knowledge and the technological advances gained over the past 25 years to develop a realistic consequence analysis that considers the risk, design features, improvements in mitigative measures, and emergency response capabilities to determine the potential consequences from a severe accident and the potential health effects on the public.

This element of the strategy starts with evaluation of the National Response Framework (NRF). Issued in January 2008, the NRF is a guide prepared and managed by FEMA, now within the Department of Homeland Security (DHS). It details how the U.S. conducts all-hazards responses, from the smallest incident to the largest catastrophe. Published as a guidance document, the NRF establishes a comprehensive, national, all-hazards approach to domestic incident response. The NRF identifies the key response principles, as well as the roles and structures that serve to organize the national response. It describes how communities, States, the Federal Government and private-sector and nongovernmental partners apply these principles for a coordinated, effective national response. In addition, the NRF describes special circumstances where the Federal Government exercises a larger role, including incidents where Federal interests are involved and catastrophic incidents where a State would require significant support. The NRF lays the groundwork for first responders, decision-makers and supporting entities to provide a unified national response.

The NRF is comprised of a base document, 15 Emergency Support Function Annexes, and eight Support Annexes, all of which are available on-line at the NRF Resource Center (www.fema.gov/nrf). The annexes total 23 individual documents designed to provide concept of operations, procedures and structures for achieving response directives for all partners in fulfilling their roles under the framework.

The Nuclear/Radiological Incident Annex (NRIA) to the NRF describes the policies, situations, concepts of operations, and responsibilities of the Federal departments and agencies governing the immediate response and short-term recovery activities for incidents involving release of radioactive materials to address the consequences of the event. These incidents may occur on Federal-owned or -licensed facilities, privately owned property, urban centers, or other areas and may vary in severity from the small to the catastrophic. The incidents may result from inadvertent or deliberate acts. The NRIA applies to incidents where the nature and scope of the incident requires a Federal response to supplement the State, tribal, or local incident response.

Because there are several categories of potential incidents and impacted entities, the NRIA identifies different Federal agencies as “coordinating agencies” and “cooperating agencies” and associated strategic concepts of operations based on the authorities, responsibilities, and capabilities of those departments or agencies. In addition, the annex describes how other Federal departments and agencies support the DHS when it leads a large-scale multi-agency Federal response.

The NRIA to the NRF states that the NRC is the Coordinating Agency for events occurring at NRC-licensed facilities and for radioactive materials licensed either by the NRC or under the NRC Agreement States Program. As Coordinating Agency, NRC has technical leadership for the Federal government’s response to the event. As the severity of an event worsens, DHS will proactively engage in the coordination of the overall Federal response to the event in accordance with the criteria outlined in HSPD-5.

A recent statement by NRC Commissioner Klein (in response to NRC staff update on evaluating the need for updating evaluation models for better integration with EPA's PAGs) provides insight [ref. 34]:

> "I encourage the staff to continue participation in multi-agency organizations such as the Federal Radiological Preparedness Coordinating Committee and to continue coordination with NRC's Federal partners, such as the Department of Homeland Security, the Environmental Protection Agency, and the Radiation Source Protection and Security Task Force. I am convinced that only through coordinated efforts such as these will the Federal government be able to achieve and maintain an integrated, comprehensive and consistent event response platform."

Finally, the NGNP emergency plan must be developed in recognition of other regional and/or local plans that may be in place for facilities sited in close proximity to the NGNP (see subsection 3.2.4).

3.2.7 Element 7 − Develop an NGNP White Paper for Submittal to the NRC Describing the NGNP Emergency Planning Approach

A white paper on the NGNP approach to emergency planning should be prepared and submitted to the NRC so that related issues can be discussed during the pre-application period. It is recognized that some issues (e.g., mechanistic source term and plant security) will not be resolved in the near term, but the paper should be written contingent on completion of the related activities. This paper should describe the overall emergency planning and EPZ reduction program, including (1) ties to other NGNP initiatives such as the expected white paper on the approach to Defense-in-Depth, (2) the specific subtasks identified in Section 4.1 and (3) the outcome objectives for the pre-application engagement.

3.3 Summary of Approach

The basic recommendation is to pursue reduction of the most onerous emergency planning requirements, including (1) a reduction of the plume exposure pathway EPZ to the EAB or the area encompassing industrial plant workers, whichever is larger and (2) a reduction of the ingestion pathway EPZ (i.e., that for which action may be required to protect the food chain) to a smaller size appropriate to the accident source term from a HTGR.

Based on the review of regulations and guidance summarized in Section 2 of this report and our current understanding of the NGNP design, the approach to licensing basis events and corresponding mechanistic radioactivity release source terms, simplification of emergency planning requirements can be pursued within the current regulations. However, it is likely that additional NRC staff guidance with Commission review and approval may be required before reduced emergency planning requirements including reduced EPZs can be implemented for the NGNP.

The specific tasks proposed to advance the NGNP EPZ reduction and/or simplification program are identified in the following Section 4.1.

4 PROPOSED IMPLEMENTATION TASKS AND SCHEDULE

4.1 Recommended Tasks

The following tasks are recommended based upon the strategy elements identified and discussed in Section 3:

1. Establish the basis for a best estimate dose analysis of the conceptual design
   a. Identify reactor design and reactor building characteristics,
   b. Define Licensing Basis Event (LBE) sequences and their corresponding mechanistic accident source terms, and
   c. Address other factors (e.g., siting, security, co-located facilities) required to define the EAB for candidate site type(s).

2. Perform the analysis and compare the results with the PAGs to determine available margin, timing and uncertainties sufficient for emergency planning simplification for the candidate site type(s):
   a. Establish methods and input assumptions and collect input data for each candidate site type,
   b. Perform the PAG analyses based on the NGNP LBEs and mechanistic source terms, and
   c. Compare results to the PAG criteria and evaluate.

3. Identify and establish positions for closure of Commission policy issues related to the emergency planning effort (e.g., containment function performance requirements)

4. Coordinate policy initiatives with NRC and identify any newly apparent areas where regulatory policy, guidance or requirements must be modified or revised, and develop the supporting justification arguments.

5. Prepare a white paper for pre-application discussions with the NRC which:
   a. Summarizes the approach and expected results from dose analyses,
   b. Assesses interfaces with and requirements of coordinating agencies (e.g., within the National Response Framework),
   c. Describes the integration of emergency planning efforts for near sited nuclear and non-nuclear industrial facilities, and
   d. Proposes communications strategies for engaging with Federal, State and local authorities.

6. Prepare plan(s) for engaging with Federal, State and local authorities and conduct communications.

7. Prepare plan(s) for and conduct communications and outreach activities within the affected communities for the candidate site type(s).

8. Prepare the emergency plan portion (Part 5) of the COL application.[23]

4.2 Proposed Schedule

The tasks described in Section 4.1 are shown on the following page in Gantt chart form.

[23] The basic content of the emergency plan for NGNP is described in the report "Conceptual Design Studies for the NGNP with Hydrogen Production - Licensing Specification Development," NGNP-NHS WEC-LIC-1, Revision 0, dated May 2009.

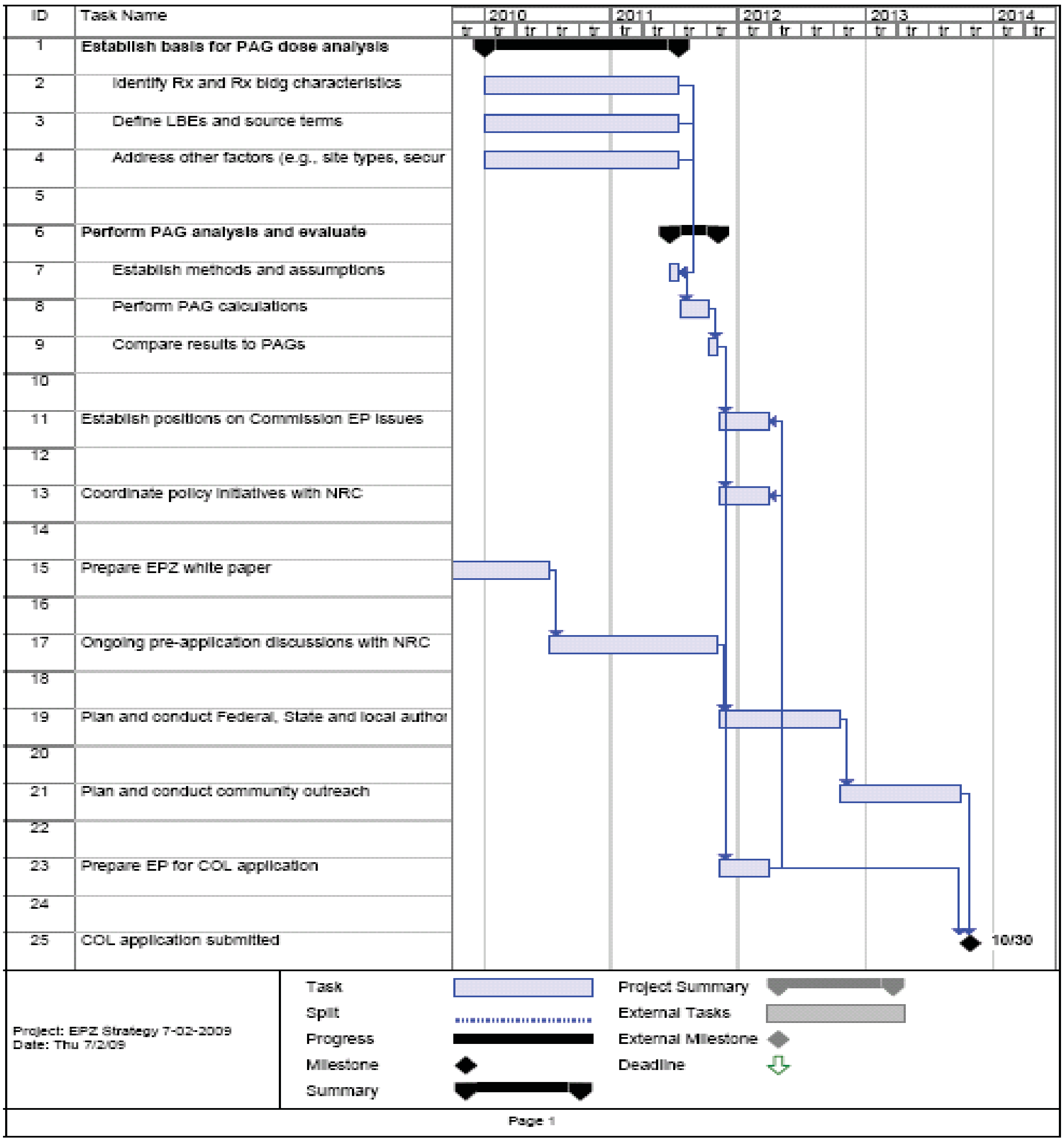

Figure 4-1: *Schedule for Proposed NGNP EPZ Reduction Program*

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APPENDIX A. HISTORICAL BACKGROUND

A.1 Early Regulation – Siting Away from Population Centers

Initial siting of test reactors followed a principle of siting in sparsely populated areas. This siting practice, described in WASH-3 [1950], was based on the consideration of a postulated serious accident that involved overheating or melting of the fuel, rupture of the reactor coolant system, and an uncontrolled release of radionuclides from a relatively conventional building that housed the reactor. Allowing for meteorological effects on the transport and dispersion of radionuclides, an exclusion zone around the reactor facility within which residents were to be excluded was recommended by the Advisory Committee on Reactor Safeguards (ACRS). The exclusion distance followed a rule of thumb based on the thermal power of the reactor.

$$R = 0.016\sqrt{P(kWt)}$$

Where R is expressed in kilometers.

Outside the exclusion area, it was stipulated that the calculated radiation exposure should be less than 300 rem (which is roughly the threshold for a lethal dose), or evacuation should be possible. For a 50 MWt reactor, this rule of thumb yields an exclusion distance of 3.6 km (2.2 miles) and for a 3,000 MWt reactor a distance of 27.8 km (17.3 miles).

Recognizing that power reactors needed to be sited close to load centers, more robust “containment” buildings were introduced (i.e., the Shippingport site was located about 32 km (20 miles) from Pittsburgh).

Nuclear powered submarines, developed in parallel with the early commercial power reactors, however, could not readily incorporate containment. As a result, the Navy relied on an accident prevention strategy based on stringent procedures for operator training, system/component testing, and quality control. Systems and components were designed with considerable margins to be able to withstand substantially higher than anticipated temperatures and pressures. Potential equipment malfunctions and failures were postulated, and redundant systems were included in the design so that each safety function could be performed by more than one system or component.

A.2 Introduction of Zones and Site Evaluation Factors – 10 CFR Part 100

By the late 1950's, it became clear that the various reactor designs under consideration required a more considered approach than remote siting or mandating of containment buildings. The location of nuclear power plants near cities necessitated the evaluation of zones around the plants. The need to establish a consistent set of siting criteria arose.

In its notice of proposed rulemaking on a new 10 CFR Part 100 [24 FR 4148, May 23, 1959], the AEC stated:

> "In view of the complex nature of the environment, the wide variation in environmental conditions from one location to another and the variations in reactor characteristics and associated protection which can be engineered into a reactor facility, definitive criteria for general application to the siting problems have not been set forth.

* * *

> There are wide possible variations in reactor characteristics and protective aspects of such facilities which affect the characteristics that otherwise might be required of the site. However, the following factors are used by the Commission as guides in the evaluation of sites for power and test reactors. …"

- Exclusion distance around power and test reactors
- Population density in surrounding areas
- Meteorological considerations
- Seismological considerations
- Hydrology and geology
- Interrelation of factors

When the AEC published the final 10 CFR Part 100 rule [27 FR 3509, April 12, 1962], it included these site evaluation factors and introduced three "zones".

> "An ***exclusion area*** of such size that an individual located at any point on its boundary for two hours immediately following onset of the postulated fission product release would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

> A ***low population zone*** of such size that an individual located at any point on its outer boundary who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

A ***population center distance*** of at least one and one-third times the distance from the reactor to the outer boundary of the low population zone. In applying this guide, due consideration should be given to the population distribution within the population center."

The site evaluation factors, listed in 10 CFR §100.10, were stated as:

(a) Characteristics of reactor design and proposed operation including:
  (1) Intended use of the reactor including the proposed maximum power level and the nature and inventory of contained radioactive materials;
  (2) The extent to which generally accepted engineering standards are applied to the design of the reactor;
  (3) The extent to which the reactor incorporates unique or unusual features having a significant bearing on the probability or consequences of accidental release of radioactive materials;
  (4) The safety features that are to be engineered into the facility and those barriers that must be breached as a result of an accident before a release of radioactive material to the environment can occur.

(b) Population density and use characteristics of the site environs, including the exclusion area, low population zone, and population center distance;

(c) Physical characteristics of the site, including seismology, meteorology, geology and hydrology.
  (1) The design for the facility should conform to accepted building codes or standards for areas having equivalent earthquake histories, No facility should be located closer than one-fourth mile from the surface location of an active earthquake fault.
  (2) Meteorological conditions at the site and in the surrounding area should be considered.
  (3) Geological and hydrological characteristics of the proposed site may have a bearing on the consequences of an escape of radioactive material from the facility. Special precautions should be planned if a reactor is to be located at a site where a significant quantity of radioactive effluent might accidentally flow into nearby streams or rivers or might find ready access to underground water tables.

(d) Where unfavorable physical characteristics of the site exist, the proposed site may nevertheless be found to be acceptable if the design of the facility includes appropriate and adequate compensating engineering safeguards.

In response to comments on the proposed rule, numerical guides, originally proposed to be included in the rule itself, were dropped in lieu of a guidance document. Here, the AEC noted:

> "In consequence of these many comments, criticisms and recommendations, the proposed guides have been rewritten, with incorporation of a number of suggestions for clarification and simplification, and elimination of the numerical values and example calculation formally constituting the appendix to the guides. In lieu of the appendix, some guidance has been incorporated in the text itself to indicate the considerations that led to establishing the exposure values set forth. However, in recognition of the advantage of example calculations in providing preliminary guidance to application of the principles set forth, the AEC will publish separately in the form of a technical information document a discussion of these calculations.
>
> These guides and the technical information document are intended to reflect past practice and current policy of the Commission of keeping stationary power and test reactors away from densely populated centers. It should be equally understood, however, that applicants are free and indeed encouraged to demonstrate to the Commission the applicability and significance of considerations other than those set forth in the guides."

The technical information document (TID) referred to in this rulemaking is TID-14844, *Calculation of Distance Factors for Power and Test Reactor Sites* (March 1962). Using a water moderated (cooled) reactor as an example reactor type, the TID presented a set of radii for the exclusion area and low population zone distances that was derived from an example analytical method for postulating a major reactor accident (defined as the "maximum credible accident").

> "In evaluating proposed reactor sites, the basic safety questions involve the possibility of accidents which might cause radioactivity release to areas beyond the site, the possible magnitudes of such releases and the consequences these might have. Practically, there are two difficult aspects to the estimation of potential accidents in a proposed reactor which affect the problem of site evaluation.
>
> 1. The necessity for site appraisal arises early in the life of a project when many of the detailed features of design which might affect the accident potential of a reactor are not settled.
> 2. The inherent difficulty of postulating an accident representing a reasonable upper limit of potential hazard.
>
> In practice, after systematic identification and evaluation of foreseeable types of accidents in a given facility, a nuclear accident is then postulated which would result in a potential hazard that would not be exceeded by any other accident considered credible during the lifetime of the facility. Such an accident has come to be known as the "maximum credible accident".
>
> For pressurized and boiling water reactors, for example, the "maximum credible accident" has frequently been postulated as the complete loss of coolant

> upon complete rupture of a major pipe, with consequent expansion of the coolant as flashing steam, meltdown of the fuel and partial release of the fission product inventory to the atmosphere of the reactor building. There may be other combinations of events which could also release significant amounts of fission products to the environment, but in every case, for the events described above to remain the maximum credible accident the probability of their occurrence should be exceedingly small, and their consequences should be less than those of the maximum credible accident. In the analysis of any particular site-reactor combination, a realistic appraisal of the consequences of all significant and credible fission release possibilities is usually made to provide an estimate in each case of what actually constitutes the "maximum credible" accident. This estimated or postulated accident can then be evaluated to determine whether or not the criteria set out in 10 CFR 100 are met. As a further important benefit, such systematic analyses of potential accidents often lead to discovery of ways in which safeguards against particular accidents can be provided.
>
> Since a number of analyses have indicated that the pipe rupture-meltdown sequence in certain types of water cooled reactors would result in the release of fission products not likely to be exceeded by any other "credible" accident, this accident was designated the "maximum credible accident" (MCA) for these reactors. The remainder of this discussion will refer chiefly to this type of reactor and this type of accident. Corresponding maximum credible accidents can by similar analyses be postulated for gas-cooled, liquid metal cooled, and other types of reactors."

Thus, early on, the AEC recognized the impact of differences in reactor design on the accident analysis. Notwithstanding this, the subsequent industry focus on water cooled reactors resulted in the calculation method described in TID-14844 becoming a *de facto* standard that is retained in many Regulatory Guides in existence today.

A.3 Requiring Formal Emergency Response Plans – Appendix E to 10 CFR Part 50

In 1970, the AEC added a new Appendix E to 10 CFR Part 50, requiring formal response plans to cope with emergencies. The requirements were directed at license holders and not to local or state governmental agencies. [35 FR 7818 proposed rule, May 21, 1970; 35 FR 19567 final rule, December 24, 1970] No changes in the evaluation factors for plant siting were made as part of this rulemaking.

A.4 Coordinating Emergency Plans Amongst Agencies – Recommendations for Protective Action Guides and Emergency Planning Zones

The Office of Emergency Preparedness (within the General Services Administration (GSA)) provided an initial notice of interagency responsibilities in January 1973. [38 FR 2356, January 24, 1973] Included was the statement that the Environmental Protection Agency (EPA) will be responsible for the *[e]stablishment of action guidelines based on projected radiation exposure levels which might result from nuclear incidents.*[24] This notice was superseded in December 1975, when the (then) Federal Preparedness Agency published a more detailed notice in the Federal Register. [40 FR 59494, December 24, 1975] This expanded notice stated that the EPA is responsible for:

> "Establishment of Protection Action Guides (PAG) in coordination with appropriate Federal agencies. These guides will be in terms of projected radiation doses which might result from radiological incidents at fixed nuclear facilities or in the transportation of radioactive materials."

By the mid-1970's, Federal guidance suggested the use of a spectrum of accidents as a basis for developing emergency response plans. A 1976 resolution passed by the Task Force of the Conference of (State) Radiation Control Program Directors requested that the NRC "*make a determination of the most severe accident basis for which radiological emergency response plans should be developed by offsite agencies*". In response, a joint Task Force on Emergency Planning was formed in November 1976 between the EPA and the NRC to review the existing requirements and guidance and to recommend a consistent approach to development of plans.

The Task Force report, NUREG-0396, *Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants*, was published in December 1978.

> "The Task Force accepts the principle noted in existing NRC and EPA guidance [2,3] that acceptable values for emergency doses to the public under the actual conditions of a nuclear accident cannot be predetermined. The emergency actions taken in any individual case must be based on the actual conditions that exist and are projected at the time of an accident. For very serious accidents, predetermined protective actions would be taken if projected doses, at any place and time during an actual accident, appeared to be at or above the applicable proposed Protective Action Guides (PAGs), based on information readily available in the reactor control room, i.e., at predetermined emergency action levels[4]. Of course, ad hoc

[24] PAGs for radiological incidents were first defined in the 1960's by the Federal Radiation Council. These early PAGs were applied to restricting the use of food products that had become contaminated as the result of release of radioactivity to the stratosphere from weapons testing. In a Memorandum for the President [29 FR 12056, August 22, 1964], the Federal Radiation Council '*adopted the term "Protective Action Guide" (PAG), defined as the projected absorbed dose to individuals in the general population which warrants protective action following a contaminating event*.'

actions, based on plant or environmental measurements, could be taken at any time.

The concept of Protective Action Guides was introduced to radiological emergency response planning to assist public health and other governmental authorities in deciding how much of a radiation hazard in the environment constitutes a basis for initiating emergency protective actions. These guides (PAGs) are expressed in units of radiation dose (rem) and represent trigger or initiation levels, which warrant pre-selected protective actions for the public if the projected (future) dose received by an individual in the absence of a protective action exceeds the PAG. PAGs are defined or definable for all pathways of radiation exposure to man and are proposed as guidance to be used as a basis for taking action to minimize the impact on individuals.

The nature of PAGs is such that they cannot be used to assure that a given level of exposure to individuals in the population is prevented. In any particular response situation, a range of doses may be experienced, principally depending on the distance from the point of release. Some of these doses may be well in excess of the PAG levels and clearly warrant the initiation of any feasible protective actions. This does not mean, however, that doses above PAG levels can be prevented or that emergency response plans should have as their objective preventing doses above PAG levels. Furthermore, PAGs represent only trigger levels and are not intended to represent acceptable dose levels. PAGs are tools to be used as a decision aid in the actual response situation. Methods for the implementation of Protective Action Guides are an essential element of emergency planning. These include the predetermination of emergency conditions for which planned protective actions such as shelter and/or evacuation would be implemented offsite. Details of these methods are being provided as separate guidance[3, 4] and are not included in this report."

Footnotes:

[2] NUREG-71/111, "Guide and Check List for the Development and Evaluation of State and Local Government Radiological Emergency Response Plans in Support of Fixed Nuclear Facilities," December 1974.

[3] EPA-520/1-75-001, "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents," Environmental Protection Agency, September 1975.

[4] NRC Regulatory Guide 1.101, "Emergency Planning for Nuclear Power Plants," March 1977.

The Task Force report also recommended that '*Emergency Planning Zones" (EPZs) about each nuclear facility be defined both for the short term "plume exposure pathway" and for the longer term "ingestion exposure pathways.*' These EPZs were defined as:

> "***Plume exposure pathway*** – The principal exposure sources from this pathway are (a) whole body external exposure to gamma radiation from the plume and from deposited material and (b) inhalation exposure from the passing radioactive plume. The time of potential exposure could range from hours to days.
>
> ***Ingestion exposure pathway*** – The principal exposure from this pathway would be from ingestion of contaminated water or foods such as milk or fresh vegetables. The time of potential exposure could range in length from hours to months."

Also:

> "It is expected that judgment of the planner will be used in determining the precise size and shape of the EPZs considering local conditions such as demography, topography and land use characteristics, access routes, jurisdictional boundaries, and arrangements with the nuclear facility operator for notification and response assistance.

The Task Force concluded:

- "A spectrum of accidents (not the source term from a single accident sequence) should be considered in developing a basis for emergency planning.
- The establishment of Emergency Planning Zones of about 10 miles for the plume exposure pathway and about 50 miles for the ingestion pathway is sufficient to scope the areas in which planning for the initiation of predetermined protective action is warranted for any given nuclear power plant.
- The establishment of time frames and radiological characteristics of releases provides supporting information for planning and preparedness.
- If previous consideration has been given to the basic planning elements put forth in existing guidance documents [2,3,4] the establishment of Emergency Planning Zones should not result in large incremental increases in required planning and preparedness resources."

A detailed explanation of the Task Force reasoning (documented in NUREG-0396) is provided in SECY 1997-0020. In addition to a review of NUREG-0396 rationale, criteria, and methods, this SECY described how the rationale might be applied to advanced reactors. The NRC staff position was stated as:

> “Evolutionary and passive advanced LWRs have lower calculated probabilities of accidents than current plant designs. However, beyond design basis accidents are still possible, although very unlikely. Use of the consequence rationale is closely related to the "defense-in-depth" safety philosophy which provides multiple layers of defense so that if one layer of defense fails, another is available to protect the public. In its Safety Goal Policy Statement, 51 FR 30028, August 21, 1986, the Commission stated that: "A defense-in-depth approach has been mandated in order to prevent accidents from happening and to mitigate their consequences. Siting in less populated areas is emphasized. *Furthermore, emergency response capabilities are mandated to provide additional defense-in-depth protection to the surrounding populations.*" (emphasis added) The staff believes that the current rationale for the size of the EPZ, i.e., potential consequences from a spectrum of accidents, tempered by probability considerations, should be maintained for evolutionary and passive advanced LWRs.”

A.5 Requiring Formal Emergency Planning Zones Beyond the EAB – 10 CFR §50.47

In the rulemaking that added 10 CFR §50.47 to Part 50, the NRC described the reasoning behind their recommendation to expand emergency planning considerations beyond the EAB requirement of 10 CFR Part 100. The *Supplementary Information* to the proposed rule [43 FR 37473, August 23, 1978] drew upon the joint NRC/EPA Task Force’ efforts:

> “The principal aspects of the NRC staff review for emergency planning includes (sic) the protections of persons within the exclusion area, the onsite emergency response organization, the protection of the public beyond the exclusion area and the connection between the facilities plan and that of the offsite emergency response organization consisting of local, State and Federal agencies. These reviews are part of the safety review of each application. These matters may also be considered in identifying any potential emergency planning advantages or disadvantages of particular sites as part of the NEPA cost/benefit analysis of alternate sites.
>
> There are two elements of the NRC staff review required by the Commission's regulations as stated in 10 CFR Part 100, "Reactor Site Criteria," and 10 CFR Part 50, "'Licensing of Production and Utilization Facilities." The first review element is to determine compliance with the seting (sic) criteria of 10 CPR Part 100. Rector site criteria are established in part 100 which, in conjunction with postulated accident calculations performed by the applicant for the proposed facility design, establish boundaries for an exclusion area and a low population zone (LPZ). In this connection, the Commission has, from the earliest days of licensing reactors, required the use of conservative assumptions and calculation methods in assessing consequences of a hypothetical release from the nuclear

facility. The review conducted in conformance with 10 CFR Part 100 requirements establishes, for an acceptable site, that certain numerical exposure guidelines are met and in addition that the number and density of people within the LPZ are such that appropriate protective measures could be taken on their behalf in the event of an accident.

Beyond the siting criteria and the question of site suitability is the second review element which is to determine compliance with the licensing requirements in I0 CFR Part 50 and appendix E thereto for emergency plans. This review element focuses on the question of organizational and operational preparedness to cope with emergencies. A principal aspect of this review is to determine whether the applicant has made or will make appropriate arrangements with appropriate Federal, State and local officials to assure that, in the event of an actual emergency, necessary evacuation or other protective actions will be taken to protect offsite members of the public. Although these arrangements include the protective measures contemplated by 10 CFR Part 100, in connection with the LPZ, they need not be limited to application within the LPZ, nor to measures intended to cope primarily with the airborne pathway (cloud passage) covered by sections 100.3 and 100.11 of part 100. Such arrangements are expected to be guided by emergency action criteria, arrived at through a coordinated effort among local, State, and Federal authorities. Such criteria are believed to be a sound and prudent approach to the management of the small residual risk involved in the operation of nuclear facilities.

Indeed, their application to ingestion exposure pathways involving accidental spills into drinking water sources and accidental deposition of radioactive material onto agricultural crops or areas used for forage for milk cows has long been included as part of the review of emergency plans, Since one would anticipate that there would generally be time to monitor the actual situation for releases impacting from these pathways and to take appropriate action based on existing conditions, the Commission review has generally not emphasized postulated accident scenarios for evaluation but rather has assured that there are adequate arrangements for prompt notice to appropriate officials and arrangements to perform the appropriate monitoring, even though this may involve areas of consideration extending beyond the LPZ.

The principal considerations used in assessing emergency plans during the siting and licensing review of nuclear power plants including the need for such planning beyond the LPZ are summarized below.

1. Physical characteristics, − The Commission considers that the following physical characteristics in the vicinity of the site are relevant to the evaluation of protective actions which may be taken in the event of an accidental release of radioactive material: The numbers and proximity to the site boundary of resident and transient persons and the relative speed with which warnings can be communicated to them, the availability and character of evacuation routes and means of transportation, the availability

and locations of structures suitable for sheltering people, and the presence of institutions (such as hospitals, nursing homes, and schools) which may require special emergency planning arrangements. Measures to compensate for those characteristics that may be adverse to the effective implementation of emergency actions should be identified and proposed by an applicant and reviewed by the NRC staff. Particular attention Is to be given to the foregoing as they affect the effectiveness of taking protective actions within the LPZ established pursuant to the Commission's siting criteria of 10 CFR Part 100. This should not, however, preclude the consideration of utilizing emergency plans to provide additional protective benefit to persons beyond a LPZ as a matter of reasonable and prudent risk management, to assure protection beyond that afforded by safety design features and the siting of facilities in accordance with 10 CFR Part 100.

2. Protective measures, − An essential element for reducing individual and population exposures from accidental releases of radioactive material is effective and timely protective measures. The establishment of soundly based emergency plans which include appropriate protective measures to the initial operation of a nuclear power plant is a basic Commission requirement in its licensing process. The NRC staff has found that there may be circumstances for which the available strategies for taking protective actions outside the facility site boundaries are limited. As an example this occurs when large numbers of persons may be engaged in outdoor recreational activities in the vicinity of plant, and it is clear that existing structures are insufficient to provide needed temporary shelter. In such an instance, the has (sic) considered it appropriate to emphasize evacuation. When taken in conjunction with appropriate protective action criteria, such as EPA protective action guides,[1] these considerations may lead to planning for protective actions beyond the LPZ.
3. Emergency plans. − Protection of the public from the effects of severe natural phenomena, such as hurricanes or tornadoes, and severe man-made events, such as dam failures or toxic gas releases, are typically considered in general emergency plans. Such general emergency plans are developed and maintained by agencies of the State and local governments Emergency plans for protecting the public health and safety from accidental releases of radioactive material involve many of the same types of actions and thus are designed to be compatible with these broader genera emergency plans. Emergency plans for nuclear power plants are designed to permit protection to the public by reducing individual and population exposures resulting from postulated nuclear accidents. The benefits from the emergency plan must be commensurate with the risks to the health and safety of the public associated with the implementation of the protective action.
4. Procedures.-The general authorities and capabilities of Federal, State and local officials for carrying out emergency plans are recognized. A goal of

> the Commission's review is to determine whether the applicant has developed adequate arrangements with Federal, State, and local officials to assure that effective initiation of protection actions within and beyond the LPZ will be implemented, should the need arise. An important factor in emergency planning Is the availability to the decision-making official (Federal, State, and local) of all Information - necessary to determine the magnitude of the emergency and to decide whether protective actions should or should - not be taken in light of the total risk (nuclear and non-nuclear) to the public health and safety from the action. Each licensee must establish procedures to assure that such officials are provided with adequate information throughout the course of any emergency.

A general examination of emergency planning in the licensing of nuclear power plants is underway. In the interim, the Commission is firmly of the firm opinion that continued implementation of its practice to review the possible need for emergency plans beyond the LPZ as necessitated by circumstances in the vicinity of the site is required. However, in the New England Power Company, et al, and Public Service Company of New Hampshire decisions, ALAB-390, 5 NRC 733 (1977), the Commission's regulations were construed as not permitting licensing consideration of evacuation plans for the protection of persons outside the low population zone. In light of the above, the Commission believes that its regulations in 10 CFR Part 50, appendix E, should be amended to reflect the emergency planning considerations here discussed. The proposed change to the rule on the licensing requirements for emergency plans clarifies the intent that consideration of emergency planning beyond the LPZ is a factor in the licensing review and is not a factor in the site suitability review under 10 CFR Part 100."

Footnote [1]: "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents," (Chapter 2) U.S. Environmental Protection Agency – EPA-520/1-75-001, September 1975.

The final rule on 10 CFR §50.47 was issued in 1980 [45 FR 55402, August 19, 1980]. In addition to adding a new section §50.47, Appendix E to 10 CFR Part 50 was revised, with new requirements for provisions for communications with State and local authorities, onsite technical support center, a near-site emergency operations facility, and specialized training among the plant operating staff. Included also were requirements for detailed emergency planning implementing procedures.

A.6 Decoupling Siting from Design; Introduction of Realistic Source Terms into Licensing

By the mid-1980's the knowledge learned from severe accident research permitted a revisiting of the conservative approach to source terms. In a 1986 policy paper [SECY 1986-0228], the NRC staff summarized the issue:

> "The postulated limiting accident currently used by the staff to assess site suitability as well as to evaluate the adequacy of plant mitigation and other safety systems is derived from a 25 year old report (TID-14844) that is now regarded as outmoded. This paper presents the staff's plan to treat the releases ("source terms") from core damage and core-melt accidents in a more realistic fashion in licensing future plants. Implementation will be primarily through revisions in the Standard Review Plan and Regulatory Guides. Existing plants would not be affected unless their owners proposed license amendments calling for a review under a revised section of the Standard Review Plan.
>
> To accomplish this, the staff will select a small number of severe accident sequences and will use the source term code package (STCP) methodology described in NUREG-0956, to compute the rates of release of fission products in the containment during these sequences. The sequences selected will be chosen to represent those severe accidents which, by virtue of their probability, are considered to dominate degraded core and core-melt events. Thus, for future plants, the limiting design basis accident will be derived from a set of core-melt events. The releases into containment from these sequences will be used to set the performance levels of certain engineered safety features, and to determine containment leakage limits and site acceptability, replacing the assumptions in TID-14844 presently used in the Standard Review Plan.
>
> Emergency planning requirements would not be determined from this and will be dealt with separately following review of the Chernobyl accident."

The staff evaluated the impact of using a revised source term approach in its review of the General Electric Advanced BWR, initiated as part of its review of a Final Design Approval (FDA) application and later revisited within the context of the staff's review of the first design certification application under the new 10 CFR Part 52. In a 1990 policy issue paper [SECY 1990-0341], the NRC staff provided the Commission with an update on the siting issue:

> "Decoupling light water reactor (LWR) siting from plant design was suggested by the staff for further study because of the potential benefits which could be realized by such an approach. Specifically, decoupling would replace existing siting dose calculation requirements (which traditionally have affected plant design more than siting) with explicit requirements more directly related to acceptable site characteristics. This would be accomplished by a significant change to 10 CFR 100 and its related guidance documents. A corresponding change to 10 CFR 50 would be required to regulate aspects of plant design now controlled by siting dose calculation requirements.
>
> Decoupling would mean that reactor site requirements would be largely independent of dose calculations and source terms (except perhaps for reactor

power level). The site requirements would be expected to remain unchanged from present requirements although they would be stated more explicitly.

Decoupling would also mean that plant engineered safety features (ESF) design requirements would not be determined by the present design basis accident dose calculations. These design requirements would be based on best engineering judgment rather than a dose calculation algorithm. The ESF requirements are expected to change; development of a new ESF (including containment) criteria is a key element of this effort. Developing these criteria will result in a severe accident rulemaking. The staff believes that such decoupling could potentially be of more benefit than simply updating source term timing and composition because it would explicitly state siting requirements in a regulation and focus more realistically on those plant features which most affect risk."

SECY 1990-0341 also describes the historical background, regulatory reach, and limitations of TID-14844:

"Specifically, present reactors have been sited and designed based on their ability to cope with a group of postulated accidents, the so-called design basis accidents. The ability of the plant to withstand these events, as well as their radiological consequences, must be shown to be acceptable in order for the plant to receive a license.

Reactor siting also reflects consideration of accidents beyond the design basis. The statement of considerations (27 FR 3509) published with the issuance of Part 100 noted that accidents beyond the design basis were a factor in the establishment of the population center distance as a siting requirement.

Underlying the analysis of many of these accidents are certain regulatory assumptions regarding the accidental release of fission products which profoundly affect the design of key plant systems. Certain of these assumptions constitute what is generally referred to as the "source term", that is, the timing, composition, energy and other characteristics needed to analyze the radiological consequences of interest. The most well-known of these is the TID source term, so called because it was given in report TID-14844, issued in 1962. The TID report is referenced in a footnote to 10 CFR 100 for further guidance in developing the exclusion area, low population zone and population center distance and is also used elsewhere in 10 CFR 50 in relation to the design of certain plant features such as environmental qualification. Other applications deal with the performance of engineered safety features such as containment spray and filter systems.

Since the issuance of TID-14844, a great deal of information, based on a wealth of research data, has been accumulated. The source term and other assumptions which make up the prescription used in the siting analysis, while providing a high level of plant mitigation capability, are not consistent with the results of recent research. Use of this prescription in its present form may force plant designers to include design features that may not enhance safety (e.g., valve timing and filter design). Similarly, use of this prescription may cause designers not to focus on certain aspects of plant accidents that should warrant attention (e.g., release of Cesium and potential containment failure under severe accident conditions).

Also contributing to the need for change is the way in which site evaluations have been carried out. Part 100 refers, via a note at the end of the regulation, to the document TID-14844 as providing a sample calculation that reflects "current siting practices" of the commission. TID-14844 did not give credit for fission product cleanup systems in dose reduction. As reactor power levels increased shortly after the promulgation of Part 100, reactor designers introduced and developed such cleanup systems to keep site boundary distances from becoming excessively large. It soon became clear that such systems were, in principle, so effective in iodine dose reduction that very small site boundary distances could be found acceptable. But it also became clear that maintenance of containment integrity was pivotal to meeting Part 100 site boundary dose guidelines. In order to avoid revision to the siting regulations, the staff used a conservative methodology which allowed only limited degree of credit for the effectiveness of these systems in order to maintain acceptable site values, but assumed that containment integrity would be maintained under accident conditions. In this fashion, the staff kept exclusion area and LPZ distances roughly the same as those resulting from review of early plants. Stated another way, the staff's conservative methodology resulted in distances roughly reflecting "current (i.e., 1962)" siting practices."

Also, in the area of plant design, SECY 1990-0341 stated:

"Current practice has also had a significant impact upon plant design. This is because the TID source term, originally intended for siting purposes, has been applied to many aspects of plant design, as well. Examples of plant design aspects affected by the TID source term include control room habitability, equipment qualification, post-accident sampling systems, and timing of some containment isolation valves. Some aspects of the TID source term are now recognized as inconsistent with the results of recent research. These include such aspects as fission product timing, quantities and types of radionuclides released. As a result, a rigid application of the TID source term may not permit the best engineering solutions for the design of those plant systems, as well as related systems, for future plants.

In addition, current practice assumes that containment integrity is maintained for the duration of the accident, although the containment is assumed to be leaking. Since the containment design basis is the temperature and pressure conditions associated with a loss-of-coolant accident (LOCA), the assumption of containment integrity under severe accident conditions, which could result in a

TID-type release into containment, may not be appropriate. Therefore, current practice does not address containment integrity and performance under those conditions (i.e., severe accidents) which would likely result in a TID-type release and which most affect risk. For example, Appendix J concentrates on testing to assure low leak rates for large break LOCA conditions. While assuring low leak rates for these conditions also tends to provide some assurance of structural integrity, which in turn provides a significant degree of protection against release for a wider range of accidents, it does so only indirectly. Containment integrity requirements more closely linked to withstand the effects of severe accidents may provide better regulatory focus on principal safety attributes."

Concluding:

"The TID-14844 source term, originally intended for site evaluation purposes, has been applied to many aspects of plant design. Some aspects of this release into containment are now recognized to be incompatible with present research findings. As a result, rigid application of the TID source term may not permit the best engineering solutions on some aspects of future plant design.

The staff concludes that improved insights regarding accident source terms, particularly in areas such as fission product timing, fission product composition, quantities and chemistry should be factored into regulatory practice, consistent with the state of knowledge, so as to provide improved guidance for designers of future plants. This could be accomplished either by specifying performance requirements for each system (e.g., control room, sprays, filters, etc.) separately, or by providing guidance on the nature of the radiological conditions that plant systems should be expected to accommodate. The staff believes that providing guidance on the nature of the radiological conditions (that is, specifying a new source term) might be accomplished more quickly and offer significant improvements. Maximum benefit, however, would result from addressing ESF engineering requirements directly, without reference to a source term or dose calculation. The staff will pursue, in parallel, a major revision to both Parts 50 and 100 which would eventually replace the dose calculations currently required in Part 100.

In its SRM, the Commission approved the staff's recommendation, noting '*The staff should ensure that uncertainties are fully accounted for, without anticipation of what further research might show in the future.*'

A.7 Revision of 10 CFR Part 100 Siting Factors to Address Realistic Source Terms

The NRC described the reasoning behind the EAB sizing, source term and dose calculation requirements contained in the existing regulations in the Final Rule on 10 CFR Part 100 [61 FR 65157, December 11, 1996].

> "Since promulgation of the reactor site criteria in 1962, the Commission has approved more than 75 sites for nuclear power reactors and has had an opportunity to review a number of others. In addition, light-water commercial power reactors have accumulated about 2000 reactor-years of operating experience in the United States. As a result of these site reviews and operational experience, a great deal of insight has been gained regarding the design and operation of nuclear power plants as well as the site factors that influence risk. In addition, an extensive research effort has been conducted to understand accident phenomena, including fission product release and transport. This extensive operational experience together with the insights gained from recent severe accident research as well as numerous risk studies on radioactive material releases to the environment under severe accident conditions have all confirmed that present commercial power reactor design, construction, operation and siting is expected to effectively limit risk to the public to very low levels. These risk studies include the early "Reactor Safety Study" (WASH-1400), published in 1975, many Probabilistic Risk Assessment (PRA) studies conducted on individual plants as well as several specialized studies, and the recent "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," (NUREG-1150), issued in 1990. Advanced reactor designs currently under review are expected to result in even lower risk and improved safety compared to existing plants. Hence, the substantial base of knowledge regarding power reactor siting, design, construction and operation reflects that the primary factors that determine public health and safety are the reactor design, construction and operation.
>
> Siting factors and criteria, however, are important in assuring that radiological doses from normal operation and postulated accidents will be acceptably low, that natural phenomena and potential man-made hazards will be appropriately accounted for in the design of the plant, that site characteristics are such that adequate security measures to protect the plant can be developed, and that physical characteristics unique to the proposed site that could pose a significant impediment to the development of emergency plans are identified. The Commission has also had a long standing policy of siting reactors away from densely populated centers, and is continuing this policy in this rule.
>
> The Commission is incorporating basic reactor site criteria in this rule to accomplish the above purposes. The Commission is retaining source term and dose calculations to verify the adequacy of a site for a specific plant, but source term and dose calculations are relocated to Part 50, since experience has shown that these calculations have tended to influence plant design aspects such as containment leak rate or filter performance rather than siting. No specific source term is referenced in Part 50. Rather, the source term is required to be one that is "* * * assumed to result in substantial meltdown of the core with subsequent release into the containment of appreciable quantities of fission products." Hence,

this guidance can be utilized with the source term currently used for light-water reactors, or used in conjunction with revised accident source terms.

The relocation of source term and dose calculations to Part 50 represent (sic) a partial decoupling of siting from accident source term and dose calculations. The siting criteria are envisioned to be utilized together with standardized plant designs whose features will be certified in a separate design certification rulemaking procedure. Each of the standardized designs will specify an atmospheric dilution factor that would be required to be met, in order to meet the dose criteria at the exclusion area boundary. For a given standardized design, a site having relatively poor dispersion characteristics would require a larger exclusion area distance than one having good dispersion characteristics. Additional design features would be discouraged in a standardized design to compensate for otherwise poor site conditions.

Although individual plant tradeoffs will be discouraged for a given standardized design, a different standardized design could require a different atmospheric dilution factor. For custom plants that do not involve a standardized design, the source term and dose criteria will continue to provide assurance that the site is acceptable for the proposed design.

Rationale for Individual Criteria

(A) Exclusion Area. An exclusion area surrounding the immediate vicinity of the plant has been a requirement for siting power reactors from the very beginning. This area provides a high degree of protection to the public from a variety of potential plant accidents and also affords protection to the plant from potential man-related hazards. The Commission considers an exclusion area to be an essential feature of a reactor site and is retaining this requirement, in Part 50, to verify that an applicant's proposed exclusion area distance is adequate to assure that the radiological dose to an individual will be acceptably low in the event of a postulated accident. However, as noted above, if source term and dose calculations are used in conjunction with standardized designs, unlimited plant tradeoffs to compensate for poor site conditions will not be permitted. For plants that do not involve standardized designs, the source term and dose calculations will provide assurance that the site is acceptable for the proposed design.

The present regulation requires that the exclusion area be of such size that an individual located at any point on its boundary for two hours immediately following onset of the postulated fission product release would not receive a total radiation dose in excess of 25 rem to the whole body or 300 rem to the thyroid gland. A footnote in the present regulation notes that a whole body dose of 25 rem has been stated to correspond numerically to the once in a lifetime accidental or emergency dose to radiation workers which could be disregarded in the determination of their radiation exposure status (NBS Handbook 69 dated June 5, 1959). However, the same footnote also clearly states that the Commission's use of this value does not imply that it considers it to be an acceptable limit for an emergency dose to the public under accident conditions, but only that it represents a reference value to be used for evaluating plant features and site characteristics intended to mitigate the radiological consequences of accidents in order to provide assurance of low risk to the public under postulated accidents. The Commission, based upon extensive experience in applying this criterion, and in recognition of the conservatism of the assumptions in its application (a large fission product release within containment associated with major core damage, maximum allowable containment leak rate, a postulated single failure of any of the fission product cleanup systems, such as the containment sprays, adverse site meteorological dispersion characteristics, an individual presumed to be located at the boundary of the exclusion area at the centerline of the plume for two hours without protective actions), believes that this criterion has clearly resulted in an adequate level of protection. As an illustration of the conservatism of this assessment, the maximum whole body dose received by an actual individual during the Three Mile Island accident in March 1979, which involved major core damage, was estimated to be about 0.1 rem.

* * *

With regard to the value to be used as the dose criterion, a number of comments were received that the proposed value of 25 rem TEDE represented a more restrictive criterion than the current values of 25 rem whole body and 300 rem to the thyroid gland. These commenters noted that the use of organ weighting factors of 1 for the whole body and 0.03 for the thyroid as given in 10 CFR Part 20, would yield a value of 34 rem TEDE for whole body and thyroid doses of 25 and 300 rem, respectively. This is because the organ weighting factors in 10 CFR Part 20 include other effects (e.g., genetic) in addition to latent cancer fatality.

After careful consideration, the Commission has decided to adopt a value of 25 rem TEDE as the dose acceptance criterion for the final rule. The bases (sic) for this decision follows. First, the Commission has generally based its regulations on the risk of latent cancer fatality. Although a numerical calculation would lead to a value of 27 rem TEDE, as noted in the discussion that accompanied the proposed rule, the Commission concludes that a value of 25 rem is sufficiently close, and that the use of 27 rather than 25 implies an unwarranted numerical precision. In addition, in terms of occupational dose, Part 20 also permits a once-in-a-lifetime planned special dose of 25 rem TEDE. In addition, EPA guidance sets a limit of 25 rem TEDE for workers performing emergency service such as lifesaving or protection of large populations. While the Commission does not, as noted above, regard this dose value as one that is acceptable for members of the public under accident conditions, it provides a useful perspective with regard to doses that ought not to be exceeded, even for radiation workers under emergency conditions.

The argument that a criterion of 25 rem TEDE in conjunction with the organ weighting factors of 10 CFR Part 20 for its calculation represents a tightening of the dose criterion, while true in theory, is not true in practice. A review of the dose analyses for operating plants has shown that the thyroid dose limit of 300 rem has been the limiting dose criterion in licensing reviews, and that all operating plants would be able to meet a dose criterion of 25 rem TEDE. Hence, the Commission concludes that, in practice, use of the organ weighting factors of Part 20 together with a dose criterion of 25 rem TEDE, represents a relaxation rather than a tightening of the dose criterion. In adopting this value, the Commission also rejects the view, advanced by some, that the dose calculation is merely a “reference” value that bears no relation to what might be experienced by an actual person in an accident. Although the Commission considers it highly unlikely that an actual person would receive such a dose, because of the conservative and stylized assumptions employed in its calculation, it is conceivable.

The second change proposed in this area was in regard to the time period that a hypothetical individual is assumed to be at the exclusion area boundary. While the duration of the time period remains at a value of two hours, the proposed rule stated that this time period not be fixed in regard to the appearance of fission products within containment, but that various two-hour periods be examined with the objective that the dose to an individual not be in excess of 25 rem TEDE for any two-hour period after the appearance of fission products within containment. The Commission proposed this change to reflect improved understanding of fission product release into the containment under severe accident conditions. For an assumed instantaneous release of fission products, as contemplated by the present rule, the two hour period that commences with the onset of the fission product release clearly results in the highest dose to an individual offsite. Improved understanding of severe accidents shows that fission product releases to the containment do not occur instantaneously, and that the bulk of the releases may not take place for about an hour or more. Hence, the two-hour period commencing with the onset of fission product release may not represent the highest dose that an individual could be exposed to over any two-hour period. As a result, the Commission proposed that various two-hour periods be examined to assure that the dose to a hypothetical individual at the exclusion area boundary would not be in excess of 25 rem TEDE over any two-hour period after the onset of fission product release.”

* * *

Although the Commission recognizes that evaluation of the dose to a hypothetical individual over any two-hour period may not be entirely consistent with the actions of an actual individual in an accident, the intent is to assure that the short-term dose to an individual will not be in excess of the acceptable value, even where there is some variability in the time that an individual might be located at the exclusion area boundary. In addition, the dose calculation should not be taken too literally with regard to the actions of a real individual, but rather is intended primarily as a means to evaluate the effectiveness of the plant design and site characteristics in mitigating postulated accidents.

For these reasons, the Commission is retaining the requirement, in the final rule, that the dose to an individual located at the nearest exclusion area boundary over any two-hour period after the appearance of fission products in containment, should not be in excess of 25 rem total effective dose equivalent (TEDE).

(B) Site Dispersion Factors. Site dispersion factors have been utilized to provide an assessment of dose to an individual as a result of a postulated accident. Since the Commission is requiring that a verification be made that the exclusion area distance is adequate to assure that the guideline dose to a hypothetical individual will not be exceeded under postulated accident conditions, as well as to assure that radiological limits are met under normal operating conditions, the Commission is requiring that the atmospheric dispersion characteristics of the site be evaluated, and that site dispersion factors based upon this evaluation be determined and used in assessing radiological consequences of normal operations as well as accidents.

(C) Low Population Zone. The present regulation requires that a low population zone (LPZ) be defined immediately beyond the exclusion area. Residents are permitted in this area, but the number and density must be such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident. In addition, the nearest densely populated center containing more than about 25,000 residents must be located no closer than one and one-third times the outer boundary of the LPZ. Finally, the dose to a hypothetical individual located at the outer boundary of the LPZ over the entire course of the accident must not be in excess of the dose values given in the regulation.

While the Commission considers that the siting functions intended for the LPZ, namely, a low density of residents and the feasibility of taking protective actions, have been accomplished by other regulations or can be accomplished by other guidance, the Commission continues to believe that a requirement that limits the radiological consequences over the course of the accident provides a useful evaluation of the plant's long-term capability to mitigate postulated accidents. For this reason, the Commission is retaining the requirement that the dose consequences be evaluated at the outer boundary of the LPZ over the course of the postulated accident and that these not be in excess of 25 rem TEDE."

(D) Physical Characteristics of the Site. It has been required that physical characteristics of the site, such as the geology, seismology, hydrology, meteorology characteristics be considered in the design and construction of any plant proposed to be located there. The final rule requires that these characteristics be evaluated and that site parameters, such as design basis flood conditions or tornado wind loadings be established for use in evaluating any plant to be located on that site in order to ensure that the occurrence of such physical phenomena would pose no undue hazard.

(E) Nearby Transportation Routes, Industrial and Military Facilities. As for natural phenomena, it has been a long-standing NRC staff practice to review man-related activities in the site vicinity to provide assurance that potential hazards associated with such facilities or transportation routes will pose no undue risk to any plant proposed to be located at the site. The final rule codifies this practice.

(F) Adequacy of Security Plans. The rule requires that the characteristics of the site be such that adequate security plans and measures for the plant could be developed. The Commission envisions that this will entail a small secure area considerably smaller than that envisioned for the exclusion area.

(G) Emergency Planning. The proposed rule stated that the site characteristics should be such that adequate plans to carry out protective measures for members of the public in the event of emergency could be developed. To avoid any misinterpretation that the Commission is adopting emergency planning standards that implicitly overrule or may be in conflict with previous Commission decisions (e.g., CLI-90-02), the language in the final rule has been modified to be consistent with that of section 52.17 of the Commission's regulations regarding early site permits.

The Commission's decision in Seabrook on emergency planning, made in connection with an operating license review for a site previously approved, is being extended in considering site suitability for future reactor sites. The Commission, in its Seabrook decision, CLI-90-02, reiterated its earlier determination in the Shoreham decision, CLI-86-13, that the adequacy of an emergency plan is to be determined by the sixteen planning standards of 10 CFR 50.47(b), and that these standards do not require that an adequate plan achieve a preset minimum radiation dose saving or a minimum evacuation time for the plume exposure pathway emergency planning zone in the event of a serious accident. Rather, the Commission noted that emergency planning is required as a matter of prudence and for defense-in-depth, and that the adequacy of an emergency plan was to be judged on the basis of its meeting the 16 planning standards given in 10 CFR 50.47(b). Hence, the characteristics of the site, which determine the evacuation time for the plume exposure pathway emergency planning zone, have not entered into the determination of the adequacy of an emergency plan. Emergency plans developed according to the above planning standards will result in reasonable assurance that adequate protective measures can be taken in the event of emergency.

It is sufficient that an applicant identify any physical site characteristics that could represent a significant impediment to the development of emergency plans, primarily to assure that “A range of protective actions have been developed for the plume exposure pathway emergency planning zone for emergency workers and the public”, as stated in the planning standards.

Accordingly, appropriate sections of the rule (e.g., Sec. 100.21(g)) have been modified to state that “physical characteristics unique to the proposed site that could pose a significant impediment to the development of emergency plans must be identified." Except for the deletion of the phrase "such as egress limitations from the area surrounding the site", this language is identical to that in Sec. 52.17(b)(1). This phrase is being deleted from Sec. 100.21(g) (but Sec. 52.17(b)(1) remains unchanged), to eliminate any confusion that might arise regarding its scope.

(H) Siting Away From Densely Populated Centers. Population density considerations beyond the exclusion area have been required since issuance of Part 100 in 1962. The current rule requires a "low population zone" (LPZ) beyond the immediate exclusion area. The LPZ boundary must be of such a size that an individual located at its outer boundary must not receive a dose in excess of the values given in Part 100 over the course of the accident. While numerical values of population or population density are not specified for this region, the regulation also requires that the nearest boundary of a densely populated center of about 25,000 or more persons be located no closer than one and one-third times the LPZ outer boundary. Part 100 has no population criteria other than the size of the LPZ and the proximity of the nearest population center, but notes that "where very large cities are involved, a greater distance may be necessary."

Whereas the exclusion area size is based upon limitation of individual risk, population density requirements serve to set societal risk limitations and reflect consideration of accidents beyond the design basis, or severe accidents. Such accidents were clearly a consideration in the original issuance of Part 100, since the Statement of Considerations (27 FR 3509; April 12, 1962) noted that:

> Further, since accidents of greater potential hazard than those commonly postulated as representing an upper limit are conceivable, although highly improbable, it was considered desirable to provide for protection against excessive exposure doses to people in large centers, where effective protective measures might not be feasible * * * Hence, the population center distance was added as a site requirement.

* * *

In summary, next-generation reactors are expected to have risk characteristics sufficiently low that the safety of the public is reasonably assured by the reactor and plant design and operation itself, resulting in a very low likelihood of occurrence of a severe accident. Such a plant can satisfy the QHOs of the Safety Goal with a very small exclusion area distance (as low as 0.1 miles). The consequences of design basis accidents, analyzed using revised source terms and with a realistic evaluation of engineered safety features, are likely to be found acceptable at distances of 0.25 miles or less."

A.8 Revision of Licensing Documents to Allow for Use of Realistic Source Term Estimates; Allowance for an Alternate Source Term Approach – 10 CFR §50.67

Rulemaking to revise 10 CFR Part 50 was undertaken in the 1990's, using as its foundation the significant research on severe accident phenomena and documented in NUREG-1465, *Accident Source Terms for Light-Water Nuclear Power Plants*. This NUREG became a modern day analogue (albeit, considerably more detailed) to TID-14844.

In the Statement of Considerations accompanying the final rule adding the new section 10 CFR §50.67, *Accident source term*, the NRC described the differences between the original approach taken by TID-14844 and the revised approach incorporating realistic source terms [64 FR 71990, December 23, 1999].

> "The source term in TID-14844 is representative of a major accident involving significant core damage and is typically postulated to occur in conjunction with a large loss-of-coolant accident (LOCA). Although the LOCA is typically the maximum credible accident, NRC experience in reviewing license applications has indicated the need to consider other accident sequences of lesser consequence but higher probability of occurrence. Some of these additional accident analyses may involve source terms that are a fraction of those specified in TID-14844. The DBAs were not intended to be actual event sequences but, rather, were intended to be surrogates to enable deterministic evaluation of the response of the plant engineered safety features. These accident analyses are intentionally conservative in order to address uncertainties in accident progression, fission product transport, and atmospheric dispersion. Although probabilistic risk assessments (PRAs) can provide useful insights into system performance and suggest changes in how the desired defense in depth is achieved, defense in depth continues to be an effective way to account for uncertainties in equipment and human performance. The NRC's policy statement on the use of PRA methods (60 FR 42622; August 16, 1995) calls for the use of PRA technology in all regulatory matters in a manner that complements the NRC's deterministic approach and supports the traditional defense-in-depth philosophy.
>
> Since the publication of TID-14844, significant advances have been made in understanding the timing, magnitude, and chemical form of fission product releases from severe nuclear power plant accidents. Many of these insights developed out of the major research efforts started by the NRC and the nuclear industry after the accident at Three Mile Island (TMI). In 1995, the NRC published NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants," which utilized this research to provide more physically based estimates of the accident source term that could be applied to the design of future light-water power reactors. The NRC sponsored significant review efforts by peer reviewers, foreign research partners, industry groups, and the general public (request for public comment was published in 57 FR 33374; July 28, 1992).
>
> The information in NUREG-1465 presents a representative accident source term ("revised source term") for a boiling-water reactor (BWR) and for a pressurized-water reactor (PWR). These revised source terms are described in

terms of radionuclide composition and magnitude, physical and chemical form, and timing of release. Where TID-14844 addressed three categories of radionuclides, the revised source terms categorize the accident release into eight groups on the basis of similarity in chemical behavior. Where TID-14844 assumed an immediate release of the activity, the revised source terms have five release phases that are postulated to occur over several hours, with the onset of major core damage occurring after 30 minutes. Where TID-14844 assumed radioiodine to be predominantly elemental, the revised source terms assume radioiodine to be predominantly cesium iodide (CsI), an aerosol that is more amenable to mitigation mechanisms.

For DBAs, the NUREG-1465 source terms (up to and including the early in-vessel phase) are comparable to the TID-14844 source term with regard to the magnitude of the noble gas and radioiodine release fractions. However, the revised source terms offer a more representative description of the radionuclide composition and release timing. The NRC has determined (SECY-94-302, December 19, 1994) that design basis analyses will address the first three release phases--coolant, gap, and in-vessel. The ex-vessel and late in-vessel phases are considered to be inappropriate for design basis analysis purposes. These latter releases could only result from core damage accidents with vessel failure and core-concrete interactions.

The objective of NUREG-1465 was to define revised accident source terms for regulatory application for future light water reactors (LWRs). The NRC's intent was to capture the major relevant insights available from severe accident research to provide, for regulatory purposes, a more realistic portrayal of the amount of the postulated accident source term. These source terms were derived from examining a set of severe accident sequences for LWRs of current design. Because of general similarities in plant and core design parameters, these results are considered to be applicable to evolutionary and passive LWR designs. The revised source term has been used in evaluating the Westinghouse AP600 standard design certification application. (A draft version of NUREG-1465 was used in evaluating Combustion Engineering's (CE's) System 80+ design.)

The NRC considered the applicability of the revised source terms to operating reactors and determined that the current analytical approach based on the TID-14844 source term would continue to be adequate to protect public health and safety, and that operating reactors licensed under this approach would not be required to reanalyze accidents using the revised source terms. The NRC concluded that some licensees may wish to use an alternative source term in analyses to support operational flexibility and cost-beneficial licensing actions and that some of these applications could provide concomitant improvements in overall safety and in reduced occupational exposure. The NRC initiated several actions to provide a regulatory basis for operating reactors to voluntarily amend their facility design bases to enable use of the revised source term in design basis analyses."

Additional guidance was provided in the staff policy papers that accompanied the rulemaking. See, for example, SECY 1996-0042, *Use of the NUREG-1465 Source Term at Operating Reactor,* as well as SECY 1998-0158, *Rulemaking Plan for Implementation of Revised Source Term at Operating Reactors,* and its Staff Requirements Memorandum (SRM).

A.9 Using Realistic Source Terms to Size EPZs for Future Plants – "A Roadmap"

In parallel with adding 10 CFR §50.67, the NRC published SECY 1997-0020, *Results of Evaluation of Emergency Planning for Evolutionary and Advanced Reactors*. Whereas 10 CFR §50.67 allows for an alternate source term (from TID-14844) for existing plants, SECY 1997-0020 provides a roadmap for utilization of realistic source terms in the sizing of EPZs for evolutionary and advanced passive plants.

The rationale upon which the emergency plan for advanced and evolutionary reactors should be based was one of the first issues brought into question. The staff determined that the NUREG-0396 approach (consequences tempered by probability considerations) was appropriate for the future types of plants. Furthermore, rigid application of the technical criteria derived from this rationale against the evolutionary and advanced reactor designs indicated that no changes to emergency planning requirements were needed because the potential consequences of severe accidents associated with those plants are similar to those for current reactors.

At the same time, however, the staff recognized that

> "…changes to EP requirements might be warranted if the technical criteria for the EP requirements were modified to account for:
>
> - The lower probability of severe accidents;
> - The longer time period between accident initiation and release of radioactive material;
> - Most severe accidents associated with evolutionary and passive advanced LWRs."

In order to justify these types of changes to the emergency planning basis, the staff stated that three main issues would need to be addressed:

- The probability level, if any, below which accidents will not be considered for emergency planning purposes;
- The use of increased safety in one level of the defense-in-depth framework to justify reducing requirements in another level; and
- The acceptance of such changes by Federal, State, and local emergency response agencies.

Because of the significant expenditure of resources that would have been required, the staff expressed its intention not to perform further studies unless a petition was received from industry.

The approach followed by the staff was essentially composed by two major parts:

Part 1

This part included a review of the rationale, criteria and methods that form the basis for emergency planning for currently licensed reactor designs in NUREG-0396. The review regarded essentially:

- The basis for the determination of the size of the two areas (plume exposure pathway and ingestion pathway EPZs), using the PAG limits;
- The time-dependent characteristics of potential releases; and
- The types of radioactive materials that potentially could be released during an accident scenario.

The conclusion was a reaffirmation of the recommendations in NUREG-0396, without considerable modifications.

Part 2

This part included an evaluation of whether improved safety features of evolutionary and passive advanced LWR designs may permit changes in the technical criteria or methods used as the basis for the emergency planning regulations. Particularly, the NRC staff considered how innovative safety features and characteristics of the advanced plants tend to influence and modify the results to which NUREG-0396 arrived, in the areas of:

- Establishing the EPZ Size Based on Meeting the PAG Criteria

The staff evaluated the two EPZ areas by applying the PAG limits, but at the same time including the improvements in safety that make the ALWR different from conventional plants. In order to determine at which distance from an advanced plant the PAG limits are met, the staff considered three criteria:

Criterion 1: The EPZ should encompass those areas where the projected dose from design-basis accidents could exceed the EPA PAGs. The application of this criterion to ALWR indicated that the PAGs would not be exceeded beyond 2 miles. Rigid application of just this criterion would indicate. Therefore, that the EPZ size could be reduced for evolutionary and passive advanced LWRs.

Criterion 2: The EPZ should encompass those areas where consequences of less-severe Class 9 (core-melt) accidents could exceed the EPA PAGs. The extent of planning should be such that protective actions could be taken in case there is a possibility of exceeding a PAG dose level if a less-severe accident occurred. Rigid application of this criterion alone did not support a change to the EPZ size. However, if some accident sequences were not applied against this criterion (either because of the low probability of their occurrence or because of the existence of design features to prevent their occurrence or mitigate their consequences), then reductions in the EPZ size might be possible. To pursue such a change, the staff stated that several issues would need to be addressed: (1) the probability level, if any, below which accidents will not be considered for emergency planning, (2) the use of increased safety in one level of the defense-in-depth framework to justify reducing requirements in another level, and (3) the acceptance of such changes by Federal, state and local emergency response agencies.

Criterion 3: The EPZ should be of sufficient size to provide for substantial reduction in early severe health effects (injures or death) in the event of the more severe Class 9 accidents. For this criterion, the NRC considered the time available for notification of off-site emergency response officials and saw no basis that the EPZ size should be modified for evolutionary and passive advanced LWRs. The NRC staff did note that if some accident sequences were not considered (i.e., due to the low probability of their occurrence or because of the existence of design features to prevent their occurrence), then perhaps the requirement for prompt public notification could be relaxed. The NRC staff did not fully evaluate the effect that this change may have on sizing of the EPZ, nor did the staff evaluate the technical and policy issues, including public acceptance, associated with this potential change in the emergency planning basis.

The application of these criteria to ALWR indicated that different results would be obtained depending on the approach followed:

- If the choice of the considered accidents didn’t account for probability limit cutoff, the results would be the same of NUREG-0396 (no EPZ reduction).
- If some accident sequences were not considered, because of the low probability of their occurrence or because of the existence of design features to prevent their occurrence or mitigate their consequences, reduction in the EPZ size was possible.
- Time of Release

The time between recognition of a severe accident and the start of the release affects the time available to take action to protect the public and, therefore, affects the need for the capability to promptly notify the public of the emergency. Currently, licensees are required to notify offsite officials within 15 minutes of declaring an emergency and offsite officials need to have the capability to notify the public within about 15 minutes of receiving notification from the licensee.

The time elapsed between recognition of a severe accident and a release of radioactive material for current plants was reported to be as early as 30 minutes in NUREG-0396.

Reviewing the evolutionary and passive advanced LWR severe-accident data the staff concluded that radioactive material could be released as early as about 90 minutes after a severe accident is recognized. The 1-hour difference between current plants and advanced LWRs was not considered large enough to justify changing the requirement for prompt notification of offsite officials and the general public. However, as discussed for the EPZ sizing question, if some accident sequences with predicted early releases of radioactive material were not applied against this criterion, due to the low probability of their occurrence or because of the existence of design features to prevent their occurrence, then perhaps the requirement for prompt public notification capability could be changed. The staff did not fully evaluate the effect that this change may have on size of the EPZ, nor did the staff evaluate the technical and policy issues, including public acceptance, associated with this potential change in the EP basis.

- Composition and Magnitude of Release

With regard to the composition of the release, the mixture of radionuclides for evolutionary and passive advanced LWRs is essentially the same as that on which current emergency planning requirements are based. The NRC staff, therefore, stated that no changes are needed to aspects of emergency planning such as specifications for monitoring equipment, dose projection models, and exposure modes.

In conclusion, the NRC staff stated that changes to emergency planning requirements may be warranted only if the technical criteria for emergency planning requirements were modified to account for the lower probability of severe accidents or the longer time period between accident initiation and release of radioactive material for most severe accidents associated with evolutionary and passive advanced LWRs.

In SECY 1997-0020, the NRC staff focused its evaluation on the evolutionary and passive advanced LWR designs. For advanced reactor designs, such as the modular high temperature gas cooled reactor, it was noted:

> "However, the same process used for evaluating EP for the evolutionary and advanced LWRs, as described in this paper, would be appropriate for evaluating EP for the more-advanced reactor designs. Changes to EP requirements may be warranted for advanced reactor designs for which the consequences from potential accidents are reduced or the timing or composition of potential releases are different from that for current reactor designs."

A.10 State-of-the-Art Reactor Consequence Analysis (SOARCA)

In SECY-2005-0233, *Plan for Developing State-of-the-Art Reactor Consequence Analyses*, the NRC staff outlined its proposed plan to perform an updated realistic evaluation of severe reactor accidents and their offsite consequences. The objectives of the SOARCA effort are to:

- Perform a state-of-the-art, realistic evaluation of severe accident progression, radiological releases and offsite consequences for frequency dominant core damage accident sequences, and
- Provide a more accurate assessment of potential offsite consequences to replace previous consequence analyses

The NRC's intent is to use the improved knowledge and the technological advances gained over the past 25 years to develop a realistic consequence analysis that considers the risk, design features, improvements in mitigative measures, and emergency response capabilities to determine the potential consequences from a severe accident and the potential health effects on the public.

The preliminary analysis of two pilot plants: a boiling water reactor (Peach Bottom Atomic Power Station) and a pressurized water reactor (Surry Power Station), has been completed and reported in SECY 2008-0029, *State-of-the-Art Reactor Consequence Analyses — Reporting Offsite Health Consequences*. The NRC staff noted that that the current modeling methodology for projecting latent cancer fatalities (LCFs) from offsite radiological releases (described in SECY 2005-0233) may not be the best approach. This is because the computation of potential LCFs for some dose response models aggregates all exposures, including trivial exposures to large populations. The NRC staff proposed six options, each having advantages and disadvantages.

In their SRM on SECY 2008-0029, the NRC Commissioners approved option 6, e.g., calculate the average individual likelihood of an early fatality and LCF that is expressed as the average probability of a population-weighted, average individual (age and gender averaged) dying from cancer conditional to the occurrence of a severe reactor accident (using a 10 mrem cutoff). This option thus allows for the calculation of consequences that could be compared with the occurrence of LCFs in the general population from causes other than a reactor accident. In approving option 6, the NRC Commissioners noted:

> "SOARCA provides a unique opportunity to develop a more balanced approach to risk communication by engaging stakeholders in the development of a common understanding of how to communicate radiation risk from small doses of radiation. This approach must be clearly articulated as part of a comprehensive communication strategy when the SOARCA project results are released to the public."

Additionally, the NRC Commissioners noted:

> "The staff should continue to coordinate with NRC's federal partners such as the National Infrastructure Simulation and Analysis Center (NISAC) and the Department of Homeland Security's Science and Technology Directorate, as well as NRC's international partners, as consequence modeling technology evolves such that all have the opportunity to participate in an integrated program to develop and deploy a common, accepted, well conceived methodology."

A SOARCA website is available at http://www.nrc.gov/aboutnrc/regulatory/research/soar.html to assist with keeping the public and other stakeholders informed of the objective, progress made, and future activities associated with this project.

A.11 Implications of Security Events on Siting

In SECY 2009-0007, *Proposed Rule Related to Enhancements to Emergency Preparedness Regulations (10 CFR Part 50) (RIN 3150-AI10)*, the NRC staff discussed their comprehensive review of requirements and proposed a number of revisions to emergency planning requirements for security based events. This effort was directed by the Commission following a December 2004 briefing on the topic as well as in an SRM to SECY 2005-0010, *Recommended Enhancements of Emergency Preparedness and Response at Nuclear Power Plants in the Post 9/11 Environment*. While both SECY 2005-0010 and its SRM were not released, subsequent Commission policy papers are available. Notably, SECY 2006-0200 describes the NRC staff's proposal for proceeding with rulemaking. In the SRM to SECY 2006-0200, the NRC Commissioners directed that the staff prepare a rulemaking plan.

SECY 2009-0007 outlined a series of NRC orders and policy papers issued since 9/11 that addressed coordination measures between emergency planning and security areas. The proposed rule changes, while not specific to the topic of EPZ sizing, did address aspects related to the adequacy of onsite emergency response capabilities (as well as offsite coordination). Such considerations have potential implications for co-locating nuclear heat generation and application facilities (as with the NGNP).

The NRC Commissioners approved the staff's recommendation for publishing the proposed changes in the Federal Register. Subsequently, the proposed rule was published requesting public comments [74 FR 23254, May 18, 2009]. The comment period, initially set to close August 3, 2009, has been extended to October 19, 2009 [74 FR 27724, June 11, 2009].

APPENDIX B. BIBLIOGRAPHY OF RELATED DOCUMENTS

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showing that applicant must make to demonstrate that a credible accident would not result in radioactive releases in excess of regulatory limits; LBP-03-04, 57 NRC 136 (2003)

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APPENDIX C. NRC REVIEW OF EMERGENCY PLANNING REQUIREMENTS FOR THE MHTGR

At the request of the Department of Energy (DOE), the NRC in 1986 undertook a preapplication review of the MHTGR design. Included was a review of emergency planning requirements for advanced reactor designs. The NRC staff defined the proposed reduction in EPZ size as a policy issue in SECY 1988-0203, '*Key Licensing Issues Associated with DOE Sponsored Advanced Reactor Designs*'. NRC's review findings for the MHTGR are documented in NUREG-1338, *Draft Preapplication Safety Evaluation Report for the Modular High-Temperature Gas-Cooled Reactor*'.

<u>Preapplication Safety Evaluation Report – Draft (March 1989)</u>

Section 3.2.2.4 discusses the policy issue.

> "3.2.2.4 Offsite Emergency Planning*
>
> Currently, offsite protective actions are recommended when a situation occurs that could lead to offsite doses in excess of the protective action guidelines (PAGs), which are 1 to 5 rem to the whole body and 5 to 25 rem to the thyroid. At the lower projected dose, protective actions should be considered. At the higher projected dose, protective actions are warranted. A dose that has already been accumulated before the decision on whether to take protective actions is not considered to be part of this planning decision. In the past, the Commission has not required offsite emergency planning in those situations where the lower-level PAGs were not expected to be exceeded. For example, emergency planning for research reactors is restricted to the area around the reactor where the lower-level PAGs are expected to be exceeded. This is usually within the owner-controlled area. For fuel-cycle facilities, the proposed rule on emergency preparedness exempts those facilities where the lower-level PAGs will not be reached outside the owner-controlled areas. Therefore, there is a precedent for not requiring offsite emergency planning, beyond simple notification, where warranted by operation. Response of certain offsite agencies into the owner-controlled area (for example, police, fire, and medical personnel) is traditionally considered part of the onsite planning.
>
> The staff believes that emergency-planning requirements for advanced reactors should be based on the characteristics of the designs. This principle is similar to that in the emergency planning rule (10 CFR 50.47), which states that the size of the emergency planning zone for HTGRs can be determined on a case-by-case basis. In addition, the power level of each advanced-reactor module is much smaller than that of a conventional LWR and, based on size alone, some reduction

in the radius of the emergency planning zone may be warranted similar to what has been done for the existing small-size LWRs. In addition to these considerations, it is the staff's judgment that a plant's ability to prevent significant releases of radioactive material (particularly the prevention of release by core melt) and to provide long times before releases for all but the most remotely probable events should also be reflected in any emergency-planning requirements. Accordingly, the staff proposes criteria that consider such ability, consistent with evaluating a range of events similar to those evaluated for LWRs.

Specifically, the staff proposes the following criteria as guidelines for the advanced-reactor designs in order for NRC to accept the DOE proposal of no traditional offsite emergency planning (other than simple notification). While an offsite emergency plan would still be required, such a plan would not have to include early notification, detailed evacuation planning, and provisions for exercising the plan if

(2) the lower-level PAGs were not predicted to be exceeded at the site boundary within the first 36 hours following any event in categories EC-I, -II, and –Ill
(2) a PRA for the plant, which included at least all events in categories EC-I through EC-IV, indicated that the cumulative mean value for the frequency of exceeding the lower-level PAGs at the site boundary within the first 36 hours did not exceed approximately 10^{-6} per year.

These criteria give credit for designs that provide long times before significant radiation release. For designs such as these, the staff believes that because sufficient time is available, prompt notification of offsite authorities will permit effective evacuation on an ad hoc basis."

Sections 13.1.3 and 13.1.4 of draft NUREG-1338 then discussed DOE's proposal for reducing the EPZ to the site boundary for the MHTGR:

"13.1.3 DOE Proposal for Reduced Emergency-Preparedness Requirements for the MHTGR

In the Emergency Planning Basis Report, DOE developed its position with respect to emergency planning on the basis that the design features of the MHTGR, with its passive reactor shutdown and cooling systems and with core-heatup times much longer than those for LWRs, result in a system that is safe enough to warrant a reduction in the plume exposure pathway EPZ radius to the site boundary. Accordingly, DOE proposed that prompt public notification and provision for sheltering and evacuation of the general public not be included in the emergency plan.

In support DDE offered an analysis that considered low-frequency events in an approach similar to that in NRC report NUREG-0396, "Planning Basis for the

Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants." DOE's probabilistic risk assessment analyses for the MHTGR indicated that the MHTGR would not exceed the plume-exposure protective action guidelines (PAGs) at the site boundary for any transient or event with a mean frequency greater than 5 x 10^{-7} per plant-year. This result was also found for the staff-postulated bounding events discussed in Section 15.2.3.3. These conclusions, based on DOE's analyses, were tentatively confirmed by the staff's contractors at ORNL and BNL. The analyses showed that maximum fuel temperatures would not exceed the fuel-failure thresholds expected by DOE at any time and that the temperatures at 36 hours are well below the 60- to 100-hour maximum values computed. The staff believes that the analyses indicate sufficient margin so that the staff's proposed criteria could be met on the basis that the information provided by DOE at this stage of the review is later confirmed. At later review stages, the staff will make other and separate determinations based on improved descriptions of the MHTGR safety features, further safety analyses, the results of the research programs on fuel integrity, and specific siting considerations. The overall result for present consideration is that the MHTGR could conservatively meet a 36-hour criterion for not exceeding the PAGs.

It is this tentative conclusion that forms the conditional basis for the staff's proposals in Sections 13.1.5 and 13.1.6. The use of these staff proposals for a specific site is also conditioned on the successful resolution of the underlying siting and safety issues involved and, of course, resolution of the containment adequacy issue as described in the "Preface."

13.1.4 Relationship of Emergency Planning Zone Size to Emergency-Planning Policy

Although 10 CFR 50.47(c) states that the size of the EPZ may be determined on a case-by-case basis for gas-cooled nuclear reactors, the staff has concluded that this provision is only indirectly relevant to the emergency-planning considerations for the MHTGR. Rather, the staff has concluded that the DOE proposal for restricting the plume exposure pathway EPZ to the site boundary is equivalent to not requiring offsite emergency planning for the protection of the public. Since the current policy of the NRC is that offsite emergency planning is a requirement for the licensing and operation of a nuclear power plant, the staff has addressed the DOE proposal as a request for a change in this policy rather than an adjustment of the EPZ size. This is because an adjustment of the EPZ size, particularly a radical one like that proposed for the MHTGR, is in conflict with a stated objective of the current EPZ requirement in that the current 10-mile EPZ provides a substantial base for expansion of response efforts beyond the 10-mile boundary if this should prove necessary. This is explicit in the planning bases given in NRC report NUREG-0654, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear

Power Plants." To date, proposals for smaller EPZs have not addressed this important issue.

Should DOE's research and final design development programs satisfactorily address the staff's concerns regarding the potential for large offsite releases, the staff concludes that such a change in policy could be warranted. Current emergency-planning regulations are based on an underlying assumption that a serious accident could occur and that such an accident could result in offsite individuals being exposed, in a relatively short time, to levels of radiation high enough to require medical care. Based on the staff review of the DOE submittal for the MHTGR, it appears that releases exceeding the lower-level PAGs of 1 rem to the whole body and 5 rem to the thyroid would not occur at all, or if they did occur it would not be for a few days, and that higher-level releases that could require the need for medical care as contemplated by the current regulatory policy would not occur at all.

The remainder of this section reflects the staff's evaluation and conclusions regarding the minimum emergency planning that could be approved should the final design of the MHTGR support such a change in policy. Consideration of sites-specific parameters may require that additional requirements be imposed at a later time.

Because of the long times available, the staff concludes that any evacuation triggered by an MHTGR accident could be accomplished ad hoc, that is, by using State and local government plans that already exist for dealing with national hazards (for example, hurricanes, floods, fire, earthquakes, and technological hazards such as chemical accidents, explosions, and fires) to respond to potential MHTGR accidents.

Historically, ad hoc evacuations for such emergencies as hurricanes, chemical fires, and transportation accidents in the United States have taken from 2 to 8 hours including the time to notify the population. This is typically accomplished by route alerting using fire trucks and police cars, with door-to-door followup. Newspapers, radios, and televisions assist in the notification process. In many respects, the response to an MHTGR accident would be similar to the response to a hurricane, for which there is a long period to monitor the course of the event and to determine and implement protective actions.

As described in Section 13.1.6, the staff is proposing criteria that would ensure that at least 24 hours would be available for emergency response before any offsite protective actions became necessary. The staff believes that this is sufficient time for local agencies to take such protective actions (for example, sheltering or evacuation) using their existing emergency plans coupled with radiological emergency plans as described in Section 13.1.5.

13.1.5 Content of Emergency Plans for the MHTGR

Section 8 of the Emergency Planning Basis Report states that the MHTGR's emergency plan will be prepared later. However, DOE stated that it would not include offsite exercises and drills or prompt public notification but that it would include ingestion-pathway plans. The staff herein describes what it would propose to require for emergency plans for the MHTGR and other advanced reactors that meet the qualifying criteria in Section 3.2.2.4. The staff's proposal for these emergency plans is described in narrative form by comparing them with the current requirements for LWRs. In addition, the existing requirements and the proposed requirements are given in Table 13.1.

The requirements for onsite utility plans for the MHTGR (that is, notifications, exercises, and arrangements for requesting and using offsite assistance on site) would be essentially the same as the current regulations except where the onsite plans correlate with offsite plans. For example, exercises involving the plume exposure pathway would no longer be part of either plan.

The remainder of this section focuses primarily on offsite plans. First, for the MHTGR, the 10-mile plume exposure pathway EPZ would be eliminated and the 50-mile ingestion exposure pathway EPZ would remain. Further, the prompt-public notification requirements in offsite plans would be eliminated for the MHTGR primarily because of the much longer times available to make notifications and to take protective actions (24 hours or more). The dose projections and assessment requirements in offsite plans for the plume exposure pathway would be eliminated because the much longer times available would permit an independent confirmation of the utility's projections by State and Federal organizations. Offsite environmental monitoring requirements for the plume exposure pathway would be eliminated for the same reasons; that is, the utility's monitoring provisions would suffice until others could be put in place. However, at a later review stage, it would be necessary for the utility to demonstrate through technical specifications or other acceptable administrative controls that the necessary equipment could be made available within a reasonable period and that personnel would be adequately trained for its use. For the ingestion exposure pathway EPZ, requirements for dose projections and assessment and environmental monitoring would remain.

Requirements in offsite plans related to arrangements for medical services for contaminated or injured members of the general public would not be necessary because of the lower releases and in any case could be determined as the need arose because of the longer times available. The present requirement in offsite plans for primary and backup communications would be retained because such communications must be in place before any accident occurs.

Training for response in the plume exposure pathway EPZ would not be required for offsite plans for the MHTGR because the extra time would permit instruction to be given, if necessary, to supplement the general training in emergency response that is part of State and local governments' normal programs. The requirement for training for response in the ingestion exposure pathway EPZ would be retained. The exercise requirement for State and local governments for the plume exposure pathway EPZ would also be eliminated; however, the exercise requirement for State and local governments for the ingestion exposure pathway EPZ would be retained. The current requirement for training and exercises for offsite emergency workers who would respond on site, such as, police, fire, and rescue personnel, is traditionally part of the onsite plan. This would remain a requirement for the onsite plan.

Finally, the ability to shelter and evacuate the general public would involve the use of present State and local government sheltering and evacuation plans for responding to natural and other technological hazards. That is, the existing State and local emergency plans for other hazards would be bolstered by the minimum additional offsite planning described herein.

13.1.6 Qualifying Criteria

Instead of accepting the DOE proposal for a plume exposure pathway EPZ at the site boundary based on a NUREG-0396-type analysis, the staff proposes to accomplish the same objective by using the criteria in Section 3.2.2.4 as the basis for qualifying for reduced offsite emergency planning. Although an offsite emergency plan for the ingestion exposure pathway EPZ would still be required, offsite planning would not have to include early notification, detailed evacuation planning, and provisions for training and exercising within a plume exposure pathway EPZ.

The criteria in Section 3.2.2.4 give credit for designs such as that of the MHTGR that provide a sufficiently long time before a significant radiation release. For designs such as these, the staff concludes that because sufficient time is available, reasonably timely notification of offsite authorities will permit effective protective actions without the level of planning currently required for LWRs.

The first qualifying criterion in Section 3.2.2.4 ensures that all events considered for design and siting purposes do not lead to offsite doses in excess of the PAGs early in the event sequence. Based on historical ad hoc evacuations in the United States (which have ranged between 2 and 8 hours), 24 hours is sufficient time for local agencies to take protective actions (for example, sheltering or evacuation), and in these cases planning does not substantially reduce the risk to the public. The 24 hours, combined with 12 hours for the plant staff to diagnose the event and attempt corrective action before initiating evacuation or sheltering, is the basis for the 36-hour criterion.

The second criterion in Section 3.2.2.4 ensures that events beyond those considered for design and siting purposes (of a frequency similar to those events considered in NUREG-0396 for LWR emergency-planning purposes) are considered for advanced-reactor emergency-planning purposes and that they do not contribute substantially to overall risk."

Preapplication Safety Evaluation Report – Final Draft (June 1995)

In 1995, a final draft of NUREG 1338 was released along with SECY 1995-0299, *Issuance of the Draft of the Final Preapplication Safety Evaluation Report (PSER) for the Modular High-Temperature Gas-Cooled Reactor (MHTGR)*. Section 5.2.4 of the final draft noted:

"5.2.4 Emergency Planning

This issue involves whether advanced reactors with passive safety features should have reduced emergency planning zones and requirements. Although emergency plans are not required for design certification under 10 CFR Part 52, they are necessary for issuance of an operating license. 10 CFR 50.47 requires that no operating license can be issued unless the NRC finds that there is reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency and 10 CFR 52.79(d) requires that an application for a combined operating license must contain emergency plans which provide adequate protective measures.

DOE has proposed reduced offsite emergency planning for the MHTGR design. An MHTGR emergency plan, described in DOE-HTGR-87-001, would include any agency that would be involved in the response to a radiological emergency (i.e., sheltering and evacuating the public, and controlling the food supply) for an MHTGR plant. DOE proposed the following differences and reductions from a typical emergency plan for LWRs:

- The exclusion area boundary (EAB) of 10 CFR Part 100 may also function as the boundary of the emergency planning zone (EPZ), as may be allowed by Appendix E of 10 CFR Part 50 for gas-cooled reactors.
- There would be no rapid notification (e.g., local sirens) or annual drills for the public and offsite agencies.

DOE based these proposed differences and reductions on the following reasoning:

- predicted dose consequences estimated for the EAB/EPZ are below the lower-limit EPA sheltering PAGs, and the public can be excluded from being within the EAB
- a significantly long time is calculated for the core to return to criticality after, shutting down in an accident from the Doppler coefficient, without either of the two safety-grade reactor protection systems functioning (i.e., about 37 hours)
- a significantly long time is calculated for the fuel and reactor vessel to reach maximum temperatures (i.e., about 100 hours) during an accident with only-the reactor cavity cooling system functioning

DOE asserted that the public around the plant would always be outside that area where exposure would be above the PAGs, and in which member of the public may need to be sheltered or evacuated, and that there would always be ample time to notify the public and move people out if it should be necessary, considering experience with such relatively common events as hurricanes.

The DOE proposed emergency planning for the MHTGR does not mean that there would be no offsite emergency plan developed but rather that such a plan could have fewer details concerning movement of people, need not contain provisions for early notification of the public, and need not require periodic exercises of the offsite plan. The plans used to move people out of areas for such events as hurricanes may serve as examples because the time periods for people to respond to hurricanes are similar to the time periods for the public to respond to MHTGR core heatup during an accident.

The Commission has not approved any changes to the existing regulations governing emergency preparedness for the MHTGR design or any other advanced reactor design. The Commission stated that it was premature to reach a conclusion on emergency planning for advanced reactors and that the staff should remain open to proposals to simplify emergency planning requirements for reactors that are designed with greater safety margins. It also stated that emergency planning requirements should be correlated with the work being done on accident evaluation and source term, which are discussed in the previous two sections, to avoid unnecessary conservatism, and with the work being done on emergency planning for advanced LWRs. The staff will provide its recommendation on this issue at or before the start of the design certification review phase so that any implications on the design can be addressed.

Consistent with the current LWR regulatory approach, the staff views the inclusion of emergency preparedness by advanced reactor designers as an essential element in NRC's "defense-in-depth" philosophy. Briefly stated, this philosophy (1) requires high quality in the design, construction, and operation of nuclear plants to reduce the likelihood of malfunctions, (2) recognizes that equipment can fail and operators can make mistakes, thus requiring safety systems to reduce the chances that malfunctions or mistakes will lead to accidents that release fission products from the fuel, and (3) recognizes that, in spite of these precautions, serious fuel damage accidents can happen, thus requiring containment structures and other safety features to prevent the release of fission products off site. The added feature of emergency planning to this philosophy provides that, even in the unlikely event of an offsite fission product release, there is reasonable assurance that emergency protective actions can be taken to protect the population around nuclear power plants.

Information obtained from accident evaluations conducted, as outlined in Section 5.2.1 above will be factored into the emergency planning requirements for advanced reactors. Based in part upon these accident evaluations, the staff will consider whether some relaxation from current requirements may be appropriate for advanced reactor offsite emergency plans. The relaxations to be considered will include, but will not be limited to, notification requirements, size of the EPZ, and frequency of the exercises, and will take into account the Commission policy decisions on passive LWR emergency planning.

In Section 13.1 of draft NUREG-1338, the staff discussed the evaluation of emergency planning for the design. Except for Section 13.1.6, the conclusions of the staff in Section 13.1 are not changed by the conclusions of the Commission for this policy issue and, as discussed in Section 3.4.3.5 of this report, remain valid.

In Section III.G of SECY-93-087, the staff addressed simplification of emergency planning for the passive advanced LWRs. The staff discussed the proposals made by Electric Power Research Institute (EPRI) to reduce emergency planning requirements on early public notification, detailed emergency planning, and provisions for offsite emergency planning drills. These proposals are similar to what DOE has proposed for the MHTGR. The staff has concluded that its resolution on these proposals should be presented in a separate SECY paper which will also discuss issues related to source term.

There are two current staff endeavors involving emergency planning. The first is SECY-95-090 giving the staff's views on how emergency planning requirements should be addressed at each phase of nuclear power plant licensing under 10 CFR Part 52. The staff briefed the Advisory Committee for Reactor Safeguards on August 5, 1993 and a notice of the availability of a draft of this paper for public comment was published in the *Federal Register* on May 20, 1994 (59 FR 26530). SECY-95-090 addressed the public comments.

The second endeavor is a progress report (February 27, 1995) to the Commission on the efforts of the staff to develop recommendations for possible simplification of emergency planning requirements for reactor designs with greater safety margins. This report addressed the Commission request in the SECY-93-092

SRM (discussed above) that the staff submit recommendations for proposed criteria and methods to justify simplifying existing emergency planning requirements. The staff stated in the report that it is concentrating on the evolutionary and passive advanced LWRs and described the parametric studies being conducted to assess industry-proposed initiatives. The staff stated that the contract work should be completed by the end of 1995; industry representatives have stated that documents for the emergency preparedness initiatives will be submitted during 1995 and 1996.

Emergency planning is also discussed for the PRISM advanced reactor in Section 13.1 of NUREG-1368, and this discussion should provide additional guidance for the MHTGR design.

DOE should reflect in its design approval application the work the staff is doing on the passive advanced LWRs in response to the Commission's SRM on SECY-93-092."

This discussion notes that the conclusions presented in the initial draft of NUREG 1338 remain valid, referring the reader to section 3.4.3.5 for additional information:

"3.4.3.5 Conduct of Operations

In Chapter 13 of draft NUREG-1338, the staff discussed emergency preparedness, the role of the control room operators, and safeguards and security. Emergency preparedness and the role of the operators are policy issues that are discussed in Section 5.2 of this report. Except for the statements about emergency preparedness review criteria in Section 13.1.6, as explained in Section 3.3, the staff's statements in Chapter 13 of draft NUREG-1338 remain valid."

Section 3.3 describes differences between the Fort St. Vrain reactor design and the MHTGR. Of significant note are the failed fuel fraction, containment design, and reliance on passive cooling. In noting that the MHTGR containment design leak rate (less than one building volume per day) significantly departed from previous NRC practices (calling for substantially less leakage), the NRC staff did state that a high-leakage containment in itself is not a licensability issue.