U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Planning Basis for Radiological Emergency Preparedness

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Objective of Radiological EP

- The objective of emergency preparedness (EP) is to provide ***dose savings*** for a spectrum of accidents that could produce doses in excess of the Environment Protection Agency (EPA) protective action guides (PAG)
- Meeting NRC EP regulations provides reasonable assurance that ***adequate protective measures can and will be taken*** in the event of a radiological emergency
  - Reasonable assurance finding is made before a nuclear facility is licensed
  - Inspected over the lifetime of that facility

EP $\neq$ EPZ

The NRC employs a graded approach to EP

- A graded approach is a process by which the safety requirements and criteria are set commensurate with several factors including magnitude of hazards involved, characteristics of a facility, the balance between radiological and nonradiological hazards.
- EP regulations employ a graded approach, which is a risk-informed process
  - Power reactors (low-power testing, power operations, decommissioning)
  - Research and test reactors
  - Fuel Fabrication Facilities
  - Independent Spent Fuel Storage Installations
  - Monitored Retrievable Storage

EP has a firmly established risk-informed basis

The consequences from a **spectrum of accidents**, tempered by probability considerations, should be considered to scope the planning efforts for:

- *The **distance** to which planning for predetermined protective actions is warranted*
- *The **time** dependent characteristics of a potential release*
- *The type of radioactive **materials***

The planning basis document included a recommended 10 mile plume exposure path emergency planning zone (EPZ) and a 50 mile ingestion pathway zone for large light water reactors (PWR and BWR)

NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," November 1978

Planning Distance

The __distance__ to which planning for predetermined protective actions is warranted

- The EPZ is a planning tool

  "…it was the consensus of the Task Force that emergency plans could be based upon a generic distance out to which predetermined actions would provide dose savings…"

  "…beyond the generic distance it was concluded that actions could be taken on an ad hoc basis…"

  "The EPZ guidance does not change the requirements for emergency planning, it only sets bounds on the planning problem."

NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," November 1978

The EPZ is scalable

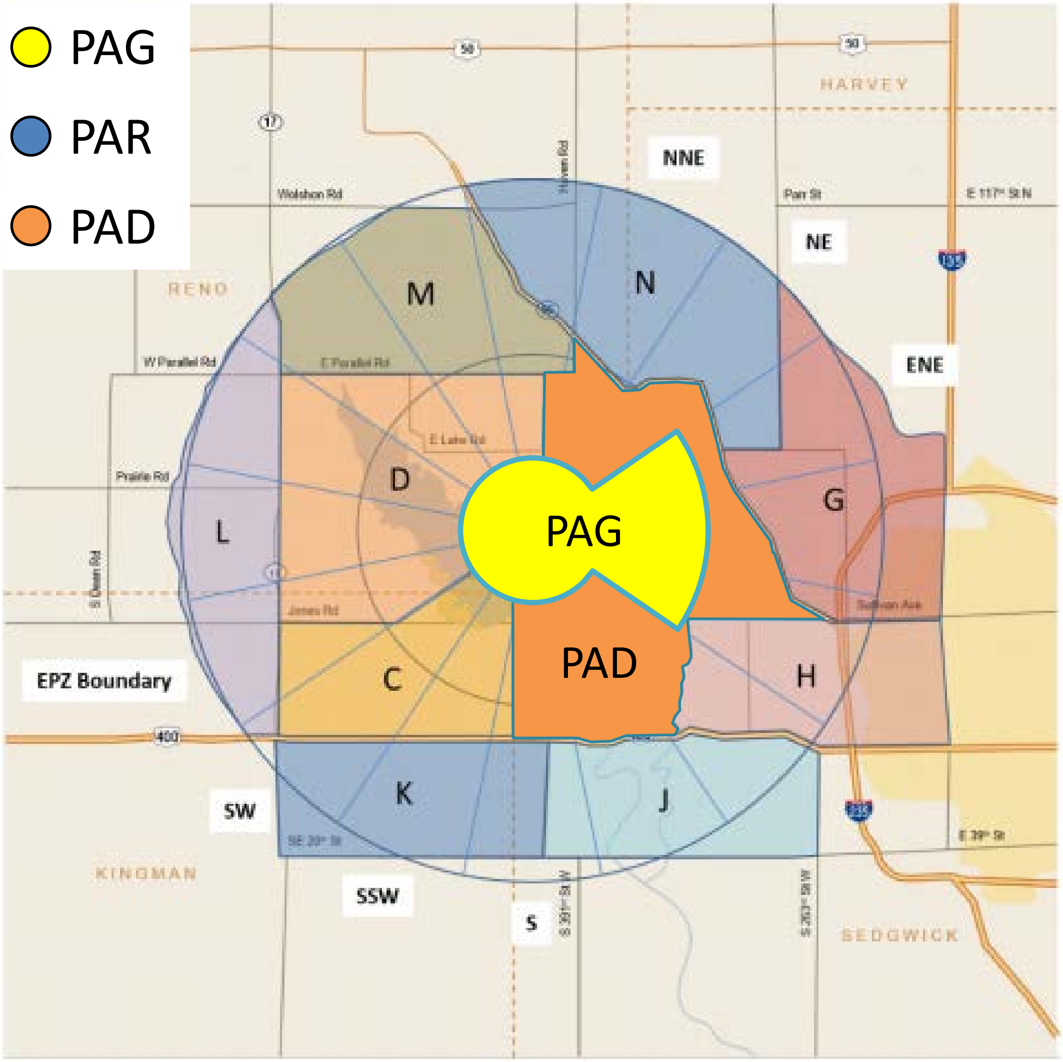
- EPZ size based on the consequences from a spectrum of accidents, tempered by probability considerations.
- NRC regulations provide for scalable EPZs
- Reactors have been approved for a 5 mile EPZ in the past
- Depending on facility type, the EPZ may be at the site-boundary or have no EPZ
- Considerable number of studies since the 1980s on sizing EPZs for passive and advanced reactor designs, many based on the NUREG-0396 methodology

EPZ simplifies decisions for a prompt response

Protective Action Guide (PAG)
projected dose to an individual member of the public that warrants protective action

Protective Action Recommendation (PAR)
recommended protective measure from the nuclear power plant to offsite response organizations (OROs)

Protective Action Decision (PAD)
measures taken in response to an actual or anticipated radiological release



Planning Time

*The **time** dependent characteristics of a potential release*

Table 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

NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," November 1978

Effectiveness of protective actions related to timing

“The guidance cannot be very specific because of the wide range of time frames associated with the spectrum of accidents considered.”

“Therefore, it will be necessary for planners to consider the possible different time periods between the initiating event and arrival of the plume and possible time periods of release in relationship to time needed to implement protective actions.”

NUREG-0396, “Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants,” November 1978

Timing considerations are conservatively bounded

TABLE V 2-1 SUMMARY OF ACCIDENTS INVOLVING CORE

RELEASE CATEGORY	PROBABILITY per Reactor-Yr	TIME OF RELEASE (Hr)	DURATION OF RELEASE (Hr)	WARNING TIME FOR EVACUATION (Hr)	ELEVATION OF RELEASE (Meters)	CONTAINMENT ENERGY RELEASE (10^6 Btu/Hr)	FRACTION OF CORE INVENTORY RELEASED[a] Xe-Kr	Org. I	I	Cs-Rb	Te-Sb	Ba-Sr	Ru[b]	La[c]
PWR 1	9×10^{-7}	2.5	0.5	1.0	25	520[d]	0.9	6×10^{-3}	0.7	0.4	0.4	0.05	0.4	3×10^{-3}
PWR 2	8×10^{-6}	2.5	0.5	1.0	0	170	0.9	7×10^{-3}	0.7	0.5	0.3	0.06	0.02	4×10^{-3}
PWR 3	4×10^{-6}	5.0	1.5	2.0	0	6	0.8	6×10^{-3}	0.2	0.2	0.3	0.02	0.03	3×10^{-3}
PWR 4	5×10^{-7}	2.0	3.0	2.0	0	1	0.6	2×10^{-3}	0.09	0.04	0.03	5×10^{-3}	3×10^{-3}	4×10^{-4}
PWR 5	7×10^{-7}	2.0	4.0	1.0	0	0.3	0.3	2×10^{-3}	0.03	9×10^{-3}	5×10^{-3}	1×10^{-3}	6×10^{-4}	7×10^{-5}
PWR 6	6×10^{-6}	12.0	10.0	1.0	0	N/A	0.3	2×10^{-3}	8×10^{-4}	8×10^{-4}	1×10^{-3}	9×10^{-5}	7×10^{-5}	1×10^{-5}
PWR 7	4×10^{-5}	10.0	10.0	1.0	0	N/A	6×10^{-3}	2×10^{-5}	2×10^{-5}	1×10^{-5}	2×10^{-5}	1×10^{-6}	1×10^{-6}	2×10^{-7}
PWR 8	4×10^{-5}	0.5	0.5	N/A	0	N/A	2×10^{-3}	5×10^{-6}	1×10^{-4}	5×10^{-4}	1×10^{-6}	1×10^{-8}	0	0
PWR 9	4×10^{-4}	0.5	0.5	N/A	0	N/A	3×10^{-6}	7×10^{-9}	1×10^{-7}	6×10^{-7}	1×10^{-9}	1×10^{-11}	0	0
BWR 1	1×10^{-6}	2.0	2.0	1.5	25	130	1.0	7×10^{-3}	0.40	0.40	0.70	0.05	0.5	5×10^{-3}
BWR 2	6×10^{-6}	30.0	3.0	2.0	0	30	1.0	7×10^{-3}	0.90	0.50	0.30	0.10	0.03	4×10^{-3}
BWR 3	2×10^{-5}	30.0	3.0	2.0	25	20	1.0	7×10^{-3}	0.10	0.10	0.30	0.01	0.02	3×10^{-3}
BWR 4	2×10^{-6}	5.0	2.0	2.0	25	N/A	0.6	7×10^{-4}	8×10^{-4}	5×10^{-3}	4×10^{-3}	6×10^{-4}	6×10^{-4}	1×10^{-4}
BWR 5	1×10^{-4}	3.5	5.0	N/A	150	N/A	5×10^{-4}	2×10^{-9}	6×10^{-11}	4×10^{-9}	8×10^{-12}	8×10^{-14}	0	0

NUREG-075/014 (WASH-1400), "Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," October 1975

***Time* basis informs functional requirements**

- …nuclear power reactor licensees shall establish and maintain the **capability** to assess, classify, and declare an emergency condition within **15 minutes** after the availability of indications to plant operators that an emergency action level has been exceeded…
- A licensee shall have the **capability** to notify responsible State and local governmental agencies within **15 minutes** after declaring an emergency
- The design objective of the prompt public alert and notification system shall be to have the **capability** to essentially complete the initial alerting and initiate notification of the public within the plume exposure pathway EPZ within about **15 minutes**

Appendix E to 10 CFR Part 50

Our understanding of accidents has evolved…

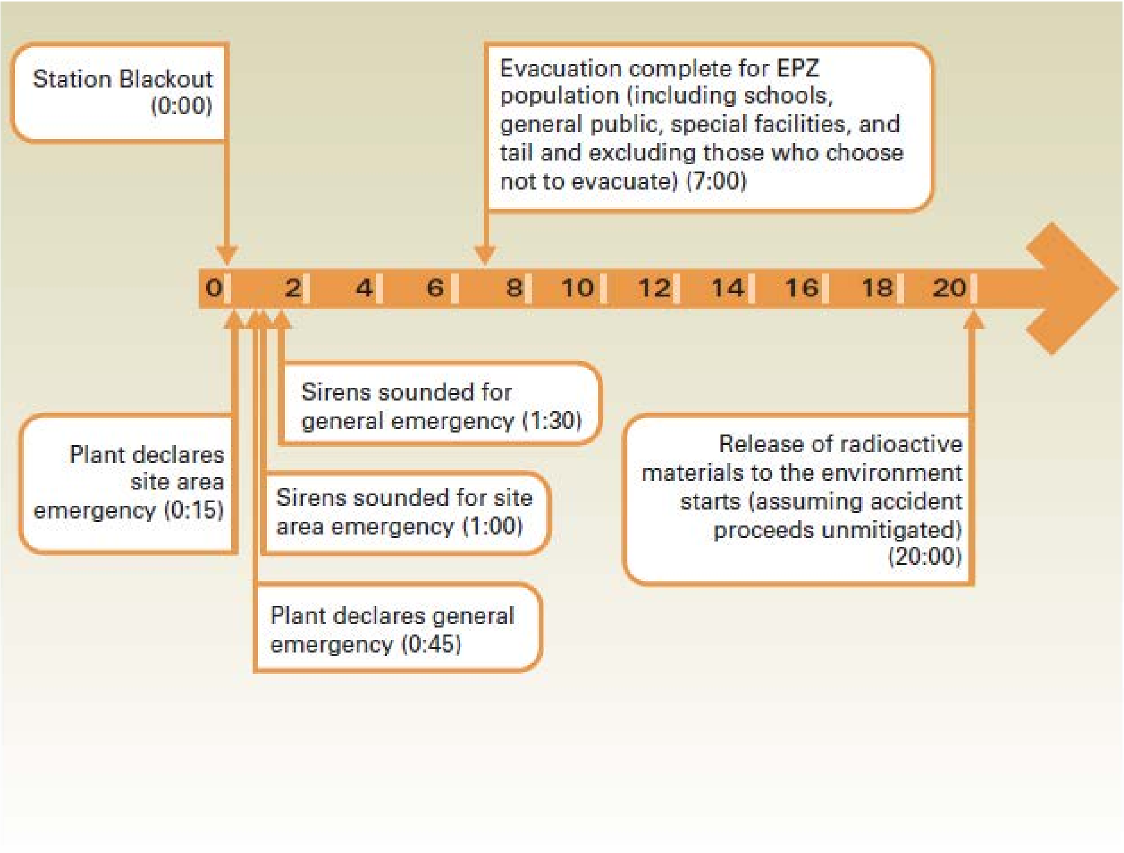
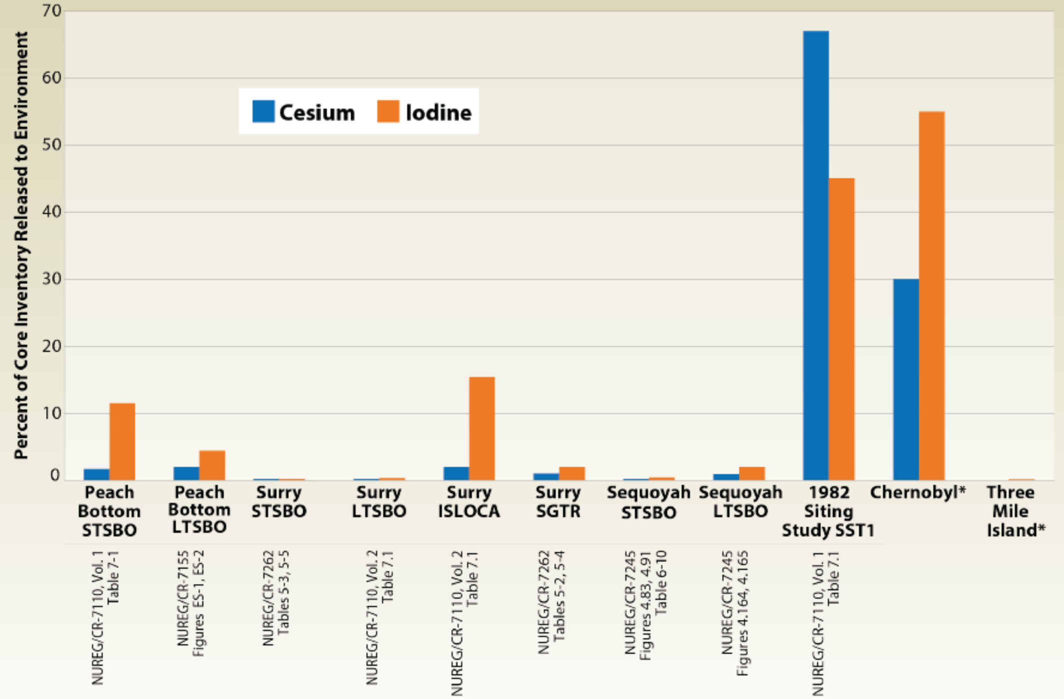


Figure 4.1 Percentages of Cesium and Iodine Released to the Environment for SOARCA Unmitigated Scenarios, 1982 Siting Study (SST1), and Historical Accidents

The SOARCA unmitigated release of Cesium-137 and Iodine-131, for each of the modelled scenarios, are much smaller than estimated in the earlier 1982 Siting Study Source Term 1 (SST1) case. Some of these releases develop over a period of time and are also much smaller than those from the Chernobyl accident.



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Release Characteristics

*The type of radioactive **materials***

Table 3

RADIONUCLIDES WITH SIGNIFICANT CONTRIBUTION TO DOMINANT EXPOSURE MODES

Radionuclides with Significant Contribution to Thyroid Exposure

Radionuclide	Half Life (days)
I-131	8.05
I-132	0.0858
I-133	0.875
I-134	0.0366
I-135	.028
Te-132	3.25
Kr-88	0.117

Radionuclides with Significant Contribution to Whole Body Exposure

Radionuclide	Half Life (days)
I-131	8.05
Te-132	3.25
Xe-133	5.28
I-133	0.875
Xe-135	0.384
I-135	.028
Cs-134	750
Kr-88	0.117
Cs-137	11,000

Radionuclides with Significant Contribution to Lung Exposure* (Lung only controlling when thyroid dose is reduced by iodine blocking or there is a long delay prior to releases).

Radionuclide	Half Life (days)
I-131	8.05
I-132	0.0858
I-133	0.875
I-134	0.0366
I-135	.028
Cs-134	750
Kr-88	0.117
Cs-137	11,000
Ru-106	365
Te-132	3.25
Ce-144	284

NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," November 1978

WASH-1400 informed early understanding

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PWR 6	6×10^{-6}	12.0	10.0	1.0	0	N/A	0.3	2×10^{-3}	8×10^{-4}	8×10^{-4}	1×10^{-3}	9×10^{-5}	7×10^{-5}	1×10^{-5}
PWR 7	4×10^{-5}	10.0	10.0	1.0	0	N/A	6×10^{-3}	2×10^{-5}	2×10^{-5}	1×10^{-5}	2×10^{-5}	1×10^{-6}	1×10^{-6}	2×10^{-7}
PWR 8	4×10^{-5}	0.5	0.5	N/A	0	N/A	2×10^{-3}	5×10^{-6}	1×10^{-4}	5×10^{-4}	1×10^{-6}	1×10^{-8}	0	0
PWR 9	4×10^{-4}	0.5	0.5	N/A	0	N/A	3×10^{-6}	7×10^{-9}	1×10^{-7}	6×10^{-7}	1×10^{-9}	1×10^{-11}	0	0
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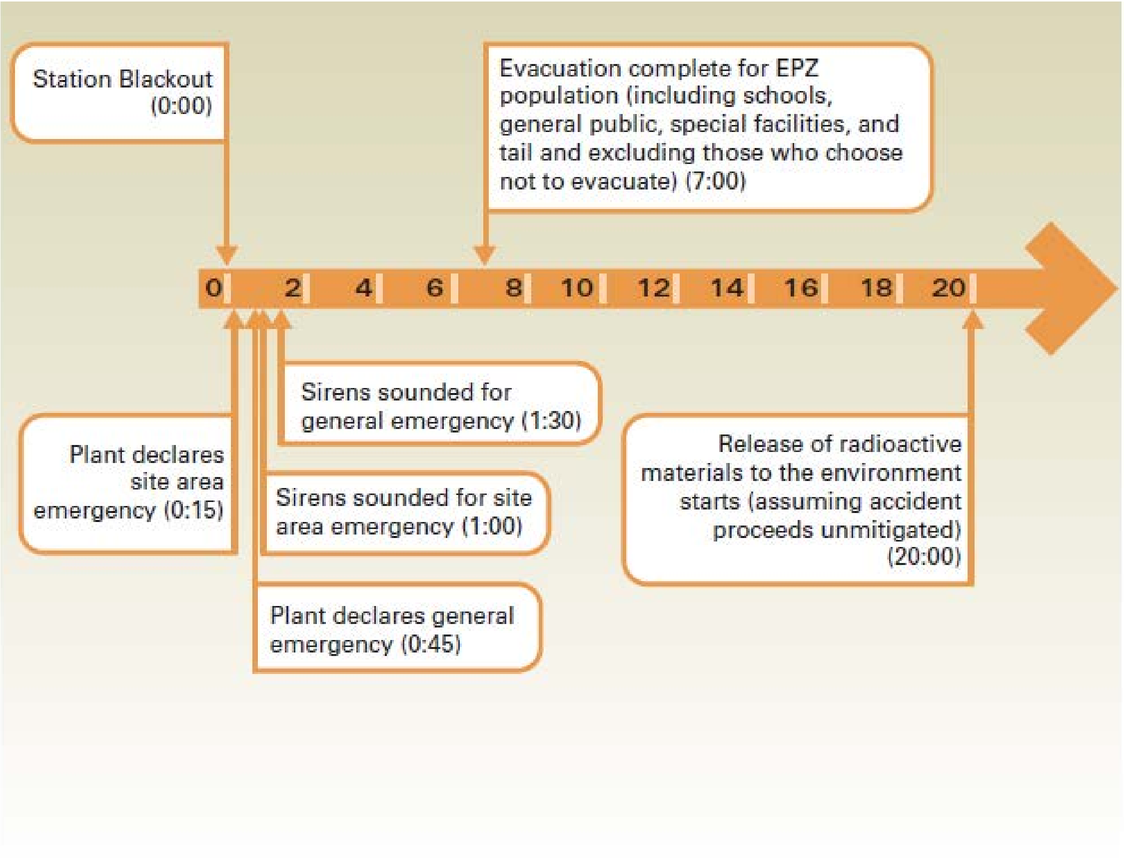

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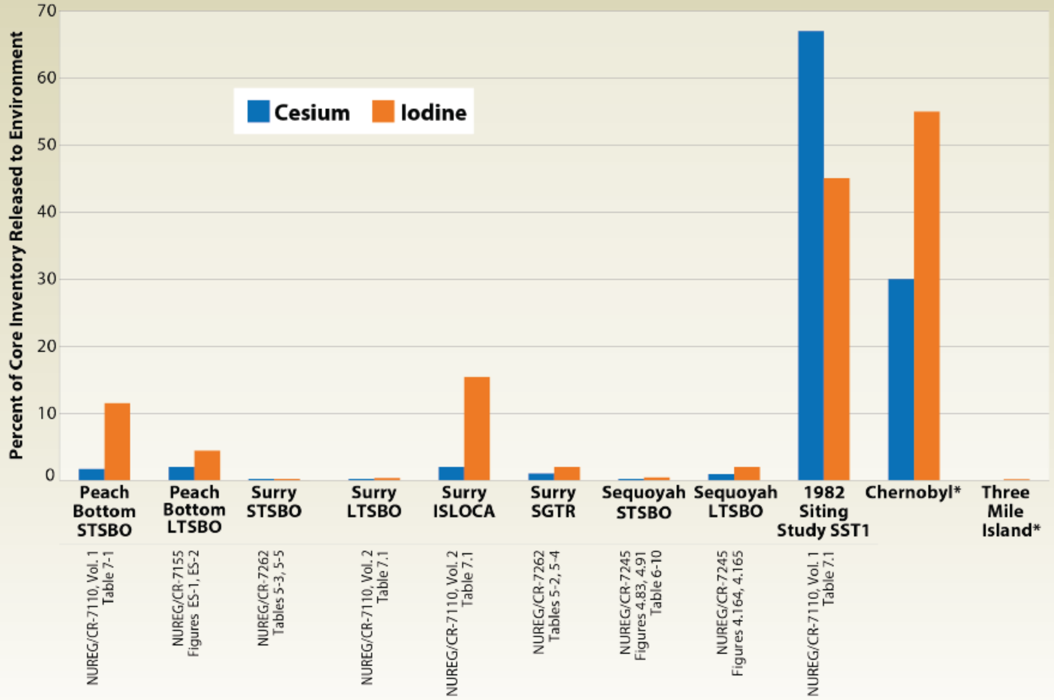

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Planning basis balances protection and resources

The consequences from a spectrum of accidents, **tempered by probability considerations**, should be considered to scope the planning efforts for:

- *The distance to which planning for predetermined protective actions is warranted*
- *The time dependent characteristics of a potential release*
- *The type of radioactive materials*

The planning basis document included a recommended 10 mile plume exposure path emergency planning zone (EPZ) and a 50 mile ingestion pathway zone for large light water reactors (PWR and BWR)

NUREG-0396, “Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants,” November 1978

The likelihood of events considered is very low

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PWR 4	5×10^{-7}	2.0	3.0	2.0	0	1	0.6	2×10^{-3}	0.09	0.04	0.03	5×10^{-3}	3×10^{-3}	4×10^{-4}
PWR 5	7×10^{-7}	2.0	4.0	1.0	0	0.3	0.3	2×10^{-3}	0.03	9×10^{-3}	5×10^{-3}	1×10^{-3}	6×10^{-4}	7×10^{-5}
PWR 6	6×10^{-6}	12.0	10.0	1.0	0	N/A	0.3	2×10^{-3}	8×10^{-4}	8×10^{-4}	1×10^{-3}	9×10^{-5}	7×10^{-5}	1×10^{-5}
PWR 7	4×10^{-5}	10.0	10.0	1.0	0	N/A	6×10^{-3}	2×10^{-5}	2×10^{-5}	1×10^{-5}	2×10^{-5}	1×10^{-6}	1×10^{-6}	2×10^{-7}
PWR 8	4×10^{-5}	0.5	0.5	N/A	0	N/A	2×10^{-3}	5×10^{-6}	1×10^{-4}	5×10^{-4}	1×10^{-6}	1×10^{-8}	0	0
PWR 9	4×10^{-4}	0.5	0.5	N/A	0	N/A	3×10^{-6}	7×10^{-9}	1×10^{-7}	6×10^{-7}	1×10^{-9}	1×10^{-11}	0	0
BWR 1	1×10^{-6}	2.0	2.0	1.5	25	130	1.0	7×10^{-3}	0.40	0.40	0.70	0.05	0.5	5×10^{-3}
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BWR 4	2×10^{-6}	5.0	2.0	2.0	25	N/A	0.6	7×10^{-4}	8×10^{-4}	5×10^{-3}	4×10^{-3}	6×10^{-4}	6×10^{-4}	1×10^{-4}
BWR 5	1×10^{-4}	3.5	5.0	N/A	150	N/A	5×10^{-4}	2×10^{-9}	6×10^{-11}	4×10^{-9}	8×10^{-12}	8×10^{-14}	0	0

NUREG-075/014 (WASH-1400), “Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants,” October 1975

…down to 1 chance in 10 lifetimes of the universe

TABLE V 3-4 PWR LARGE LOCA ACCIDENT SEQUENCES vs. RELEASE CATEGORIES

Core melt | No core melt

	Release Categories								
	1	2	3	4	5	6	7	8	9
	Dominant Large LOCA Accident Sequences With Point Estimates								
	AB-α 1x10^{-11} AF-α 1x10^{-10} ACD-α 5x10^{-11} AG-α 9x10^{-11}	AB-γ 1x10^{-10} AHF-γ 2x10^{-11} AB-δ 4x 10^{-11}	AD-α 2x10^{-8} AH-α 1x10^{-8} AF-δ 1x10^{-8} AG-δ 9x10^{-9}	ACD-β 1x10^{-11}	AD-β 4x10^{-9} AH-β 3x10^{-9}	AB-ε 1x10^{9} ADF-ε 2x10^{-10} AHF-ε 1x10^{-10}	AD-ε 2x10^{-6} AH-ε 1x10^{-6}	A-β 2x10^{-7}	A 1x10^{-4}
	Other Large LOCA Accident Sequences								
	ACDGI-α AHFI-α ACHF-α ACDI-α ACDG-α AGI-α AFI-α ACG-α ACGI-α ACF-α ACDF-α ACEI-α ACEG-α ACEGI-α ACEF-α ACE-α AHF-α	ADF-β AHFI-δ ACHF-δ ACHF-γ ACDF-γ ACEF-γ AHFI-β ADFI-β ACHF-β ACDF-β AHF-δ AHFI-γ AEF-β AEFI-β ACEF-β AEF-δ AEFI-δ ACEF-δ AB-β AHF-β	AHG-α AHGI-α ADF-α ADFI-α ACH-α ACHI-α ACHG-α ACHGI-α AGI-δ AFI-δ ACG-δ ACGI-δ ACF-δ AHI-α ADGI-α ADI-α ADG-α AE-α AEI-α AEF-α AEFI-α AEG-α AEGI-α	ACDGI-β ADG- β ACDI-β ACDG-β ADGI- β ACE- β ACEI- β ACEG- β ACEGI-β AEG-β AEGI-β	AHI- β AHG- β AHGI-β ADI-β ACH-β ACHI-β ACHG-β AE- β AEI-β	ACHGI- ε AHFI- ε ADFI- ε ACDF- ε ACDGI-ε ACHF- ε AEF- ε AEFI-ε ACEF-ε ACEGI-ε	AHG-δ AHGI- δ AHGI- ε ACH-ε ACHI- ε ACHG- δ ACHG- ε ACHGI- ε ACDI- ε ACDG- δ ACDG- ε ADG- δ ADGI-δ AHG- ε ADI- ε ADG- ε ACD-ε ADGI-ε AHI-ε AE-ε AEI-ε ACE-ε ACEI-ε ACEG-ε ACEG-δ ACEGI-δ ACHGI-δ AEG-δ AEGI-δ AEG-ε AEGI-ε	AI-β AC-β ACI-β	AI AC ACI
$\Sigma_P^{(a)}$	3×10^{-10}	2×10^{-10}	5×10^{-8}	1×10^{-11}	7×10^{-9}	1×10^{-9}	3×10^{-6}	2×10^{-7}	1×10^{-4}

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	AB-α 1x10^{-11} AF-α 1x10^{-10} ACD-α 5x10^{-11} AG-α 9x10^{-11}	AB-γ 1x10^{-10} AHF-γ 2x10^{-11} AB-δ 4x 10^{-11}	AD-α 2x10^{-8} AH-α 1x10^{-8} AF-δ 1x10^{-8} AG-δ 9x10^{-9}	ACD-β 1x10^{-11}	AD-β 4x10^{-9} AH-β 3x10^{-9}	AB-ε 1x10^{9} ADF-ε 2x10^{-10} AHF-ε 1x10^{-10}	AD-ε 2x10^{-6} AH-ε 1x10^{-6}	A-β 2x10^{-7}	A 1x10^{-4}
	Other Large LOCA Accident Sequences								
	ACDGI-α AHFI-α ACHF-α ACDI-α ACDG-α AGI-α AFI-α ACG-α ACGI-α ACF-α ACDF-α ACEI-α ACEG-α ACEGI-α ACEF-α ACE-α AHF-α	ADF-β AHFI-δ ACHF-δ ACHF-γ ACDF-γ ACEF-γ AHFI-β ADFI-β ACHF-β ACDF-β AHF-δ AHFI-γ AEF-β AEFI-β ACEF-β AEF-δ AEFI-δ ACEF-δ AB-β AHF-β	AHG-α AHGI-α ADF-α ADFI-α ACH-α ACHI-α ACHG-α ACHGI-α AGI-δ AFI-δ ACG-δ ACGI-δ ACF-δ AHI-α ADGI-α ADI-α ADG-α AE-α AEI-α AEF-α AEFI-α AEG-α AEGI-α	ACDGI-β ADG- β ACDI-β ACDG-β ADGI- β ACE- β ACEI- β ACEG- β ACEGI-β AEG-β AEGI-β	AHI- β AHG- β AHGI-β ADI-β ACH-β ACHI-β ACHG-β AE- β AEI-β	ACHGI- ε AHFI- ε ADFI- ε ACDF- ε ACDGI-ε ACHF- ε AEF- ε AEFI-ε ACEF-ε ACEGI-ε	AHG-δ AHGI- δ AHGI- ε ACH-ε ACHI- ε ACHG- δ ACHG- ε ACHGI- ε ACDI- ε ACDG- δ ACDG- ε ADG- δ ADGI-δ AHG- ε ADI- ε ADG- ε ACD-ε ADGI-ε AHI-ε AE-ε AEI-ε ACE-ε ACEI-ε ACEG-ε ACEG-δ ACEGI-δ ACHGI-δ AEG-δ AEGI-δ AEG-ε AEGI-ε	AI-β AC-β ACI-β	AI AC ACI
$\Sigma_P^{(a)}$	3×10^{-10}	2×10^{-10}	5×10^{-8}	1×10^{-11}	7×10^{-9}	1×10^{-9}	3×10^{-6}	2×10^{-7}	1×10^{-4}

NUREG-075/014 (WASH-1400), “Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants,” October 1975

“Worst case” is addressed in the planning

“Regulation does not require dedication of resources to handle every possible accident that can be imagined. The concept of the regulation is that there should be core planning with sufficient planning flexibility to develop reasonable response to those very serious low probability accidents which could affect the public.”

[SONGS CLI-83-10, 17 NRC 528, (1983)]

Capabilities are available at Federal level

"The Task Force believes that it ***is not appropriate*** to develop specific plans for the most severe and most improbable Class 9 events."

"The Task Force, however, does believe that consideration should be given to the ***characteristics*** of Class 9 events in ***judging*** whether emergency plans based primarily on smaller accidents can be expanded to cope with larger events."

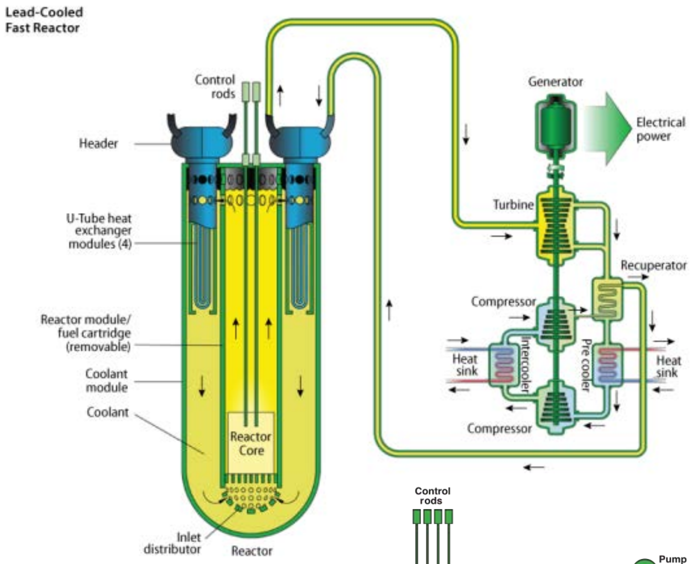
"The planning basis recommended by the Task Force therefore includes some of the key characteristics of very large releases to assure that ***site specific capabilities could be effectively augmented*** with general emergency preparedness (response) resources of the Federal government should the need arise."

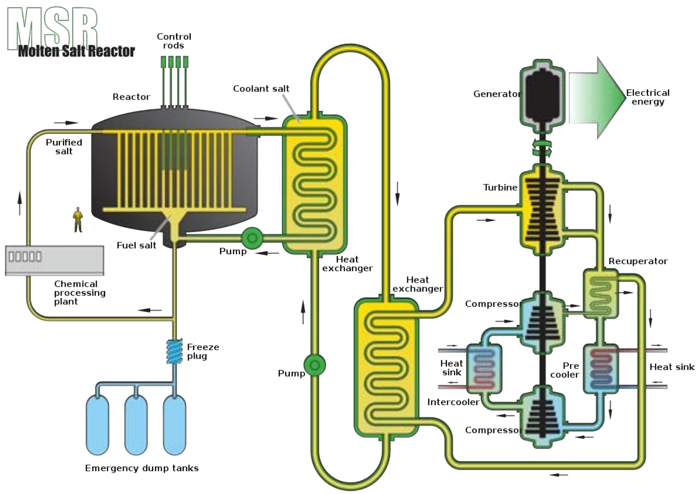
NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," November 1978

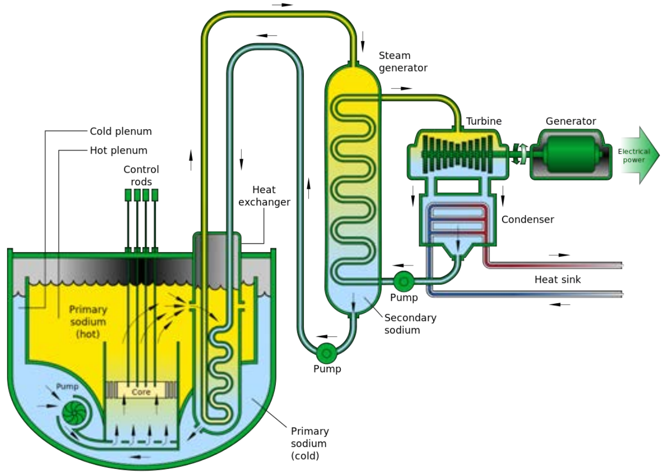
Response capabilities are coordinated across levels

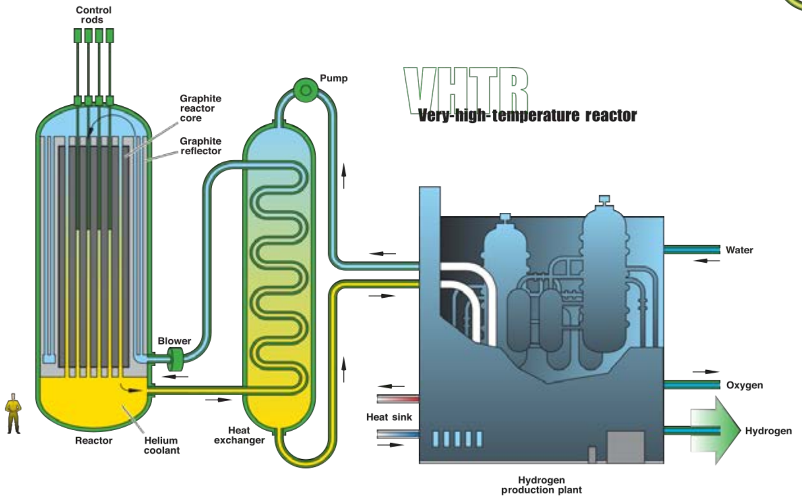
Licensee ***State*** ***Federal***

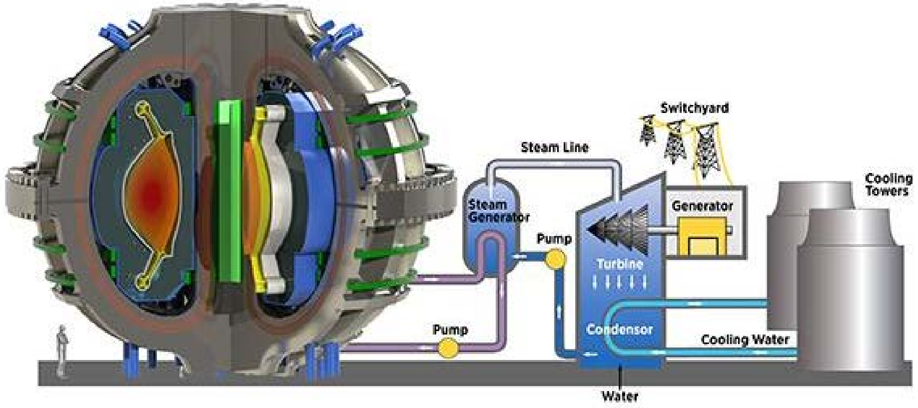
Different facilities require different capabilities











U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

The planning basis informs EP planning functions

Ensure capabilities exist to detect, classify, notify, assess, mitigate, and effectively respond to an emergency

Planning Basis		Emergency Planning Needs and Functions
Spectrum of Accidents	Distance	EPZ size, exposure pathways, protective action strategies
	Time	Timeliness of classification and notification, protective action strategies, mitigation
	Materials	Detection and assessment capabilities, radiological protection, mitigation

EP > EPZ

Key Takeaways Emergency Preparedness…

- EP ensures protective actions can and will be taken
- The EP planning basis is valid and useful
- EP regulations are risk-informed and commensurate to the potential hazards presented by the class of facility
  - Informed by characteristics of a spectrum of accidents
  - Evidence-based
  - Contain built-in conservatisms
  - Emphasize capabilities