6.0 EMERGENCY RESPONSE

Enhancements

~~Advancements~~ in consequence modeling provide an opportunity to integrate realism in the implementation of protective action decisions applied for discrete population segments. To best utilize these ~~advancements~~, detailed information was developed from area information and obtained from offsite response organizations (OROs). Through a user interface added to the model, this detailed information was input to reflect differences in the implementation of protective actions by various population segments. ~~These advancements are significant because they now allow the modeling of response activities, timing of decisions, and implementation of protective actions across different population segments.~~

They always did! But not 20 miles!

Emergency response programs for nuclear power plants (NPPs) are designed to protect public health and safety in the event of a radiological accident. These emergency response programs are developed, tested, and evaluated and are in place as defense in depth to respond in the unlikely event of an accident. To support a state of the art approach and integrate realism in the analyses, the modeling of the emergency response was based on the site-specific emergency planning documentation and on evaluation of public response to non-nuclear emergencies. The information developed in this Emergency Response section was used to support the MACCS2 consequence analyses for the accident scenarios. For each accident scenario, full evacuation of the plume exposure pathway emergency planning zone (EPZ) was assessed along with consideration of a shadow evacuation to a distance of 20 miles from the plant. Sensitivity analyses were completed for one accident scenario assessing evacuation to distances of 16 miles and 20 miles from the plant. Figure 60 identifies the location of the Peach Bottom plant and radial distances of 10 and 20 miles from the plant.

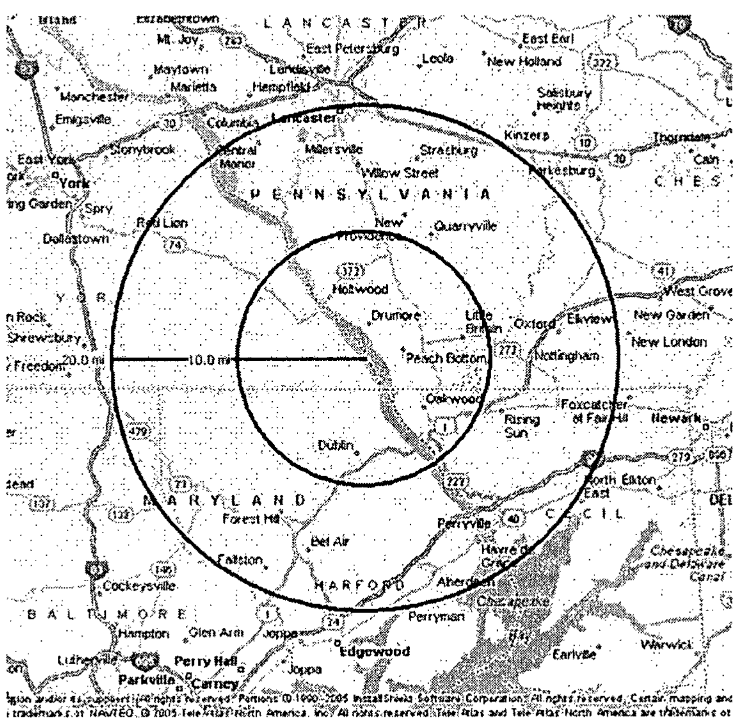


Figure 60 Peach Bottom 10 and 20 Mile Analysis Areas

Is this the place where we should indicate that everyone evacuates to 30 miles from the plant before closing from the door calculation?

3/7

As required by 10 CFR 50, offsite response officials (OROs) develop emergency response plans for implementation in the event of an NPP accident. These plans are regularly drilled and inspected biennially through a demonstration exercise performed in conjunction with the licensee. In biennial exercises, ORO personnel demonstrate timely decision making and the ability to implement public protective actions. Emergency plans escalate response activities in accordance with a classification scheme based on emergency action levels (EALs). Preplanned actions are implemented at each classification level including Unusual Event, Alert, Site Area Emergency (SAE), and General Emergency (GE). Public protective actions are required at the GE level, but ORO plans commonly include precautionary protective actions at the SAE level and sometimes at an Alert.

does PBo? If no, say that. If not take out

The plume exposure pathway EPZ is identified in NUREG-0654/FEMA-REP-1, Rev. 1 [24] as the area around an NPP of about 10 miles. Within the EPZ, detailed emergency plans are in place to reduce the risk of public health consequences in the unlikely event of an accident. Emergency planning within the EPZ provides a substantial basis for expansion of response efforts should it be necessary [24]. ORO personnel have repeatedly demonstrated the ability to implement protective actions within the EPZ during inspected biennial exercises. Modeling of expected protective action response is described in this section. Analyses were conducted for accident scenarios identified in Table 9.

Table 9 Scenarios Assessed for Emergency Response

#	Scenario
1	LTSBO Unmitigated
2	STSBO – with RCIC Blackstart
3	STSBO – without RCIC Blackstart
4	Sensitivity 1 STSBO (without RCIC Blackstart) and evacuation to 16 miles
5	Sensitivity 2 STSBO (without RCIC Blackstart) and evacuation to 20 miles
6	Sensitivity 3 STSBO (without RCIC Blackstart) with a delay in implementation of protective actions
7	Seismic Analysis - STSBO without RCIC Blackstart

6.1 Population Attributes

allow for a large

SOARCA modeled the population near the Peach Bottom plant as several cohorts. A cohort is any population group that mobilizes or moves differently from other population groups. WinMACCS uses census data for cohort modeling. Cohorts were established for each population subgroup where there was a meaningful number of individuals. Modeling includes member of the public who evacuate early, evacuate late, and those who refuse to evacuate. WinMACCS d~~oes not constrain the~~ number of cohorts but there is no benefit to defining an

yes, there is an upper limit

excessive number of cohorts with little difference in characteristics. The following cohorts were established for SOARCA analyses:

Cohort 1: 0 to 10 Public. This cohort includes the public residing within the EPZ.

Cohort 2: 10 to 20 Shadow. This cohort includes the shadow evacuation from the 10 to 20 mile area beyond the EPZ. A shadow evacuation occurs when members of the public evacuate from areas that are not under official evacuation orders and generally begin when a large scale evacuation is ordered [21].

Cohort 3: 0 to 10 Schools and 0 to 10 Shadow. This cohort includes elementary, middle and high school populations within the EPZ. Schools receive early and direct warning from OROs and have response plans in place to support busing of students out of the EPZ. A shadow evacuation from within the EPZ is included because sirens are sounded at SAE. This is expected to stimulate an evacuation of some of the residents from within the EPZ beginning about the same time as the evacuation of the schools.

Cohort 4: 0 to 10 Special Facilities. The Special Facilities population includes residents of hospitals, nursing homes, assisted living communities and prisons. Special facility residents are assumed to reside in robust facilities such as hospitals, nursing homes, or similar structures which provide additional shielding. Shielding factors for this population group consider this fact.

Cohort 5: 0 to 10 Tail. The 0 to 10 Tail is defined as the last 10 percent of the public to evacuate from the 10 mile EPZ. The approach to modeling the Tail is an analysis simplification to support inclusion of this population group. In reality, this population group is performing multiple activities prior to the evacuation of this cohort. The Tail takes longer to evacuate for many valid reasons such as the need to return home from work to evacuate with the family, pick up children, shut down farming or manufacturing operations or performing other actions prior to evacuating as well as those who may miss the initial notification.

Cohort 6: **Non-evacuating public.** This cohort group represents a portion of the public from 0 to 10 miles who may refuse to evacuate and is assumed to be 0.5 percent of the population. Research of large scale evacuations has shown that a small percent of the public refuses to evacuate [21] and this cohort accounts for this potential group. Emergency planning is in place to support evacuation of 100 percent of the public. ~~Any member of the public who refuses to evacuate is therefore considered to receive a voluntary dose as reflected in the consequence analyses.~~

So it's there own fault?!

6.1.1 Population Distribution

The Peach Bottom evacuation time estimate (ETE) was used to develop the population estimates for the analysis of the EPZ. The Peach Bottom ETE presents a detailed estimate of the population of the 0 to 10 mile region. The detailed population analysis developed for the Peach Bottom ETE was used for SOARCA.

What is the risk communication aspect for statements like this

No need to characterize!

A separate estimate was developed for the permanent residents and special needs population beyond the EPZ. SECPOP2000 was used to estimate the population within 20 miles of the plant. The population was projected to 2005 using a multiplier of 1.0533 obtained from Census Bureau information. The population of the 10 to 20 mile area beyond the EPZ was then calculated as the difference between the total estimated population within 20 miles and the EPZ population. These population values are represented in Table 10. School children are not a separate cohort in the 10 to 20 mile area because it is assumed there is ample time for schools to close and children to go home and evacuate with families; therefore they are included in the 10 to 20 public.

To establish the population distributions, the shadow population was assessed first and defined as 20 percent of the total population from 10 to 20 miles beyond the EPZ. This value for the shadow population was then combined with non-evacuee, special facilities, and schools and then subtracted from the remaining total to establish the general public. Ten percent of the general public defines the evacuation tail, and the remainder was used as the total for the general public. The non-evacuating population is 0.5 percent of the total population in each region. Cohort populations are provided in Table 10.

Table 10 Peach Bottom Cohort Population Values

Cohort	Description	Population
1	Public (0 to 10)	39,438
2	Shadow (10 to 20)	77,096
3	Schools (0 to 10) and Shadow (0 to 10)	26,413
4	Special Facilities (0 to 10)	400
5	Tail (0 to 10)	4,382
6	Non-evacuating public	355

6.1.2 Evacuation Time Estimates

The WinMACCS network evacuation application was used in the modeling and allows input of site specific travel direction and speed. The travel direction and speed parameters are derived from the ETEs. As required by 10 CFR 50.47 Appendix E, each licensee is required to estimate the time to evacuate the EPZ. Appendix 4 of NUREG-0654/FEMA-REP-1, Rev. 1 [21] provides information on the requirements of ETEs, and NUREG/CR-6863, "Development of Evacuation Time Estimate Studies for Nuclear Power Plants," provides detailed guidance on development of ETEs [24]. A typical ETE includes many scenarios to help identify the combination of events for normal and off-normal conditions and provides emergency planners with estimates of the time to evacuate the EPZ under varying conditions [24]. The SOARCA project used a normal weather weekday scenario that includes schools in session. This scenario was selected because it presents several challenges to timely protective action implementation including evacuating residents at work and mobilizing buses to evacuate children at school.

In calculating evacuation time estimates for the SOARCA project, the most recent ETE available from the licensee was used for the EPZ [32]. The following ETEs, rounded to the nearest quarter hour, were used in the development of evacuation speeds within the EPZ. These ETEs correspond to the winter weekday scenario.

- 100 percent evacuation: 5 hours and 15 minutes; and
- 90 percent evacuation: 4 hours and 15 minutes.

These values were used to derive the speeds for the cohorts used in the analysis. The summer weekend ETE and the winter weeknight ETE were also provided in the Peach Bottom study [32] and were considered for use; however, the ETEs for these two scenarios were each approximately 4 hours and 45 minutes for the 100 percent evacuation. The winter weekday scenario was therefore selected because with an ETE of 5 hours and 15 minutes it can be considered the bounding ETE case for the analysis.

For the evacuation scenarios, a speed is input into the consequence model. The evacuation speed is derived from the ETE and is primarily influenced by population density and roadway capacity. When using ETE information, it is important to understand the components of the time estimate. The ETE includes mobilization activities the public undertakes upon receiving the initial notification of the incident [21][24]. These actions include receiving the warning, verifying information, gathering children, pets, belongings, etc., packing, securing the home, and other evacuation preparations. Thus, a 5 hour ETE does not indicate that all of the vehicles are en route for 5 hours, but is the end of a 5 hour period in which the public mobilizes and evacuates the area. An evacuating population does not enter the roadway system at once. Rather an ideal model would include a "road loading function" that represents the expected movement. Most ETEs use such a model. However, MACCS does not currently have the capability to move populations in this manner. This being the case, cohorts are modeled to begin moving together at a specific time after notification.

Evacuations can therefore be represented as a curve that is relatively steep at the beginning and tends to flatten as the last members of the public exit the area. Through review of more than 20 existing ETE studies, the point at which the curve tends to flatten occurs where approximately 90 percent of the population has evacuated. This is consistent with research that has shown that a small portion of the population that takes a longer time to evacuate than the rest of the general public and is the last to leave the evacuation area [21]. This last 10 percent of the population is identified as the evacuation tail. To best achieve the goal of protecting the public health and safety, it is not appropriate to utilize the total ETE in the analysis. For the analyses in this study, the 90 percent ETE value was used to derive evacuation speeds.

6.2 WinMACCS

facilitates accounting

WinMACCS Version 3.~~4~~3 was used to generate input for MACCS2 model runs. WinMACCS ~~has the ability to account~~ for the specific actions of different population groups and accommodates variations in speed and direction of evacuating cohorts. To utilize these features, the entire evacuation area was mapped onto a radial sector grid network around the plant. The roadway network was reviewed against site-specific evacuation plans to determine likely evacuation direction in each grid element. Traffic movement was approximated at the grid element level. The results of the ETE were reviewed to determine localized areas of congestion as well as areas were no congestion occurs. Using this information, speed adjustment factors were applied at the grid element level to speed up vehicles in the rural uncongested areas and to slow vehicles in more urban settings where the modeling indicates that speeds are lower than the average values used in the analyses.

6.2.1 Hotspot and Normal Relocation and Habitability

OROs generally do not develop detailed protective action plans for areas beyond the EPZ. However, in the unlikely case of a severe accident and radiological release, the population outside the EPZ could be relocated if their potential dose exceeds protective action criteria. OROs would base this determination on dose projections using State, utility and national laboratory computer models as well as measurements taken in the field. Hotspot relocation and normal relocation models are included in the MACCS2 code to reflect this contingency. Total dose commitment pathways for the relocation models are cloudshine, groundshine, direct inhalation, and resuspension inhalation. Relocated individuals are removed from the calculation for the remainder of the emergency phase and receive no additional dose during that phase. The dose criteria are applied after plume arrival at the affected area.

For the hotspot relocation, individuals beyond twenty miles are relocated 12 hours after plume arrival if the total lifetime dose commitment for the weeklong emergency phase exceeds 0.05 Sv (5 rem). For the normal relocation, such individuals are relocated 24 hours after plume arrival if the total lifetime dose commitment exceeds 0.005 Sv (0.5 rem). The relocation times of 12 hours for hotspot and 24 hours for normal relocation were established based on review of the emergency response time lines which suggest that OROs would not likely be available earlier to assist with relocation due to higher priority tasks in the evacuation area.

A non-evacuating cohort has been included in the analysis. Although it is assumed this cohort does not evacuate, this population is still subject to the Hotspot and Normal Relocation criterion.

was

R Site-specific values ~~are~~ used to determine long-term habitability. ~~Most states adhere to~~ EPA ~~guidelines that allow a dose of 2 rem in the first year~~ and 500 mrem per year thereafter. The EPA recommendation has ~~traditionally been implemented in MACCS2~~ as 4 rem during the first 5 years (2 rem + 4 * 0.5 rem) of exposure. ~~However~~, Pennsylvania has a ~~more strict~~ habitability criterion of 500 mrem/yr beginning in the first year and this value was used in the Peach Bottom analysis.

if it does not apply to PB, what

6.2.2 Shielding Factors

Shielding factors vary by geographical region across the United States, and those used in the Peach Bottom analysis are shown in

Table 11. The factors represent the fraction of dose that a person would be exposed to when performing normal activities, evacuating, or staying in a shelter in comparison to a person outside with full exposure and are applied to all cohorts except the Special Facilities. Special

Facilities are typically larger and more robust structures than housing stock and therefore have better shielding factors as identified in the table.

Table 11 Peach Bottom Shielding Factors.

ID	Ground Shine			Cloud Shine			Inhalation/Skin		
	Normal	Evac.	Shelter	Normal	Evac.	Shelter	Normal	Evac.	Shelter
Cohorts	0.18	0.50	0.10	0.60	1.00	0.50	0.46	0.98	0.33
Special Facilities	0.05	0.50	0.05	0.31	1.00	0.31	0.33	0.98	0.33

The shielding factors provided in

for the cohorts

Table 11 were obtained from a variety of sources. Where appropriate, site specific values for sheltering were obtained from NUREG-1150 [11]. An updated inhalation/skin evacuation shielding factor was obtained from NUREG/CR-6953, Vol. 1, "Review of NUREG-0654, Supplement 3, 'Criteria for Protective Action Recommendations for Severe Accidents'"[22]. The normal activity shielding factors have been adjusted to account for the understanding that people do not spend a great deal of time outdoors. The normal activity value~~s~~ are all weighted average~~s~~ of indoor and outdoor values based on being indoors 81 percent of the time and outdoors 19 percent of the time [31]. Indoor values are assumed to be the same as sheltering. For the special facilities, the normal value is the same as the sheltered value, reflecting the fact that the special facilities population would not be expected to spend part time outdoors.

6.2.3 Potassium Iodide

Pennsylvania implements a potassium iodide (KI) program, and the State distributes KI tablets through several different means. The Department of Health district offices are responsible for coordinating with county emergency management agency officials to make KI available to residents living and working within the EPZ. The distribution of KI occurs on an annual basis for the Peach Bottom EPZ and is preceded by public announcements.

Should KI not have a much longer shelf life than 1 year

The purpose of the KI is to saturate the thyroid gland with stable iodine so that further uptake of radioactive iodine by the thyroid is diminished. If taken at the right time and in the appropriate dosage, KI can nearly eliminate doses to the thyroid gland from inhaled radioiodine. Factors that contribute to effectiveness of KI include the availability of KI (i.e., whether residents can find their KI), the timing of ingestion, and the degree of pre-existing stable iodine saturation of the thyroid gland. It is considered that some residents will not remember where they have placed their KI or may not have it available and will therefore not take KI. It is also assumed some residents will not take their KI when directed (i.e., they may take it early or late which reduces the efficacy). To account for this, KI was turned on in the model for approximately 50 percent of the public, and the efficacy of the KI was set at 70 percent.

6.2.4 Adverse Weather

Adverse weather is typically defined as rain, ice, or snow that affects the response of the public during an emergency. The affect of adverse weather on the mobilization of the public is not directly considered in establishing emergency planning parameters for this project because such a consideration more approximates a worst case scenario. However, adverse weather was addressed in the movement of cohorts within the analysis. The ESPMUL parameter in WinMACCS is used to reduce travel speed when precipitation is occurring as indicated from the meteorological weather file. The ESPMUL factor was set at 0.7 which effectively slows down the evacuating public to 70 percent of the established travel speed when precipitation exists.

6.2.5 Modeling using Evacuation Time Estimates

The purpose of using the ETE ~~as a parameter~~ in consequence modeling is to better approximate the real time actions expected of the public. Although consequence modeling has evolved to allow use of many cohorts and can address many individual aspects of each cohort, the approach to modeling evacuations is not direct. As stated earlier, evacuations include mobilizing and evacuating the public over a period of time, which is best modeled as a distribution of data. To use WinMACCS, this distribution of data must be converted into discrete events. For instance, upon the sounding of the sirens and issuance of the Emergency Alert System messaging, it is assumed all members of the public shelter and one hour later all members of the public enter the roadway network at the same time and begin to evacuate. In research of existing evacuations for technological hazards, it is shown that members of the public would actually enter the roadway network over a period of about an hour. It is not realistic that all vehicles would load simultaneously; however, this treatment within the model is necessary due to the current modeling abilities of WinMACCS.

Following the above constraint, it is necessary to establish reasonable speeds for each cohort. The speeds are derived from the ETE, and the elements that factor into the speeds include:

- Time to receive notification and prepare to evacuate (mobilization time);
- Time to evacuate; and
- Distance of travel.

With few exceptions, travel speeds were established as whole numbers.

A simple ratio of distance to time would show that evacuation of the 0 to 10 public from the 10 mile EPZ at Peach Bottom which has an ETE of 4 hours 15 minutes, would provide a speed of 2.4 mph. However, as indicated above, notification and preparation to evacuate are included in the ETE.

This all sounds like a major issue - But it really isn't the effect on speeds considered how the working takes place. Further, given the long time the plume release to this whole

evacuation parameters is relatively unimportant changing from SSS base to this was at most a 10% effect

For the general public, a one hour delay to shelter is assigned to reflect the mobilization time where residents receive the warning and prepare to evacuate. If the one hour mobilization time is subtracted from the ETE (4:15 – 1 hour) there remains 3 hours and 15 minutes to travel a maximum of 10 miles. As observed in actual evacuations due to technological or other hazards, people perform these mobilization activities at varying times with some residents ready to evacuate quickly while others can take up to an hour or longer. While this cohort is sheltered, a greater shielding factor is applied, and while en route during the evacuation, a lower shielding factor is applied.

During the evacuation, roadway congestion occurs rather quickly and traffic exiting the EPZ begins to slow. In review of over 20 ETE studies, this congestion typically occurs in 1 to 2 hours depending upon the population density and roadway capacity of the EPZ and considering that the vehicles are loaded onto the roadway network as a distribution. In the SOARCA analysis the 0-10 public is sheltered and preparing to evacuate for one hour. The public is then loaded onto the roadway and congestion is assumed to occur within 15 minutes. This total time of 1 hour 15 minutes for congestion to occur was established to be consistent with ETE studies.

The calculation of the speed of evacuees includes the first 15 minutes to the point when congestion occurs. For this first 15 minutes, evacuees are assumed to travel at 5 mph. This appears slow, but considering stop signs, traffic signals, and the build up of congestion, the speed is comparable to ETE modeling results. In the first 15 minutes at 5 mph, a distance of 1.25 miles has been traveled. At that time congestion is heavy and speeds slow for the next 8.75 miles.

The ETE is 4 hours 15 minutes for this cohort. Having sheltered and prepared to evacuate for 1 hour and then traveled the first 15 minutes at 5 mph, the remaining time is 3 hours (4:15 - 1 hour shelter - 15 minutes at 5 mph). To determine the speed of travel for the remaining 8.75 miles, the distance is divided by the time (8.75 miles / 3 hours) which provides a speed of 2.9 mph. The calculated speed used in the analysis for this cohort was rounded to 3 mph for this cohort.

6.2.6 Establishing the Initial Cohort in the Calculation

The cohorts described earlier are intended to represent discrete population groups that respond differently during an emergency. There are some rules within WinMACCS that must be applied to establish the cohorts for this analysis. The rule that most affects the analysis is that the first cohort in the model must be defined over the full area to be modeled. However, in this analysis there is no population segment that is both within the 0 to 10 mile area and the 10 to 20 mile area. To account for this in WinMACCS, Cohort 1 was described as the 0 to 10 mile public and Cohort 2 was described as the 10 to 20 mile Shadow. The population fractions for these two cohorts reflect the population modeled, but within the model, these fractions were established to meet the WinMACCS rule and do not reflect the individual values of these two cohorts. For Cohort 1, the model uses 20 percent of the population in the 0 to 20 mile area which is the shadow fraction used for all but the seismic analysis. The remaining 80 percent of the 0 to 10 mile population is represented by Cohort 2. Cohorts 1 and 2 are assigned identical emergency response behaviors for delays, durations, speeds, and shielding factors.

? I thought you could have defined individual population files & take care of this problem.

6.3 Accident Scenarios

An emergency response timeline was developed for each accident scenario using information from the MELCOR analyses, expected timing of Emergency Classification declarations, and information from the ETE. The timeline identifies points at which cohorts would receive instruction from OROs to implement protective actions. In practice, initial evacuation orders are based on the severity of the accident and in Pennsylvania would likely include an evacuation of the entire EPZ. This action is readily accommodated in the WinMACCS modeling.

6.3.1 Unmitigated LTSBO

and ?

The timing of emergency classification declarations was based on Table PBAPS 3-1 Emergency Action Level (EAL) Matrix contained in site emergency plan implementing procedures. The emergency classification timing was reviewed with the licensee for accuracy. The SAE EAL MS1 specifies that at the beginning of the incident, loss of all power, an SAE is declared 15 minutes after the station blackout initiating event an EAS message 45 minutes after SAE. It is assumed that under this scenario, the SAE is declared in accordance with the EAL. A GE is declared, based on EAL MG1, 45 minutes into the event when it is assumed operators have determined offsite power will not be restored within 2 hours, and another EAS message 45 minutes later.

define

Protective actions were assumed to be recommended by OROs in accordance with approved emergency plans and procedures. Discussions were held with site representatives to help ensure proper understanding of EALs for each accident scenario and emergency response practices. In addition, exercise timelines that show the times for declaration of emergency classification, siren activation and broadcast of EAS messaging for Peach Bottom were reviewed. The timing in the exercises shows approximately 50 minutes for these activities to be complete, and as indicated in Figure 61, an estimate of 45 minutes was used in the analysis which closely approximates the exercise values. The offsite emergency plans for Peach Bottom include sounding sirens for ~~both~~ declaration of SAE and GE. The emergency response timeline for the long term station blackout scenario is shown in Figure 61. The duration of specific protective actions for each cohort are summarized in Figure 62.

both

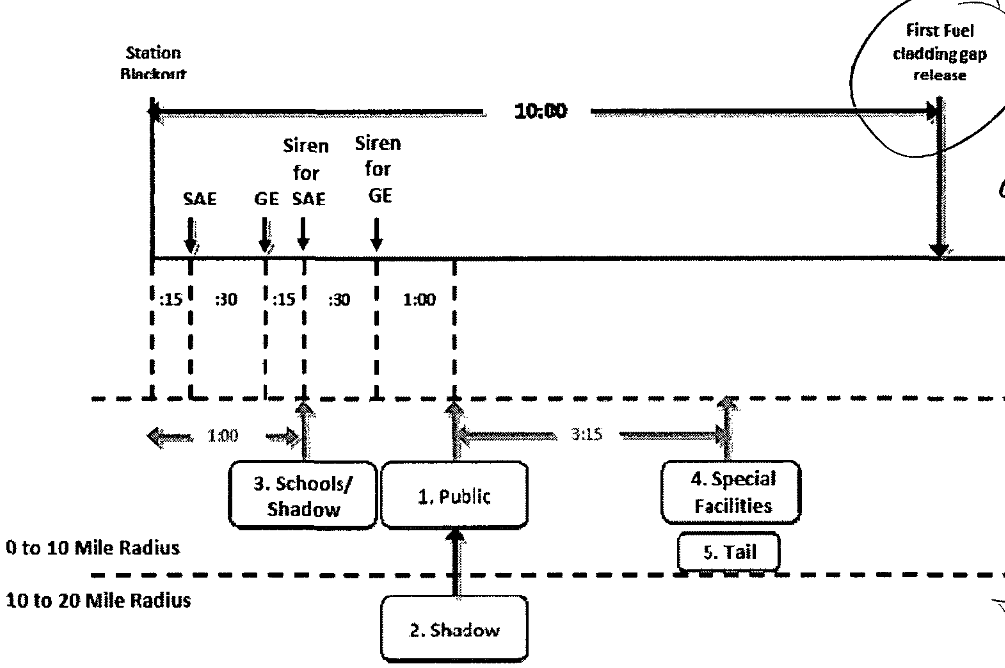


Figure 61 Unmitigated LTSBO Emergency Response Timeline

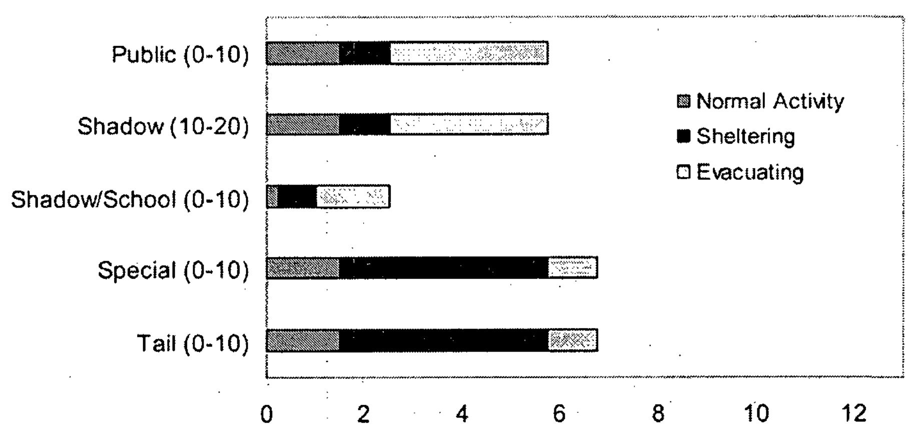


Figure 62 Duration of Protective Actions for Unmitigated LTSBO

The Pennsylvania Emergency Management Agency (PEMA) will communicate directly with schools upon receiving the declaration of SAE. This allows for school evacuation preparation activities to begin; however, the emergency plans identify that schools will only evacuate if a GE is declared. Because schools have already mobilized resources, it is assumed that 15 minutes after GE is declared, schools are ready to evacuate. Coincidentally, the evacuation of the schools is shown to begin at the same time as the sounding of sirens in response to the SAE. There is no relationship between the sounding of sirens for SAE and the evacuation of schools, the timing of various activities simply resulted in alignment of these actions.

interesting, but the important one to note time is when the containment fails & the off-site release starts — This would show that for this scenario the evac is essentially complete before release starts — Therefore, all the [illegible] vagaries in modeling that loom large in the discussion are of small consequence

The siren and EAS message broadcast in response to the SAE provides warning and notification to all residents and transients within the EPZ that there is an incident, and EAS messaging will request that people monitor the situation for further information. Credit is taken for this heightened awareness of the public, and it is assumed that this sounding of sirens causes a shadow evacuation from within the EPZ. Something missing -

Cohort 1: 0 to 10 Public. Following declaration of an SAE, sirens are sounded at which time the public is assumed to shelter. Sirens are again sounded following the declaration of GE. The time for the public to receive the warning and prepare to mobilize is assumed to be one hour after the siren sounds for the GE. One hour is based on evacuation research which shows the pubic mobilizes over a period of time with some members of the public moving soon receiving an EAS message, while most of the expect to take some time to prepare and then evacuate. The evacuation tail would take a longer time to prepare and evacuate and is a separate cohort. One hour was selected as a reasonable centroid of an evacuation curve for this cohort which is consistent with empirical data from previous large scale evacuations [26].

Cohort 2: 10 to 20 Shadow. This cohort is assumed to begin movement at the same time as the 0 to 10 Public after sirens have sounded within the EPZ and when widespread media broadcasts are underway. Residents in the 10 to 20 area begin seeing large numbers of people evacuating and initiate a shadow evacuation. There is no warning or notification for the public residing in this area which is not under an evacuation order.

Cohort 3: 0 to 10 Schools and 0 to 10 Shadow. Schools are the first to take action. Upon receipt of the declaration of SAE by the site, PEMA would notify the schools in accordance with the offsite emergency response plan. It is assumed schools begin sheltering when notified, and this notification is assumed to occur about 15 minutes after the start of the event. Buses would be mobilized, but in accordance with the emergency plan, evacuation would not begin until a GE is declared. The preliminary action to mobilize buses in response to the SAE allows for a prompt evacuation, and it is assumed schools begin evacuating 15 minutes after GE. It is only coincidence that this occurs about the same time as the sounding of the sirens in response to the GE. At this time in the event, roads are uncongested and school buses are able to exit the EPZ quickly. The sounding of sirens and broadcast of the EAS message in response to the SAE provides warning and notification to all residents and transients within the EPZ that there is an incident. The EAS messaging will request that people monitor the situation for further information. It is assumed that this sounding of sirens causes a shadow evacuation from residents within the EPZ (0 to 10 Shadow). Because the shadow population is grouped with the schools, the shadow population is also treated as if it shelters at 15 minutes.

Cohort 4: 0 to 10 Special Facilities. Special Facilities can take longer to evacuate than the general public because transportation resources, some of which are very specialized, must be mobilized. Special Facilities would be evacuated individually over a period of time based upon available transportation and the number of return trips needed. WinMACCS does not accept input over a period of time to represent a road loading function for cohorts. Therefore, the options for modeling included loading the cohort early and moving them very slowly along the evacuation routes, or loading the cohort with the evacuation tail and moving the cohort similarly to the tail. Special Facilities provide better shielding for the residents, thus while residents are in the facility, they are better protected than when they are evacuating. It was determined that the best representation of this cohort in the modeling is to evacuate with the tail and apply shielding factors consistent with the types of structures within which these residents reside. The Special Facilities cohort is assumed to depart at the same time as the evacuation tail, although it is recognized this cohort would begin mobilization about the same time as the schools.

Cohort 5: 0 to 10 Tail. Using the evacuation data provided in the Peach Bottom ETE [32], 90 percent of the evacuation of the EPZ is complete at approximately 4 hours and 15 minutes, and this corresponds to the departure time for the 0 to 10 Tail.

Cohort 6: Non-Evacuating Public. This cohort group represents a portion of the public who may refuse to evacuate and is assumed to be 0.5 percent of the population. Any member of the public who does not evacuate is still subject to the Hotspot and Normal Relocation criterion discussed earlier.

The evacuation timing for each cohort is presented in
Table 12. Selected input parameters for WinMACCS are provided to support detailed use of this study. More detailed information regarding modeling parameters is available in the MACCS2 User's Guide [26]. A brief description of the parameters is provided below.

- Delay to Shelter (DLTSHL) represents a delay from the time of the start of the accident until cohorts enter the shelter.
- Delay to Evacuation (DLTEVA) represents the length of the sheltering period from the time a cohort enters the shelter until the point at which they begin to evacuate.
- The speed (ESPEED) is assigned for each of the three phases used in WinMACCS including Early, Middle, and Late. Average evacuation speeds were derived from the Surry 2000 ETE report. Speed adjustment factors were then utilized in the WinMACCS application to represent free flow in rural areas and congested flow in urban areas.
- Duration of Beginning phase (DURBEG) is the duration assigned to the beginning phase of the evacuation and may be assigned uniquely for each cohort.
- Duration of Middle phase (DURMID) is the duration assigned to the middle phase of the evacuation and may also be assigned uniquely for each cohort.

For the 0 to 10 Public and the 0 to 10 Tail, the sum of the DLTEVA, DURBEG and DURMID is equal to the ETE.

Table 12 Unmitigated LTSBO Cohort Timing

Cohort	Delay to Shelter DLTSHL (hr)	Delay to Evacuation DLTEVA (hr)	DURBEG (hr)	DURMID (hr)	ESPEED (early) mph	ESPEED (mid) mph
0 to 10 Public	1.5	1	0.25	3	5	3
10 to 20 Shadow	1.5	1	0.25	3	5	3
0 to 10 Schools/Shadow	0.25	0.75	1	0.5	20	20
0 to 10 Special Facilities	1.5	4.25	0.5	0.5	3	20

0 to 10 Tail	1.5	4.25	0.5	0.5	3	20
Non-Evac	0	0	0	0	0	0

It should be noted that the modeling for the Special Facilities does not fully reflect the actions of this cohort. In reality, special facilities evacuate individually with each facility responsible for obtaining resources. These resources are required to have been established during emergency planning; therefore, it is a reasonable assumption that the resources will be available. However, some facilities require specialized resources of which there may be few available, such as ambulances and wheelchair vans. These types of vehicles sometimes must make return trips until everyone is evacuated. WinMACCS does not accept a road loading function to model this action precisely. For modeling purposes only, we assume that the residents of these facilities remain sheltered and evacuate in a single wave beginning when the Tail begins to evacuate recognizing that some facilities will mobilize and evacuate early in the event.

6.3.2 STSBO with RCIC Blackstart

The timing of emergency classification declaration for the STSBO with RCIC blackstart was based on Table PBAPS 3-1 Emergency Action Level (EAL) Matrix contained in site emergency plan implementing procedures. The emergency classification timing was reviewed with the licensee for accuracy and this scenario is an immediate GE. With loss of offsite power and loss of DC power, operators cannot determine whether water level is above TAF, and a GE is declared based on EAL MG1. The emergency response timeline for the STSBO scenario is shown in Figure 63 and protective action durations for each cohort are shown in

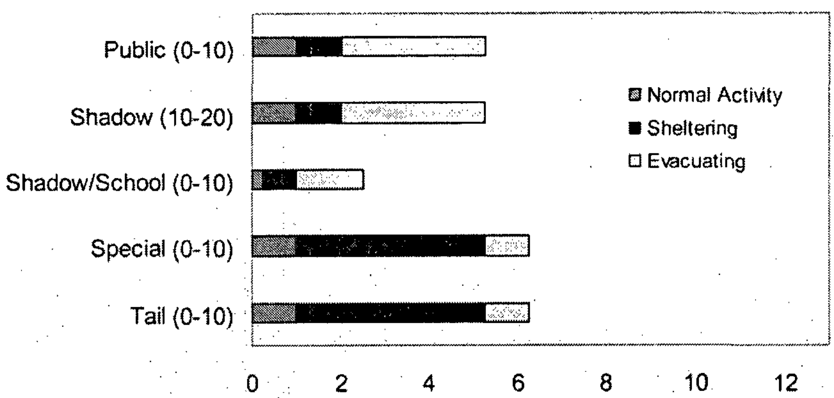
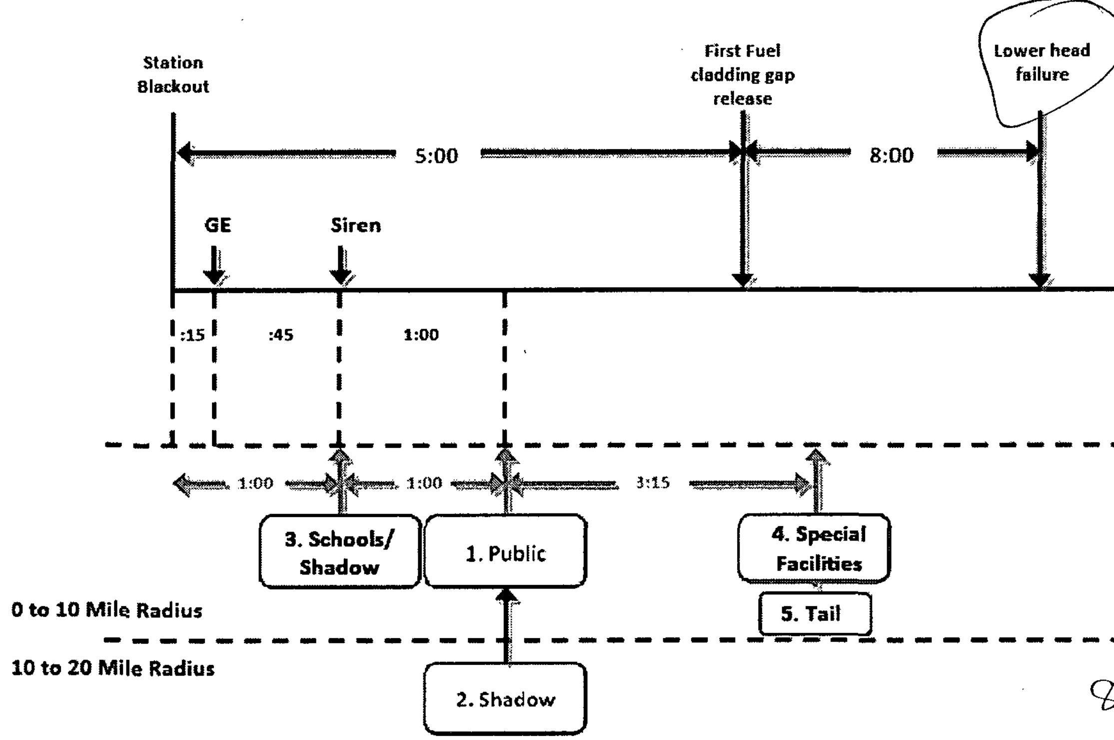


Figure 64. Core damage, as evidenced by the first fuel cladding gap release, is calculated at 5 hours into the event, with a significant radioactive release from containment beginning 13 hours into the event as indicated by the lower head failure in Figure 63.



This is also, and more importantly for EP models, the time of the start of off-site release — shows that even for this more rapidly developing scenario the evac is over before the release starts

Figure 63 STSBO with RCIC Blackstart Emergency Response Timeline

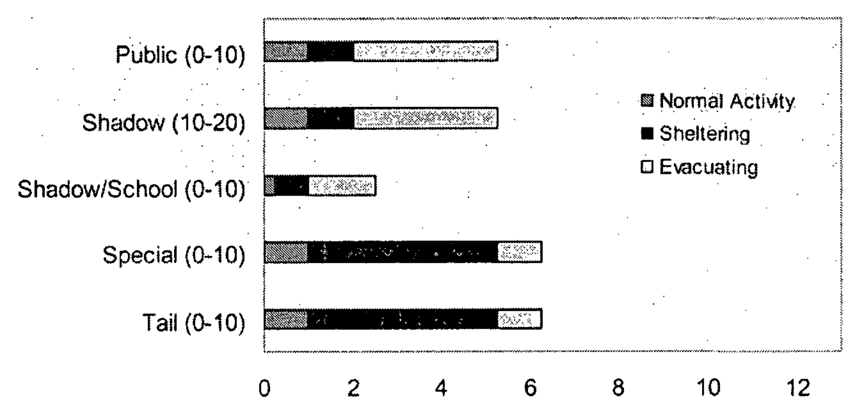


Figure 64 Protective Actions for STSBO with RCIC Blackstart

Cohort 1: 0 to 10 Public. It is assumed to take 45 minutes for OROs to sound sirens following declaration of a GE, and at which point the public is assumed to shelter. The time for the public to receive the warning and prepare to mobilize is assumed to be one hour after the siren sounds for the GE.

Cohort 2: 10 to 20 Shadow. This cohort is assumed to begin movement at the same time as the 0 to 10 Public after sirens have sounded within the EPZ and when widespread media broadcasts are underway.

Cohort 3: 0 to 10 Schools and 0 to 10 Shadow. This cohort is the first to take action. Upon receipt of the declaration of GE, PEMA would notify the schools in accordance with the emergency response plan. It is assumed schools begin sheltering when notified, buses would be mobilized, and evacuation would begin about 45 minutes after the GE is declared. It is coincidence that evacuation of the schools occurs at the same time sirens are assumed to sound. The sounding of the sirens for GE is not directly linked to evacuation of the schools.

Cohort 4: 0 to 10 Special Facilities. Special Facilities are assumed to depart at the same time as the evacuation Tail.

Cohort 5: 0 to 10 Tail. The Tail begins to evacuate approximately 4 hours and 15 minutes after notification to evacuate.

Cohort 6: Non-Evacuating Public. This cohort group represents a portion of the 0 to 10 public that may refuse to evacuate and is assumed to be 0.5 percent of the population.

The delay to shelter identified in Table 13 represents a delay before people enter the shelter, and the delay to evacuation represents the length of the sheltering period prior to initiating evacuation. These delays correspond to the different shielding factors that would be applied to each cohort during these timeframes. The speeds in this table represent average movements for the cohorts as derived from the ETEs. These values are adjusted within each grid element when developing the WinMACCS model.

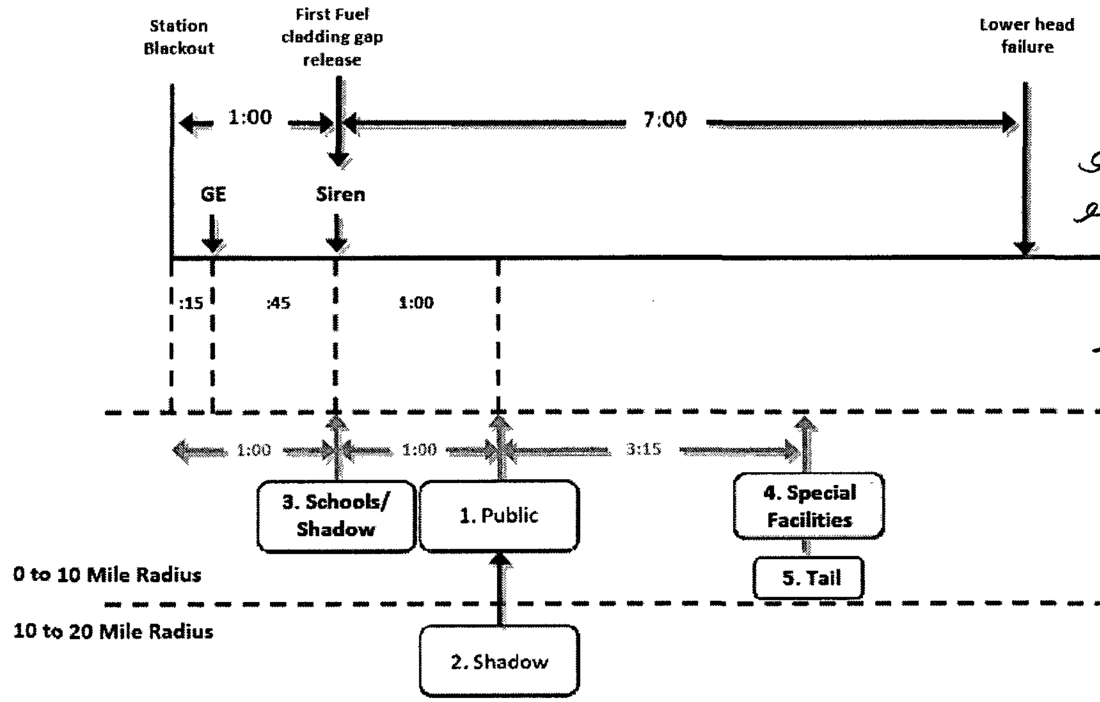
Table 13 STSBO with RCIC Blackstart Cohort Timing.

Cohort	Delay to Shelter DLTSHL (hr)	Delay to Evacuation DLTEVA (hr)	DURBEG (hr)	DURMID (hr)	ESPEED (early) mph	ESPEED (mid) mph
0 to 10 Public	1.00	1.00	0.25	3.00	5	3
10 to 20 Shadow	1.00	1.00	0.25	3.00	5	3
0 to 10 Schools/Shadow	0.25	0.75	1.00	0.50	20	20
0 to 10 Special Facilities	1.00	4.25	0.50	0.50	3	20
0 to 10 Tail	1.00	4.25	0.50	0.50	3	20
Non-Evac	0	0	0	0	0	0

6.3.3 STSBO without RCIC Blackstart

This scenario is not carried forward to the main report - only 2 LTSBO, STSBO are. Therefore this is probably a sensitivity study -

The timing of emergency classification declaration for the STSBO without RCIC blackstart was based on Table PBAPS 3-1 Emergency Action Level (EAL) Matrix contained in site emergency plan implementing procedures. The emergency classification timing was reviewed with the licensee for accuracy and this scenario is an immediate GE. With loss of offsite power and loss of DC power, operators cannot determine whether water level is above TAF, and a GE is declared based on EAL MG1. The emergency response timeline for the STSBO without RCIC Blackstart scenario is shown in Figure 65 and protective action durations for each cohort are shown in Figure 66. Core damage, as evidenced by the first fuel cladding gap release, is calculated at 1 hour into the event, with a significant radioactive release from containment beginning 8 hours into the event as indicated by the lower head failure in Figure 65.



Even 20, The evac is essentially complete before release starts

Figure 65 STSBO without RCIC Blackstart Emergency Response Timeline

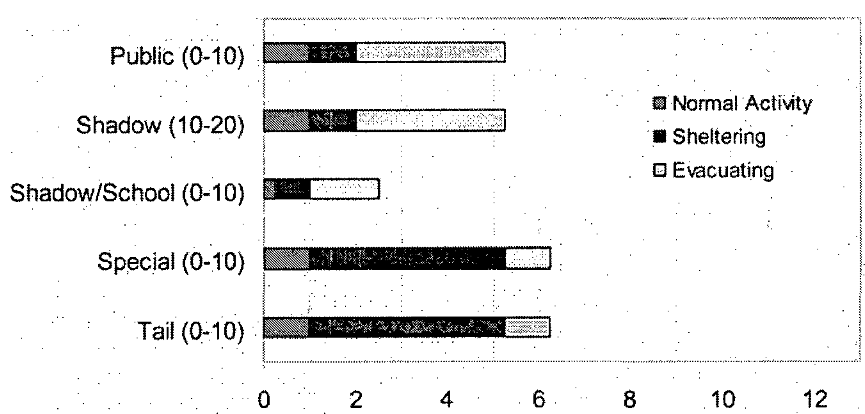


Figure 66 Duration of Protective Actions for STSBO without RCIC Blackstart

The implementation of protective actions for the STSBO without RCIC Blackstart is the same as implementation for the STSBO with RCIC Blackstart.

Cohort 1: 0 to 10 Public. It is assumed to take 45 minutes for OROs to sound sirens following declaration of a GE, and at which point the public is assumed to shelter. The time for the public to receive the warning and prepare to mobilize is assumed to be one hour after the siren sounds for the GE.

Cohort 2: 10 to 20 Shadow. This cohort is assumed to begin movement at the same time as the 0 to 10 Public after sirens have sounded within the EPZ and when widespread media broadcasts are underway.

Cohort 3: 0 to 10 Schools and 0 to 10 Shadow. This cohort is the first to take action. Upon receipt of the declaration of GE by the site, PEMA would notify the schools in accordance with the emergency response plan. It is assumed schools begin sheltering when notified, buses would be mobilized, and evacuation would begin about 45 minutes after the GE is declared. It is coincidence that this occurs at the same time sirens are assumed to sound.

Cohort 4: 0 to 10 Special Facilities. Special Facilities are assumed to depart at the same time as the evacuation Tail.

Cohort 5: 0 to 10 Tail. The Tail begins to evacuate approximately 4 hours and 15 minutes after notification to evacuate.

Cohort 6: Non-Evacuating Public. This cohort group represents a portion of the 0 to 10 public that may refuse to evacuate and is assumed to be 0.5 percent of the population.

The delay to shelter, identified in Table 14 represents a delay before people enter the shelter, and delay to evacuation represents the length of the sheltering period prior to initiating evacuation. These delays correspond to the different shielding factors that would be applied to each cohort during these timeframes. The speeds in this table represent average movements for the cohorts. These values are adjusted within each grid element when developing the WinMACCS model.

Table 14 STSBO without RCIC Blackstart Cohort Timing.

Cohort	Delay to Shelter DLTSHL (hr)	Delay to Evacuation DLTEVA (hr)	DURBEG (hr)	DURMID (hr)	ESPEED (early) mph	ESPEED (mid) mph
0 to 10 Public	1.00	1.00	0.25	3.00	5	3
10 to 20 Shadow	1.00	1.00	0.25	3.00	5	3
0 to 10 Schools/Shadow	0.25	0.75	1.00	0.50	20	20
0 to 10 Special Facilities	1.00	4.25	0.50	0.50	3	20
0 to 10 Tail	1.00	4.25	0.50	0.50	3	20
Non-Evac	0	0	0	0	0	0

6.4 Sensitivity Studies

Three additional calculations were performed to assess variations of protective actions. Each of the sensitivity studies was conducted using the STSBO without RCIC Blackstart accident scenario.

- Sensitivity 1 – Evacuation of a 16 mile area and a shadow evacuation from within the 16 to 20 mile area.
- Sensitivity 2 – Evacuation of the 0 to 20 mile area.
- Sensitivity 3 – Delay in implementation of protective actions for the public within the EPZ.

Protective actions beyond the EPZ are not planned in detail but utility, state and federal emergency response organizations will perform dose projection calculations ~~and take field measurements.~~ If assessment activities show that protective action guides would be exceeded beyond the EPZ, protective actions would be implemented in an ad hoc manner. There are no established emergency response plans developed for areas beyond the EPZ. Ad hoc protective action decision timing and extent was based on reasonable estimates and judgment for modeling of population movement.

at the time emergency response decision is made the release would not have started

Emergency response based on field measurements is relocation

what does full scale mean

A full scale evacuation model was developed to assess the sensitivity of consequences to changes in protective action strategies. Although the modeling of the area beyond the EPZ includes a full scale evacuation for the sensitivity analysis, this does not reflect likely protective action recommendations. ~~To~~ support the assessment of implementing protective actions outside of the EPZ, data was obtained for the 10 to 20 mile area around the NPP. Evacuation speeds for the cohorts in the 10 to 20 mile area were developed using OREMS Version 2.6. OREMS is a Windows-based application used to simulate traffic flow and was designed specifically for emergency evacuation modeling [25]. The main features of OREMS utilized in the analyses include:

Review this statement in view of Randy S's insights that EPA PAGs are exceeded for beyond 10 miles

- Determining the length of time associated with complete or partial evacuation of the population at risk within an emergency zone, or for specific sections of highway network or sub-zones; and
- Determining potential congestion areas in terms of traffic operations within the emergency zone.

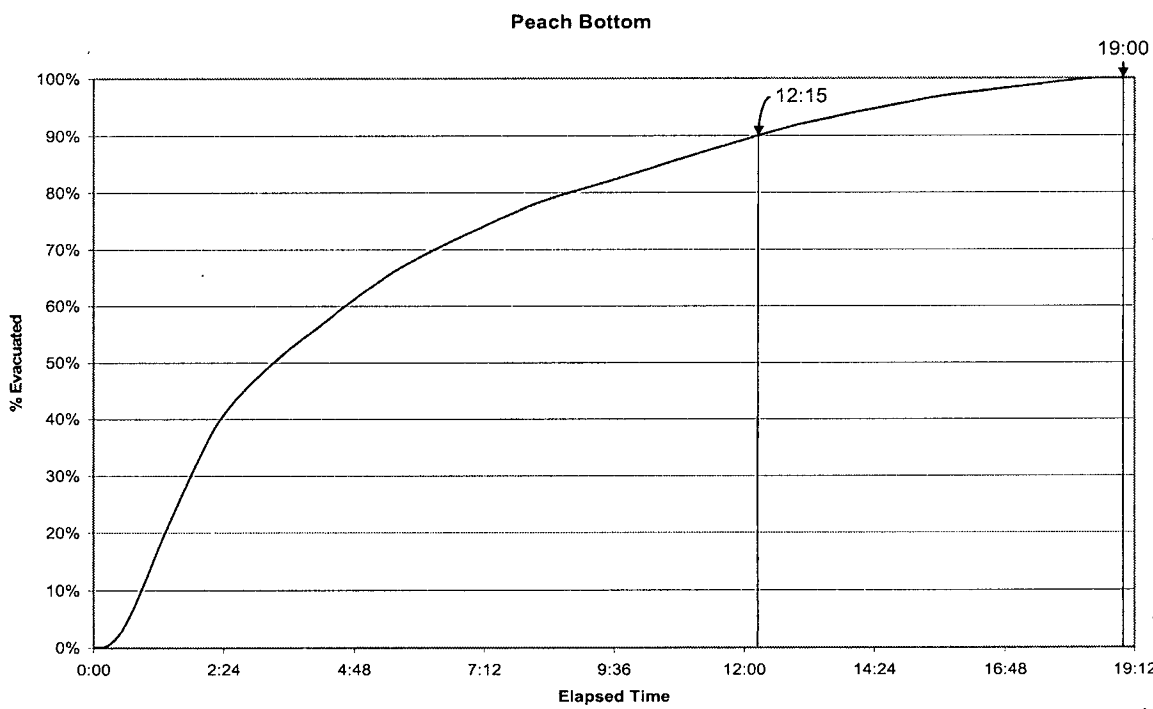
The OREMS model considers special conditions, which may be imposed during an emergency evacuation. For example, intersections that normally have pre-timed controllers are assumed to be manned by emergency personnel to facilitate traffic flow. This function is consistent with the emergency response actions that would be implemented during an evacuation. Detail for road networks was obtained from available mapping and was input into OREMS using the standard intersection functions available in the model. Judgment and experience were necessary in determining the number of nodes that are established for the model. OREMS can manage hundreds of nodes, but there is a point at which the addition of nodes and links provides little change in the total times. The nodal network established for this analysis would be considered a moderately populated network for this code.

For the Peach Bottom 10 to 20 mile ETE, 232,053 vehicles were loaded onto 118 nodes of a 442 node network. The network loading was distributed over a five hour period to account for the trip generation time. The following evacuation times were derived from the OREMS calculation as plotted in Figure 67:

- 100 percent evacuation: 19 hours;
- 90 percent evacuation: 12 hours and 15 minutes

very complex - loading
Fall out
H. ground shine
- shielding
factors

These times were used to derive the evacuation speeds input into the WinMACCS model. The evacuation modeling conducted for the Peach Bottom plant was developed consistent with the characteristics observed in prior evacuations conducted for non-nuclear incidents. As described earlier, the analysis includes the common phenomenon of evacuations in which travelers who depart the threat zone the earliest experience shorter delays because the routes have yet to become fully utilized during the emergency. Evacuees who depart during the middle part of the evacuation, when the greatest numbers of people are seeking to depart, generally experience the highest congestion and longer delay because the demand on the roadway network is at its greatest, exceeding the available capacity in many areas. Evacuees who depart the hazard zone later, ~~while potentially putting themselves at greater risk~~, enter the network as the demand nears, or goes below, the roadway capacity and they are also able to generally avoid the delays associated with the peak evacuation demand period. The ETE modeling indicates significant congestion occurs in the more populous areas in the north near Lancaster, Pennsylvania and in the south near Forest Hill, Bel Air, and Fallston, Maryland.



T=0 in this figure is declaration of GE? If so, ~80% have evacuated before plume leaves the plant.

Figure 67 Evacuation Timeline from Peach Bottom for the 10 to 20 Mile Region

WinMACCS provides considerable flexibility in the analysis of offsite protective actions. However, the initial accident scenarios were evaluated for protective actions within the EPZ. Expanding the protective actions to distances beyond the EPZ is not readily accommodated using the modeling approach selected for these analyses. Therefore, although OROs may request the 10 to 20 population shelter, this population group is treated within the modeling as performing normal activities throughout the emergency. The normal activity shielding factors are weighted averages of indoor and outdoor values based on being indoors 81 percent of the time and outdoors 19 percent of the time. The hotspot and normal relocation model within MACCS2 will move affected individuals out of the area if the dose criteria apply.

6.4.1 Sensitivity 1 for the STSBO without RCIC Blackstart Evacuation to 16 Miles

For Sensitivity 1, evacuation of a 16 mile area around the NPP is assessed. In addition, a shadow evacuation occurs from within the 16 to 20 mile area, and the remaining members of the public in the 16 to 20 mile area were assumed to shelter. Figure 68 identifies the cohort timing for Sensitivity 1 and the durations of protective actions for each cohort are shown in Figure 69.

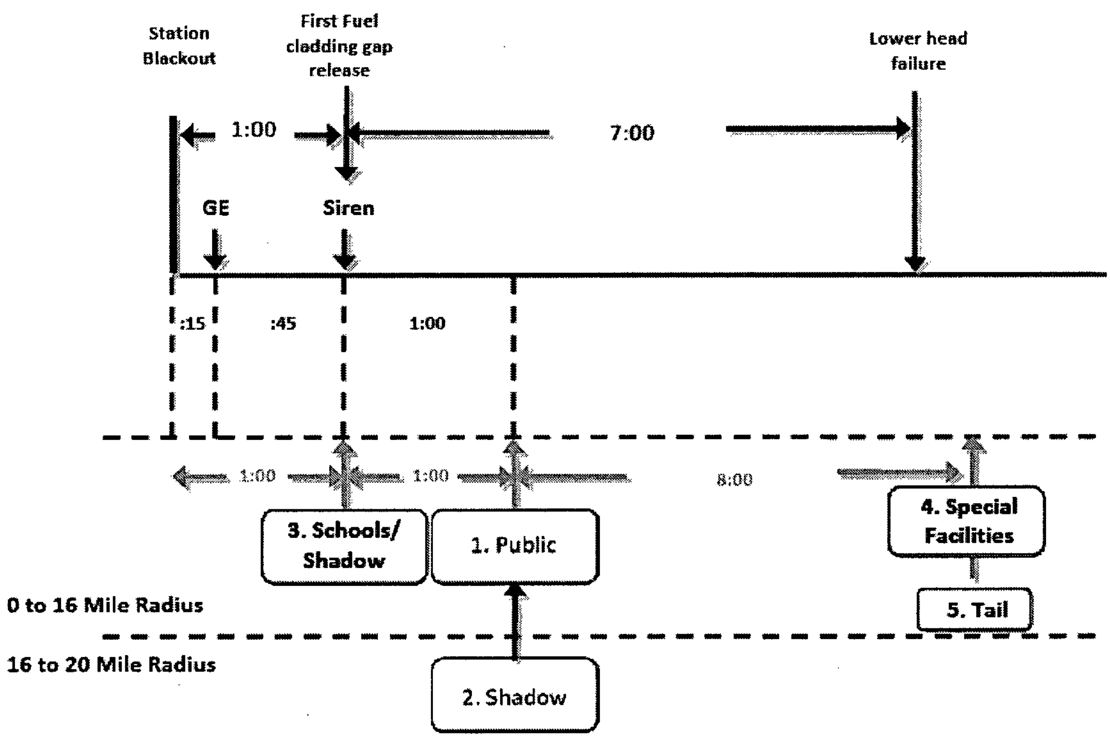


Figure 68 Sensitivity 1 STSBO without RCIC Blackstart - Evacuation to 16 Miles

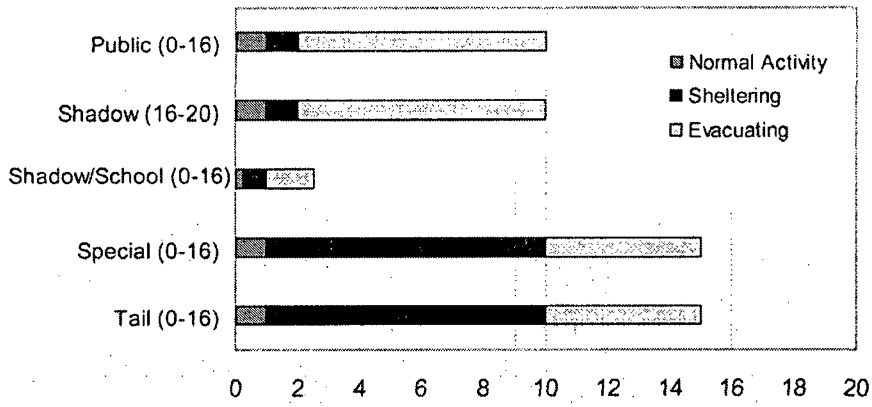


Figure 69 Duration of Protective Actions for Sensitivity 1 STSBO without RCIC Blackstart - Evacuation to 16 Miles

Cohort 1: 0 to 16 Schools and 0 to 16 Shadow. Following declaration of a GE, sirens are sounded and an EAS message is broadcast with to the affected areas within the EPZ. The public is assumed to shelter when the sirens sound, and the time to receive the warning and prepare to mobilize is assumed to be 1 hour. An assumption in this sensitivity analysis is the 16 to 20 public would be notified at the same time as the EPZ via EAS messaging and route alerting. The ETE for the public was estimated as a linear projection between the Surry 2000 ETE Study and the 10 to 20 mile ETE developed for the Sensitivity 2 analysis.

Cohort 2: 16 to 20 Shadow. This cohort is assumed to begin movement at the same time as the 0 to 16 Public after sirens have sounded within the EPZ and when widespread media broadcasts are underway. Residents in the 16 to 20 area begin seeing large numbers of people evacuating and initiate a shadow evacuation.

Cohort 3: 0 to 16 Schools and 0 to 16 Shadow. This cohort is the first to take action. Upon receipt of the declaration of GE by the site, PEMA would initiate evacuation of the schools in accordance with the emergency response plan. It is assumed schools begin sheltering in about 15 minutes, and begin evacuating 45 minutes after GE. The sounding of sirens in response to the GE provides warning and notification to all residents and transients within the EPZ that there is an incident, and EAS messaging will request that people monitor the situation for further information. It is assumed that these actions cause a shadow evacuation from within the 0 to 16 area.

Cohort 4: 0 to 16 Special Facilities. All Special Facilities are required to have evacuation plans, and in this scenario it is assumed the facilities within the 0 to 16 mile area would evacuate. Special Facilities can take longer to evacuate than the general public because transportation resources must be mobilized, some of which are very specialized; therefore, the Special Facilities cohort is assumed to depart at the same time as the evacuation tail.

Cohort 5: 0 to 16 Tail. A reasonable estimate of the departure for the evacuation tail is established as a linear projection between the Peach Bottom ETE and the OREMS 10 to 20 mile ETE developed for evacuation to a distance of 20 miles from the plant.

Cohort 6: Non-Evacuating Public. This cohort group represents a portion of the public within the 0 to 16 mile area who may refuse to evacuate and is assumed to be 0.5 percent of the population.

Table 15 identifies the cohort timing for Sensitivity 1.

Table 15 STSBO without RCIC Blackstart, Sensitivity 1

Cohort	Delay to Shelter DLTSHL (hr)	Delay to Evacuation DLTEVA (hr)	DURBEG (hr)	DURMID (hr)	ESPEED (early) mph	ESPEED (mid) mph
0 to 16 Public	1.00	1.00	0.25	7.75	5	2
16 to 20 Shadow	1.00	1.00	0.25	7.75	5	2
0 to 16 Schools/Shadow	0.25	0.75	1.00	0.50	20	20
0 to 16 Special Facilities	1.00	9.00	4.00	1.00	2	20
0 to 16 Tail	1.00	9.00	4.00	1.00	2	20
Non-Evac	0	0	0	0	0	0

6.4.2 Sensitivity 2 for the STSBO without RCIC Blackstart Evacuation to 20 Miles

For Sensitivity 2, evacuation of a 20 mile area around the NPP is assessed. There is no shadow evacuation of this area as all residents evacuate. Table 16 identifies the cohort timing for Sensitivity 2. The cohort timing and protective action durations are shown in Figure 70 and Figure 71 respectively for this sensitivity case.

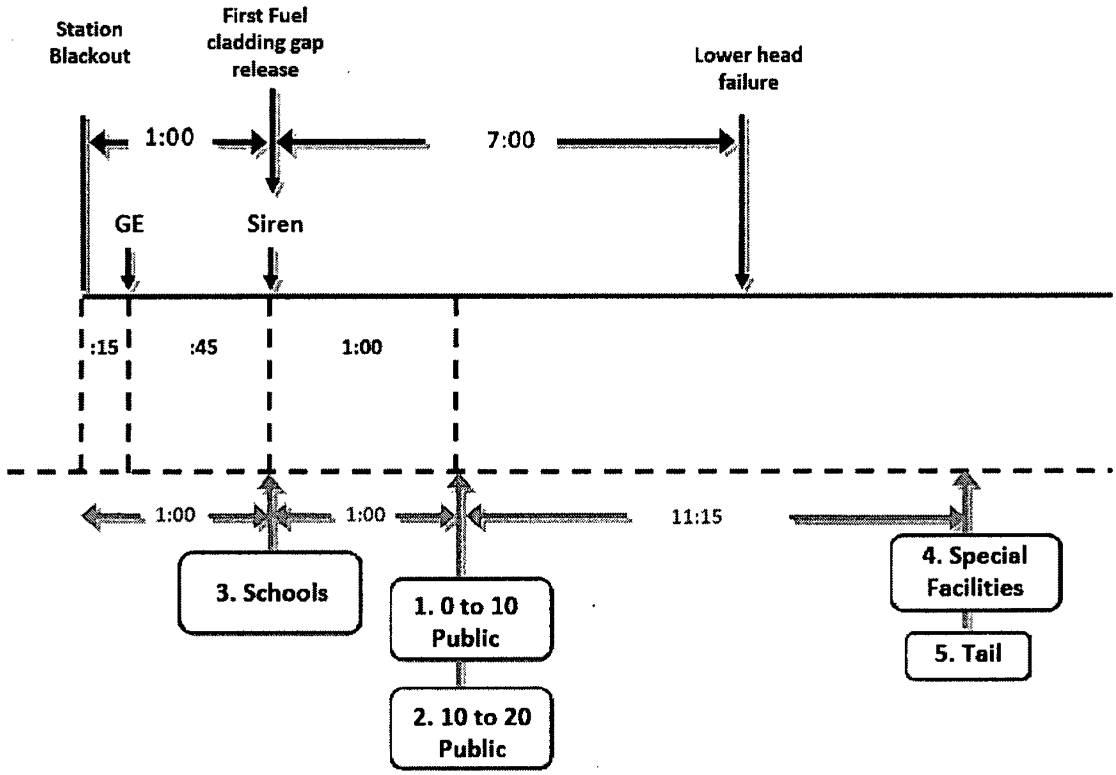


Figure 70 Sensitivity 2 STSBO without RCIC Blackstart - Evacuation to 20 Miles

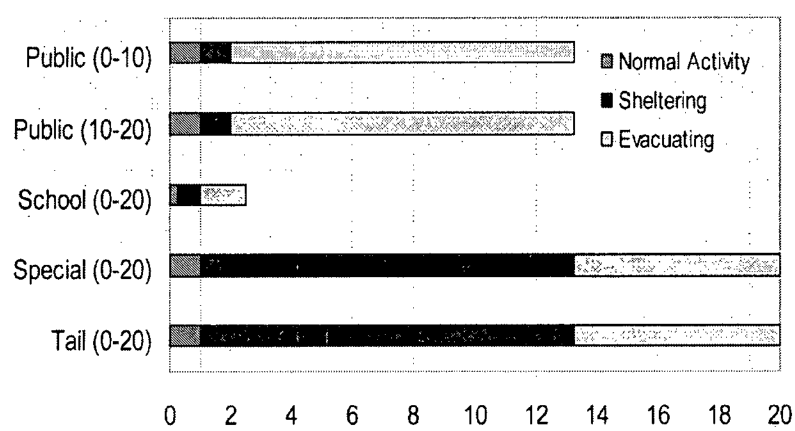


Figure 71 Duration of Protective Actions for Sensitivity 2 STSBO without RCIC Blackstart - Evacuation to 20 Miles

Cohort 1: 0 to 10 Public. Following declaration of a GE, sirens are sounded within the EPZ and an evacuation order would be issued for the EPZ. The time to receive the warning and prepare to mobilize is assumed to be 1 hour.

Cohort 2: 10 to 20 Public. Following declaration of a GE, sirens are sounded within the EPZ and an evacuation order would be issued for the EPZ. An assumption in this sensitivity analysis is the 10 to 20 public would be notified at the same time as the EPZ via EAS messaging and route alerting. The time to receive the warning and prepare to mobilize is still assumed to be 1 hour after the initial notification. The ETE for the 10 to 20 public was calculated using OREMS.

Cohort 3: 0 to 20 Schools. Upon receipt of the declaration of GE by the site, PEMA would notify the schools within the EPZ in accordance with the emergency response plan. For this sensitivity study, is assumed schools beyond the EPZ would decide, based upon media information that it is prudent to evacuate or close schools immediately.

Cohort 4: 0 to 20 Tail. The ETE for the evacuation tail was estimated based on the OREMS analysis. This cohort shelters upon hearing the sirens and begins evacuating 12 hours and 15 minutes later.

Cohort 5: 0 to 20 Special Facilities. For this sensitivity study, is assumed Special Facilities beyond the EPZ would decide, based upon media information that it is prudent to evacuate. Special Facilities can take longer to evacuate than the general public because transportation resources must be mobilized, some of which are very specialized; therefore, the Special Facilities cohort is assumed to depart at the same time as the evacuation tail.

Cohort 6: Non-Evacuating Public. This cohort group represents a portion of the public within the 0 to 20 mile area who may refuse to evacuate and is assumed to be 0.5 percent of the population.

Table 16 identifies the cohort timing for Sensitivity 2.

Table 16 STSBO without RCIC Blackstart, Sensitivity 2.

Cohort	Cohort#	Delay to Shelter DLTSHL (hr)	Delay to Evacuation DLTEVA (hr)	DURBEG (hr)	DURMID (hr)	ESPEED (early) mph	ESPEED (mid) mph
0 to 10 Public	1	1.00	1.00	0.25	11.00	5	1.8
10 to 20 Public	2	1.00	1.00	0.25	11.00	5	1.8
0 to 20 Schools	3	0.25	0.75	1.0	0.5	20	20
0 to 20 Special Facilities	4	1.00	12.25	5.75	1.00	1.8	20
0 to 20 Tail	5	1.00	12.25	5.75	1.00	1.8	20
Non-Evac	6	0	0	0	0	0	0

6.4.3 Sensitivity 3 for the STSBO without RCIC Blackstart with a Delay in Implementation of Protective Actions

There is a high level of confidence regarding the actions expected from control room operators in the event of accident scenarios identified for analysis in the SOARCA project. The initiating conditions provide clear indication to these operators and the response actions of the control room are prescribed. The Peer Review of the response timelines identified that a delay of the implementation of protective actions should be considered. Such a delay could be due to delay in control room declaration of an incident, delay in the decision process of OROs, or delay in communication to the public regarding implementation of protective actions. To address the potential for delay, an additional protective action timeline has been developed for the STSBO without RCIC Blackstart. This timeline reflects a delay in the implementation of protective actions by the public within the EPZ. Because protocols and procedures are in place, exercised and tested frequently, it is assumed that a delay of 30 minutes is adequate for this sensitivity study. The cohort timing and protective action durations are shown in Figure 72 and Figure 73 for this sensitivity case.

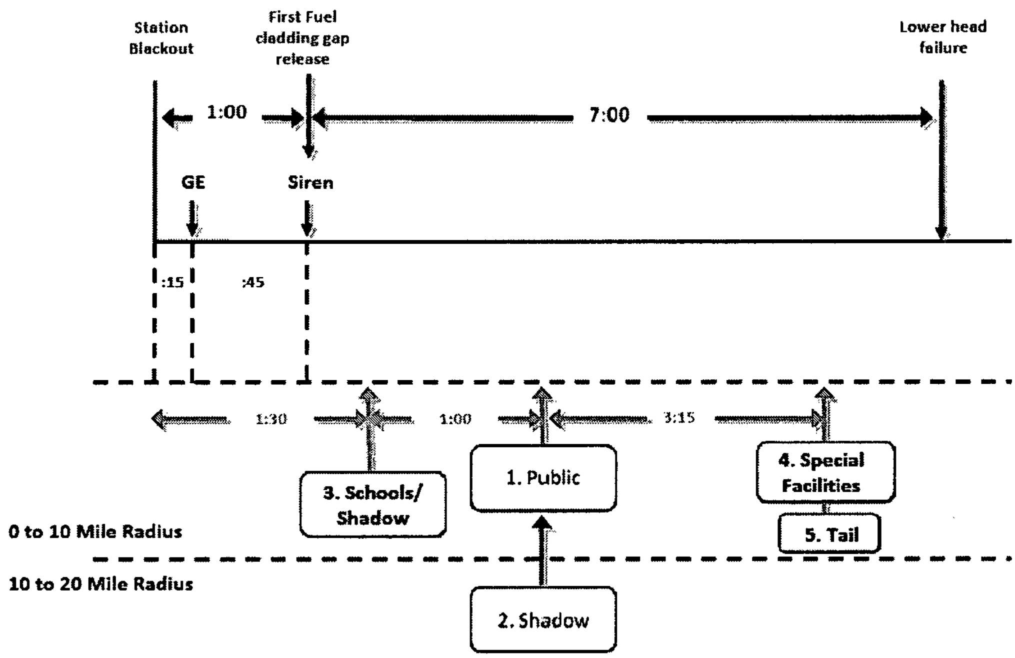


Figure 72 Sensitivity 3 STSBO without RCIC Blackstart - Delay in Implementation of Protective Actions

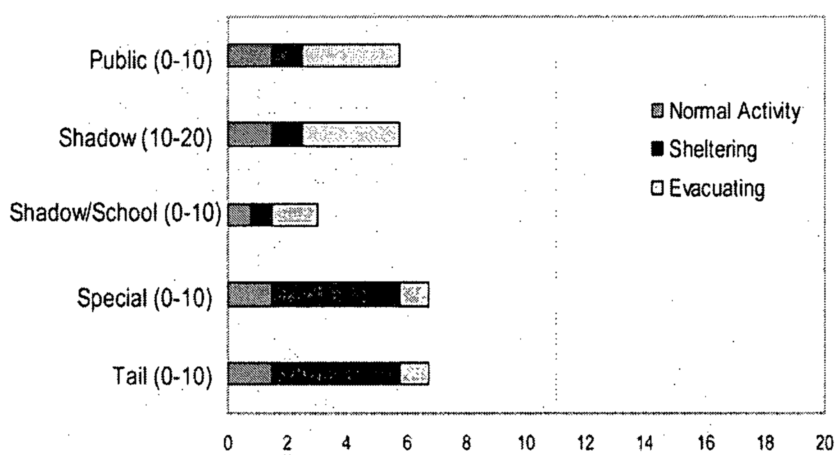


Figure 73 Protective Action Durations for Sensitivity 3 STSBO without RCIC Blackstart - Delay in Implementation of Protective Actions

The initiating event for the STSBO without RCIC Blackstart and a GE is declared based on EAL MG1. This sensitivity includes a delay of 30 minutes in the implementation of protective actions. This delay is reflected in the cohort descriptions below.

Cohort 1: 0 to 10 Public. Cohort 1 is assumed to shelter when the sirens sound and the initial EAS message is broadcast. The time to receive the warning and prepare to mobilize is assumed to be 1.5 hours after the receipt of the EAS message at which time this cohort begins to evacuate.

Cohort 2: 10 to 20 Shadow. This cohort is assumed to begin movement at the same time as the 0 to 10 Public after sirens have sounded within the EPZ and when widespread media broadcasts are underway.

Cohort 3: 0 to 10 Schools/Shadow. Upon receipt of the declaration of SAE by the site, PEMA would notify the schools in accordance with the emergency response plan. Buses would be mobilized, and it is assumed schools begin evacuating 1.5 hours after notification. The 0 to 10 Shadow is assumed to evacuate at the same time as the schools.

Cohort 4: 0 to 10 Special Facilities. The Special Facilities cohort is assumed to depart at the same time as the evacuation tail. Both of these start times were delayed an additional 30 minutes for this sensitivity study.

Cohort 5: 0 to 10 Tail. The Tail evacuates 3.25 hours after the public starts to evacuate.

Cohort 6: Non-evacuating public. This cohort group represents the portion of the public who may refuse to evacuate and is assumed to be 0.5 percent of the population.

The implementation of protective actions has been increased by 30 minutes to reflect a potential delay in providing instructions to the public regarding expectations and actions. This 30 minutes was added to the delay to shelter parameter. By allocating the delay at this point, all cohort actions move to the right on the timeline by 30 minutes and the sum of DLTEVA, DURBEG, and DURMID still equates to the ETE for the public and the tail. Table 17 identifies the cohort timing for Sensitivity 3.

Table 17 Cohort Timing for Sensitivity 3

Cohort	Delay to Shelter DLTSHL (hr)	Delay to Evacuation DLTEVA (hr)	DURBEG (hr)	DURMID (hr)	ESPEED (early) mph	ESPEED (mid) mph
0 to 10 Public	1.50	1.00	0.25	3.00	5	3
10 to 20 Shadow	1.50	1.00	0.25	3.00	5	3
0 to 10 Schools/Shadow	0.75	0.75	1.00	0.50	20	20
0 to 10 Special Facilities	1.50	4.25	0.50	0.50	3	20

0 to 10 Tail	1.50	4.25	0.50	0.50	3	20
Non-Evac	0	0	0	0	0	0

6.5 Analysis of Earthquake Impact

A seismic analysis was developed to assess the potential effects on local infrastructure, communications, and emergency response in the event of a large scale earthquake. The accident used in the earthquake analysis is the STSBO without RCIC Blackstart. Integrating the effects of the earthquake into the analysis required assessing the damage potential of the earthquake, identification of parameters that would be affected, and determining the new values for affected parameters.

The potential for an earthquake is largely identified by the occurrence of previous earthquakes in the region. Understanding of where earthquake faults exist in the eastern United States is not robust; whereas, in the west geological fault lines can be identified on the surface, faults in the east are usually buried below layers of soil and rock and are not identifiable making prediction of earthquake location and magnitude difficult. The earthquakes hypothesized in SOARCA are assumed to be close to the plant site, and it may be assumed that severe damage is generally localized. Housing stock would generally survive the earthquake, with some damage. The local electrical grid is assumed out of service due to the failure of lines, switch yard equipment, or other impacts. There is no back up power system for the sirens at Peach Bottom, and it is assumed offsite response organizations would perform route alerting to notify the population of the need to take protective actions. This is a routine and effective method of informing the public to implement protective actions [21]. Under these postulated conditions, the potential for such an earthquake to affect emergency response and public evacuation is considered.

I think the character of earthquakes in the east is very different from the west. The New Madrid earthquake rang church bells in Boston!

6.5.1 Soils Review

To approximate the extent of damage, an evaluation of the potential failure of infrastructure was conducted by NRC seismic experts to determine which, if any, roadways or bridges may fail under the postulated earthquake conditions. The assessment was performed using readily available information and professional judgment. Existing information on basic bedrock geology of the region was developed from reports and papers from the United States Geological Service (USGS), Pennsylvania Geological Survey, Maryland Geological Survey and FSAR for the Peach Bottom NPP. Generalized soils information was developed from Natural Resources Conservation Service (NRCS) soil survey information for York and Lancaster Counties, Pennsylvania. It is assumed for this analysis that the generalized soil characteristics are applicable to the entire region.

The NRCS reports break the soils into several distinct, descriptive units. The units of interest to the present evaluation are the Chester-Gleneig, Mt. Airy-Manor, Grenville, and Codorus soil groups. These are generally well-drained soils, with the Chester-Gleneig and Mt. Airy-Manor units (mostly residuum from saprolite) existing on the ridges and uplands and the Glenville and Codorus soils (mostly alluvium and colluvium) in the low regions and valley bottoms. Based on the engineering properties contained in the NRCS reports, the units described above would be either "potentially liquefiable" or "liquefiable" if the water content in the soils was sufficiently high.

Initial assumptions for the analysis include: (1) the general soil characteristics described above exist at all locations at the time of any large earthquake and the water table is sufficiently high that liquefaction/loss of strength would result; (2) liquefaction of soils beneath a roadway in flat topography would not result in any significant damage or otherwise compromise the evacuation route.

The region around Peach Bottom is generally flat to rolling topography with a relatively small number of streams and watercourses resulting in few bridges and overpasses. The general region of interest near the Peach Bottom site does not have a large number of locations where earthquake damage would render the evacuation routes non-functional. Information is not readily available on the specific engineered features of bridges and other infrastructure with which to make specific assessments on the likelihood of failure in a scenario earthquake. Therefore, it is assumed that: (1) all of the bridges across the Susquehanna River fail within 20 miles of the plant; and (2) the road across the Conowingo Dam would be unavailable.

6.5.2 Infrastructure Analysis

The seismic evaluation of the potential failure of roadway infrastructure identified 12 bridges and roadway segments that could fail under the postulated conditions.

The seismic event causes the loss of all onsite and offsite power. Offsite power affects many aspects of a potential response. Typically, sirens would sound following declaration of an SAE and GE, but without power and no backup power, sirens will not sound within the Peach Bottom EPZ. This has an effect on the initial alert and notification of the public. Loss of power limits the potential for residents to receive instructions via Emergency Alert System (EAS) messaging. Televisions, household radios, and some telephones will not operate, although battery operated radios and car radios will. It is expected that the public will utilize these means of communications as well as societal forms, such as neighbor to neighbor propagating the EAS message throughout the EPZ. The alert and notification will be supplemented by route alerting, which is a planned backup form of communication for the EPZ.

Table 18 provides a brief description of each area assumed to fail, and Figure 74 shows the transportation network and the locations of the affected roadway segments and bridges.

Table 18 Description of the Potential Evacuation Failure Locations

Location	Description
A	PA Highway 372 upstream of Susquehanna River. Two single span bridges along a single roadway segment.
B	PA 372 bridge across the Susquehanna River north of the plant. Two lane multi span bridge.
C	US 222 Robert Fulton Highway. Two lane bridge, single span.
D	PA 74 (Delta- bypass/Pylesville Rd) south of Holtwood Rd (PA#372). Single span 2 lane bridge.
E	MD 136 - Whiteford Road. Two lane segment along lakeside. Potential for slumping into lake.
F	US 1 (Conowingo Rd) east of Susquehanna River and US #222. Two lane bridge, single span.
G	US 1 across Conowingo Dam. Two lane road.

H	US 1 west of Susquehanna River, west of MD #136. Two lane road, single span bridge.
I	MD 136 south of US #1. Two lane road, single span bridge.
J	MD 222 Susquehanna River Road north of Main St. Two lane road runs along river edge. Potential for slumping into river.
K	I-95. Six lane multi span bridge.
L	US 40. Four lane multi span bridge across Susquehanna River.

The earthquake may cause structural damage in other areas of the EPZ. The structures within the EPZ are primarily light commercial and residential housing, both of which would largely be expected to stay intact. However, areas of larger commercial facilities, of which there are few within the EPZ, could sustain damage. The urban setting may also experience localized fires caused by ruptured gas lines as evidenced in earthquakes of this magnitude.

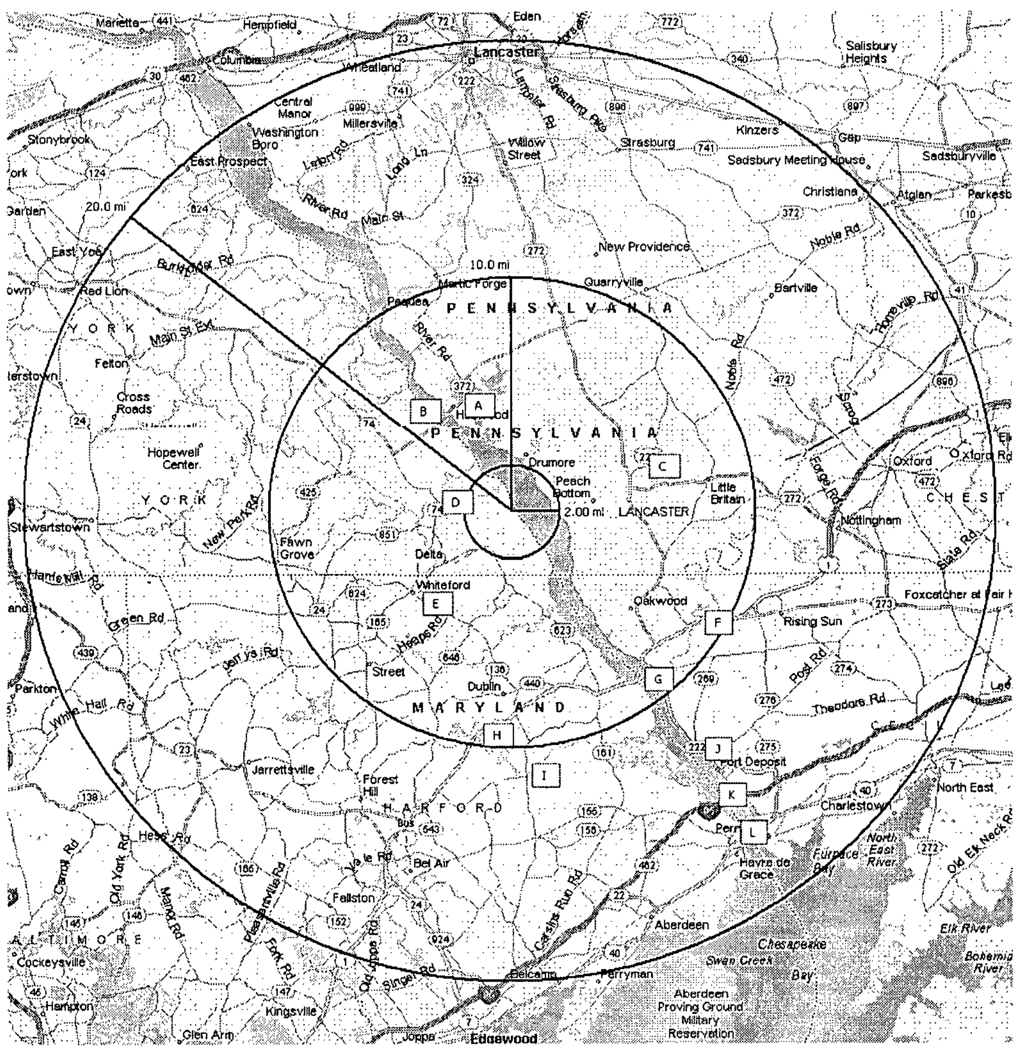


Figure 74 Roadway Network Identifying Potentially Affected Roadways and Bridges

Evacuations are planned and conducted to move the public radially away from the NPP. Evacuation routes are designated in emergency planning brochures, but all roadways within the EPZ serve the evacuees. Some of the bridges identified in the seismic analysis will have a negligible effect on the evacuation due to their location within the roadway network, while others may have a more pronounced effect.

The loss of bridges crossing the Susquehanna River does not affect the ETE. These bridges are represented as B, G, K and L on Figure 74. The EPZ evacuation routes identified in the emergency plan indicate that evacuees west of the river would generally evacuate in a westerly or southerly direction, and evacuees east of the river would evacuate in a northerly or easterly direction. The only bridge identified on a Peach Bottom evacuation route is US 1 across the Conowingo Dam. Although this road is on the evacuation route map, the evacuation routing indicates that travel west of the river would proceed westerly and travel east of the river would proceed easterly.

Bridges A, C and D, in Figure 74, serve sparsely populated areas and have additional roads available, supporting a conclusion that evacuation delay due to loss of these bridges is minimal. The two bridges with the greatest potential to affect the ETE are F and H. These bridges are located along the edge of the EPZ and serve a larger area of the EPZ. Bridge H serves the EPZ protective action sub areas of J and K in the southwest quadrant of the EPZ. However, there are many exit points out of the EPZ that serve these sub areas. The total population within J and K, as identified in the ETE report, is 12,390 which equates to 4,130 passenger cars using the factor applied in the ETE report. At this volume of traffic, only 800 cars per hour would need to exit the EPZ to stay within the 5 hour and 15 minute ETE. For one typical two lane roadway, a service volume of 1,700 passenger cars per hour may be achieved [33].

Bridge F on US 1 serves protective action sub areas H and I in the southeast quadrant of the EPZ. The total population within H and I, as identified in the ETE report, is 6,176 which equates to 2,059 passenger cars using the factor applied in the ETE report. The Susquehanna River Road (PA 222) and a few local roadways within sub area H could serve as alternate routes out of the EPZ and no appreciable delay would be expected from these sub areas.

Based on review of the ETE report, the EPZ sub areas affected by loss of bridges, and a detailed review of the roadway network, a conclusion can be made that loss of the identified bridges will not increase the total ETE. This is consistent with the Peach Bottom ETE report which identifies that sub areas A and B, located mostly in the northeast quadrant, control the evacuation time for the entire EPZ. Figure 75 shows an example of a bridge (US 222 Robert Fulton Highway) that could potentially fail under the earthquake conditions.

Figure 75 Bridge along Robert Fulton Highway

6.5.3 Electrical and Communications

The loss of power will cause traffic signals to default to a four way stop mode which is less efficient than signalization. Typically, emergency response personnel would respond to these intersections and direct traffic. A review of the roadway network within the EPZ indicates there are only a few traffic signals and most intersections are controlled with stop signs. Table 7-1, "Recommended Traffic Control Management Locations," in the ETE report identified 12 key locations for emergency management traffic control to expedite traffic out of the EPZ [32]. As indicated in the ETE report, these 12 locations are included in the county plans. It is assumed that the OROs will be able to provide the 12 staff needed to support the few locations where traffic signalization is not working; therefore, it is also concluded that the loss of signalization will not increase the total ETE.

The loss of power will affect traffic signalization within the entire affected area including areas beyond the EPZ. Typically, traffic signals default to red/red in a power outage requiring all directions to stop prior to entering an intersection. This effectively turns signalized intersections into four-way stop signs. Four-way stop, as an intersection control, is less effective signalization for moving large numbers of vehicles, particularly when traffic is present on multiple approaches [33]. The net effect within the Peach Bottom EPZ is minimal because there are very few signalized intersections within the area.

6.5.4 Emergency Response

The assumption on the event timing is a mid-week winter day in which the public is at work and children are at school. The primary shift of emergency responders would be on duty and immediately available at the time of the incident. There is an initial need to assess damage and respond to life threatening needs. These initial priorities for emergency response personnel may delay implementation of traffic control to support an evacuation. It is expected that route alerting would not be appreciably delayed because damage to infrastructure is not severe.

During large scale emergencies, OROs routinely supplement staff with on-call and off-duty personnel. Although communications are assumed to be initially limited, radios are available to contact the needed staff, and off-duty responders may be expected to report for duty during such emergencies. By the time an evacuation is ordered, it is expected that OROs would have been augmented with additional staff. Because damage to infrastructure is limited within the EPZ, it is assumed that response personnel are available to support traffic control for an evacuation.

→ quite soon after T=0! Given in Fig 76 of 16 min

6.5.4.1 Evacuation Time Estimate

The evacuation times can be influenced if bridges fail, traffic signalization does not operate effectively, and EAS messaging is not disseminated in a timely manner to inform evacuees of protective actions and preferred evacuation routes. Although there are a number of factors that can increase evacuation time, the effect on the ETE is expected to be limited because early in the event, emergency response personnel will conduct route alerting and establish traffic control.

Do you really expect augmentation?

The roadway network beyond the EPZ was also evaluated to determine if loss of infrastructure might delay evacuees traveling through this area. The seismic analysis suggests that the six lane I-95 bridge and the four lane US-40 bridge, both of which cross the Susquehanna River, could fail or be unavailable for use. Additionally, a two lane single span bridge on MD 136 and a portion of roadway along MD 222 are assumed to fail. These are represented as I, J, K and L in Figure 74. Clearly the loss of infrastructure, especially an Interstate bridge, is a problem and may potentially injure travelers; however, whether the loss of infrastructure affects the evacuation time is dependent more on the location of the facilities and the evacuating public that may be expected to use these routes.

An important consideration is that no large scale evacuation is expected for the 10 to 20 mile area. Therefore, the roadways are assumed to be substantially available to serve the evacuating public from the EPZ. Secondly, all of the bridges and the roadway section that are assumed to fail are located in the southern section of the 10 to 20 mile area beyond the EPZ. This area has a smaller population than the corresponding area to the north. OREMS was used to develop the ETE for the 10 to 20 mile area and results of the analysis demonstrated that longer evacuation times occurred in the northern section due to congestion experienced near Lancaster, Pennsylvania.

Travel along MD 136 is easily diverted to multiple alternative roadways in the event the single span bridge fails (Bridge I). MD 222 is the alternate roadway that would be used if the bridge along US 1 fails (Bridge F). However, MD 222 can still serve the evacuation and there are access roads which are readily available to travel around the section of the river road that may potentially slump off.

The loss of the two bridges (Bridge K and Bridge L) crossing the Susquehanna River should also not affect the ETE. There are interchanges on both sides of the river for both roadways, which would facilitate immediate diversion of traffic away from the bridges. This traffic control would be established very early as a safety need and would be in place well before evacuating traffic approaches the area.

The ETE is used to develop the speeds for the evacuating public. The following ETEs provided for Peach Bottom were used for the baseline analyses.

- 100 percent evacuation: 5 hours and 15 minutes; and
- 90 percent evacuation: 4 hours and 15 minutes.

These evacuation times were developed without consideration of impediments that might be experienced in an earthquake. For the seismic analysis, it is assumed that because this is a severe earthquake, the 0 to 10 shadow evacuation is increased to 30 percent of the population. This effectively removes 30 percent of the total vehicles from the roadway network, which significantly reduces potential for traffic congestion. The wide availability of roadway infrastructure at these distances from the plant provides ample access for evacuees leaving the EPZ and should not appreciably effect evacuation times.

6.5.5 Development of WinMACCS parameters

WinMACCS is the consequence analysis tool. WinMACCS accounts for the movement of different population groups and accommodates the speed and direction of the evacuating cohorts. Traffic movement was approximated in each grid element by assigning a direction and speed for the vehicles within the grid. To account for the potential loss of bridges and roadway sections, the routing patterns in the WinMACCS model were adjusted to divert traffic around the locations identified.

6.5.5.1 Relocation Outside the Evacuation Area

In the event of a significant release, the population in the region outside the evacuation area would be moved if their potential dose exceeds protective criteria based on field measurements. The MACCS2 code uses the hotspot and normal relocation, which is a dose based rather than distance based protective action. The values used in the earthquake analysis are the same as those used in the baseline analysis.

For hotspot relocation, individuals beyond twenty miles are relocated 12 hours after plume arrival if the total lifetime dose commitment for the weeklong emergency phase exceeds 0.05 Sv (5 rem). For the normal relocation, individuals are relocated 24 hours after plume arrival if the total lifetime dose commitment exceeds 0.005 Sv (0.5 rem). Review of the accident sequence timelines suggest that OROs would not be available for about 12 hours to assist with relocation due to higher priority tasks in the evacuation area.

6.5.5.2 Shielding Factors

Shielding factors are the same as those used in the baseline analyses. It may be expected that the damage to structures caused by an earthquake of this magnitude would include broken windows and some structural damage. Additionally, earthquakes frequently cause residents to go outside until they are more certain of the extent of structural damage that may have occurred. These factors would reduce the shielding capacity; however, because of the limited time residents within the seismic area are assumed to shelter, no adjustments in the modeling were made.

6.5.6 STSBO without RCIC Blackstart

The timing of emergency classification declarations for the STSBO without RCIC Blackstart was based on the emergency action levels contained in site emergency plan implementing procedures. The timing of emergency classification declaration for the STSBO without RCIC Blackstart was based on Table PBAPS 3-1 Emergency Action Level (EAL) Matrix contained in site emergency plan implementing procedures. The emergency classification timing was reviewed with the licensee for accuracy and this scenario is an immediate GE. With loss of offsite power and loss of DC power, operators cannot determine whether water level is above TAF, and a GE is declared based on EAL MG1. The emergency response timeline for the STSBO without RCIC Blackstart scenario is shown in Figure 76. The duration of specific protective actions for each cohort are shown in Figure 77. Core damage, as evidenced by the first fuel cladding gap release, is calculated at 1 hour into the event, with a significant radioactive release from containment beginning 8 hours into the event as indicated by the lower head failure.

fix out centering

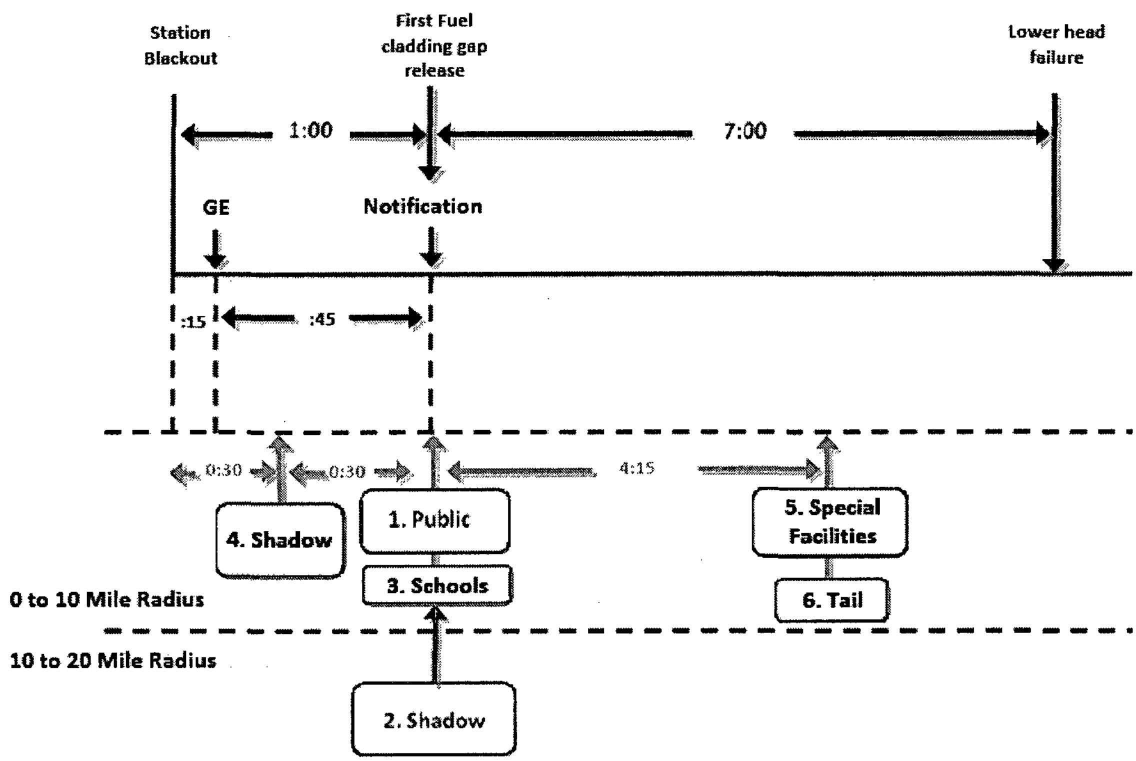


Figure 76 STSBO without RCIC Blackstart Emergency Response Timeline (Seismic Analysis)

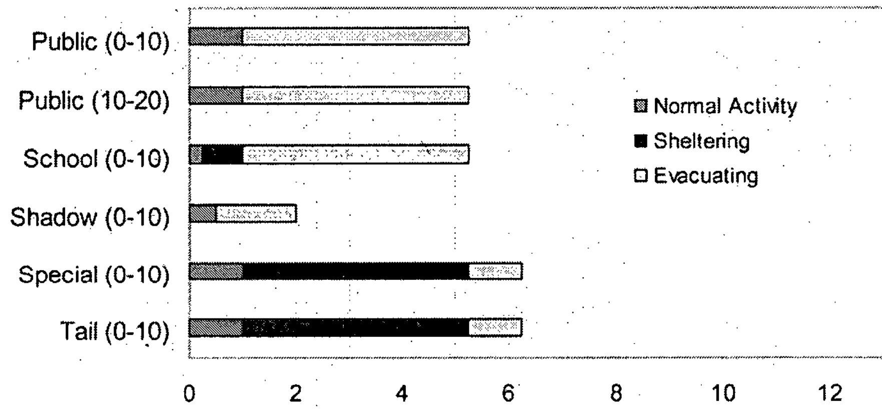


Figure 77 Protective Action Durations for STSBO without RCIC Blackstart (Seismic Analysis)

The timeline identifies points at which cohorts would receive instruction from OROs to implement protective actions. Cohorts would then implement the protective actions. Discussions were held with ORO and site representatives to help ensure proper understanding of emergency response practices. While protective actions within the EPZ can be modeled in accordance with procedures, assumptions were made that reasonably approximate those actions that could be taken due to the effects of the earthquake; however, the actual decisions made by OROs could differ. The evacuation is assumed to include the full EPZ which is consistent with emergency planning in Pennsylvania.

It is assumed the large earthquake will be felt by everyone within the EPZ instilling a heightened preparedness. It is assumed the public is ready to respond to protective actions once they receive information, and some individuals will begin to prepare for an evacuation prior to receiving official notice.

Cohort 1: 0 to 10 Public. The 0 to 10 Public is assumed to begin evacuating upon receipt of notification which is provided primarily via route alerting. It is assumed that the effects of the earthquake are severe such that members of the public, knowing they live within an EPZ, begin preparations for evacuation shortly after the earthquake and are ready to leave when sirens sound.

Cohort 2: 10 to 20 Shadow. This cohort is assumed to begin movement at the same time as the 0 to 10 Public after when widespread media broadcasts, beyond the EPZ, are underway. It is assumed that the shadow population increases to 30 percent of the public in the area beyond the EPZ.

Cohort 3: 0 to 10 Schools. Although communication systems may have been impacted, after receipt of the GE declaration, it is assumed that PEMA notifies the schools promptly. Having felt the earthquake, it is also assumed schools take the initiative to prepare to evacuate as they would for an emergency. Buses would be mobilized, and it is assumed schools begin evacuating about 1 hour after the start of the incident. The limited effect on infrastructure within the EPZ is

does not square with Fig 77 above or with Table 19 below not expected to appreciably delay bus mobilization. It is also assumed that given the magnitude of the earthquake, parents in the vicinity of the schools will pick up their children, reducing the need for a full compliment of buses.

Cohort 4: 0 to 10 Special Facilities. The Special Facilities cohort is assumed to depart at the same time as the evacuation tail. Special Facilities need to have transportation resources mobilized, some of which are very specialized. Inbound lanes on roadways will be useable for emergency support vehicles, but localized congestion will delay the arrival of specialized vehicles. Special Facilities are assumed to leave at the same time as the evacuation tail; however, as discussed earlier, this is a simplification of the analysis because Special Facilities would realistically evacuate individually as resources are available.

Cohort 5: 0 to 10 Tail. The Tail takes longer to evacuate for many valid reasons such as the need to return home from work to evacuate with the family; the need to shut down farming or manufacturing operations prior to evacuating; and for the earthquake, the need to move rubble or other items prior to evacuating.

Cohort 6: Non-evacuating public. This cohort group represents the portion of the 0 to 10 public that may refuse to evacuate and is assumed to be 0.5 percent of the population.

Table 19 provides a summary of the evacuation timing for each cohort. The values in the table represent the minimum evacuation speeds corresponding to the area north of the site. In general, the cohorts in the seismic study have faster mobilization times and for Peach Bottom have the same evacuation speeds. The delay to shelter represents a delay before people get to the shelter, and delay to evacuation represents the length of the sheltering period prior to evacuation. These delays correspond to the different shielding factors that were applied to each cohort during these timeframes. The speeds and durations in this table represent constant movement speeds for the cohorts. These values are adjusted within each grid element of the WinMACCS model.

Table 19 Cohort Timing STSBO without RCIC Blackstart

Cohort	Delay to Shelter DLTSHL (hr)	Delay to Evacuation DLTEVA (hr)	DURBEG (hr)	DURMID (hr)	ESPEED (early) mph	ESPEED (mid) mph
0 to 10 Public	1.00	0.00	0.25	4.00	5	3
10 to 20 Shadow	1.00	0.00	0.25	4.00	5	3
0 to 10 Schools	0.25	0.75	0.25	4.00	5	3
0 to 10 Shadow	0.50	0.00	1.00	0.50	20	20
0 to 10 Special Facilities	1.00	4.25	0.50	0.50	3	20
0 to 10 Tail	1.00	4.25	0.50	0.50	3	20
Non-evac	0	0	0	0	0	0

Some where need to mention that the population was assumed to evacuate to 30 miles for dose purposes

6.6 Accident Response and Mitigation of Source Terms

The SOARCA analyses ~~which~~ that reflected best-estimate thermal hydraulics and accident progression parameters, showed no offsite radiological consequences because all scenarios are mitigated ~~by licensees~~ through the use of safety and security enhancements, including SAMGs ~~and 10 CFR~~ 50.54(hh) mitigation measures. Analyses were conducted of the consequences that may result if the onsite emergency response organization (ERO) ~~takes no~~ mitigative action other than to notify offsite authorities. ~~The staff does not believe the unmitigated scenario is realistic, because there is no foreseen reason that the licensee would not implement mitigative measures. Furthermore, the assumption of no mitigative response does not comport with the realistic assumptions that have been used elsewhere in SOARCA.~~ However, staff did not perform a human reliability assessment or a detailed seismic damage assessment for implementation of mitigative measures. The staff believed it appropriate to perform the ~~sensitivity~~ analysis to further understanding of core melt sequences, source term evolution and offsite response dynamics. Perhaps the most important objective of the ~~sensitivity~~ analyses is to quantify the benefit of mitigation enhancements. ~~To further support the expectation of mitigative response, a detailed discussion of the expansive resources available to support a national incident is provided below.~~ were not successful w/R

This analysis describes the likely national response to a severe nuclear plant accident and provides a basis for truncating the release ~~no later than~~ 48 hours after the accident begins. The discussion presents a timeline for bringing resources onto the Peach Bottom site in order to flood the reactor building to a level above a hypothetically melted core. Specific options are discussed but there could be a number of additional efforts led by multiple organizations ~~should it be~~ could necessary. While the staff believes it ~~is most likely~~ that plant personnel ~~would~~ mitigate the accident before core melt, if efforts were unsuccessful, the national level response ~~would~~ could mitigate the source term.

The NRC has onsite inspectors that are available to provide first hand knowledge of accident conditions. Concurrently, the NRC region office, would send a full Site Team to the licensee's EOF to support the response. A Site Team would include reactor safety experts and protective measures experts to review actions taken to mitigate the accident and to review protective action decisions that will be recommended to the public to assure the most appropriate actions are taken. Although a Site Team would arrive after protective actions within the EPZ have been initiated, the Site Team would be available to support decisions on mitigation measures.

Peach Bottom is part of the Exelon fleet which includes a remote EOF that would be activated and has access to fleet wide emergency response personnel and equipment, including equipment from sister plants following 10 CFR 50.54(hh) reactor security requirements to mitigate the effects of large fires and explosions. Significant resources would be made available to the site to mitigate the accident. In addition to those directly involved in the incident and those agencies that fully test and exercise response plans, the Institute for Nuclear Power Operations and the Nuclear Energy Institute would activate their emergency response centers to assist the site. These efforts would provide knowledgeable personnel and an extensive array of equipment would be available and as such are considered in the decision to truncate the release at 48 hours.

The National Response Framework (NRF) establishes a coordinated response of national assets. Under established agreement, the DHS would be the coordinating agency and NRC would be the primary cooperating agency for an event in which a General Emergency is declared. Some of the other agencies cooperating in an incident include EPA, FEMA, HHS, and any other Federal agency that may be needed. The assets of the Department of Energy (DOE) would be activated and brought to bear on the accident. Every licensee participates with many of these organizations in a full onsite and offsite exercise biennially. The NRC has a extensive well trained and exercised emergency response capability that would support, and, under unusual circumstances, direct licensee efforts. Communications systems require battery backup in accordance with 10 CFR 50.54 Appendix E, and multiple communication bridge lines would be established to facilitate structured communication among the various response teams. Satellite phones, cell phones, radios, and other means are available for those instances where communications have been affected.

Offsite mitigation strategies are different from onsite mitigation strategies as indicated in Table 20. An onsite mitigation strategy is specific for the accident scenario, has only onsite resources, and has a limited amount of time to prevent core melt and radiological release. For the unmitigated cases, the SOARCA project assumes onsite mitigative efforts are not effective and that a radiological release occurs. Offsite mitigation strategies would bring national resources to the site but take more time than onsite measures. The mitigation strategy considered in this evaluation is to fill the containment building with water and cover core debris in order to cool the core and scrub the radiological release.

Table 20 Mitigation Strategies

	Onsite Mitigation	Offsite Mitigation
Objective	Prevent release	Stop release
Strategy	Specific to accident	Cover molten core
Time	Less	More
Equipment Available	Onsite	Onsite & portable offsite

6.6.1 External Resources

The primary focus of the site and utility ERO would be mitigating core damage, and State and local resources would focus on the public evacuation. However, it is typical, as demonstrated in drills and exercises, for EROs develop contingency plans in case initial onsite mitigative actions are not successful. The NRC ERO would focus on protection of the public and methods to reduce consequences reviewing the licensee and ORO information, actions, and decisions while performing independent analyses. If the site ERO is not successful with the onsite mitigative actions~~, as the sensitivity study assumes~~, various EROs would be considering in parallel the availability of portable power and pumping capacity from offsite locations. Portable generators of various sizes are available from dozens of providers within 100 miles of the site. Large portable generators could be ordered and brought into the site within the first 10 hours.

The initiating event for the reactor accident is a moderate strength earthquake in ~~close~~ proximity to the plant. This event causes significant ground motion and damage to certain types of structures, and long span bridges may not be passable. Smaller bridges, culverts and most housing stock would likely survive the event. Two long span bridges south of the Peach Bottom site cross the Susquehanna River. These two bridges are the 6 lane I-95 and 4 lane U.S. 40. Loss of these bridges would not affect delivery of equipment because there are equipment suppliers on both sides of the river. Roads would likely not be compromised due to the quake, but could be blocked by rock slides where that is possible. Approaches to the plant along the river valley could be blocked.

As indicated, it is expected that the roads would be passable; however, there is heavy airlift capacity in the region if needed. The Pennsylvania State National Guard air wing in Ft. Indiantown Gap, Pennsylvania is less than 100 miles from the site. The air wing flies 25 helicopters (Chinook-47), each rated to lift about 26,000 pounds. Trailer mounted 600 kW generators weigh about 22,000 pounds, and may be the largest generators that can be airlifted to the site in a timely manner. The air wing Public Information Officer confirmed there has are typically 5 to 25 operational helicopters available. If this air wing were not available, there are others in the Mid-Atlantic region. Given national response to a General Emergency, heavy lift helicopters would be made available if requested within about 12 hours. A source of electrical generators would already have been located and arrangements made for obtaining one or more. It is estimated that the largest generator(s) could be airlifted onsite and be operational within about 20 hours. If smaller generators were useful, they would be more readily available. All times discussed above are from start of accident.

6.6.2 Mitigation Strategies

Team members of the site ERO, utility ERO and NRC ERO are responsible for identifying methods to maintain core cooling and would focus on injecting water into the vessel. After this event the most likely mitigative measure is filling the reactor building with water above the molten core. This action would provide a scrubbing of the source term and would reduce any further release. Covering the core debris on the drywell floor would truncate the fission product aerosol release to the environment, because the overlying water would cool the debris and scrub any fission product releases from the debris. Although a fraction of the degraded core may remain in-vessel, this is unlikely to lead to substantive offsite releases to the environment for the following reasons:

- Potential injection paths for containment flooding include core spray and drywell spray. Use of either of these paths would provide water spray to cool any core debris remaining in-vessel and scrub any release of radioactive aerosols from that debris.
- Core debris remaining in-vessel may be too cold to release fission product aerosols, because it did not heat up and relocate down into the RPV lower plenum.

Any release from core debris remaining in-vessel would have to go through the hole in the drywell liner at the bottom edge of the vent pipe and would be scrubbed by the water covering the hole. Although the drywell head may have lifted as a result of containment pressurization during the time period between RPV failure and liner melt-through, it is expected to reseat after lifting because the head bolt material is in the elastic range.

After the release begins, the site would be contaminated and working conditions are more difficult. However, the plant staff is trained in radiological work and are supported by a full staff of health physics technicians. Staff from Exelon fleet plants could be at the site beginning very early with technical experts responding as needed. Nuclear power plant expertise would be available and obtained from neighboring plants in the event that such resources were needed.

The two core spray systems at Peach Bottom each have the capacity to inject 3000 gpm into the vessel. If a water source can be found these pumps are ideal for injection into containment. The analysis assumes that condensate storage tanks fail due to the earthquake. However, the site ERO would have accomplished a survey of plant damage to identify any of the many tanks that have some capacity to hold water. One of these could be aligned to the core spray suction with make up to the tank coming from the river. Even if the dam fails, there is an impound structure at Peach Bottom and the river would still have water in it. Fire trucks could be used to lift water from the river to the impound structure to provide a source for the pumps.

Additional pumping capacity to move river water to the site could be performed by fire trucks. Based on the proximity of these resources, these vehicles could traverse potentially affected roadways and be on site within a few hours and would begin operations within 6 hours. If roads are not passable, transportation is more difficult and the use of helicopters would be necessary. The ERO would work with the state ERO to identify local resources and pumping capacity that could be airlifted onto the site in approximately the same 20 hours assumed for electrical generation equipment. The smallest fire trucks have a capacity of 400 gpm but large portable pumps are available from various suppliers in the region. It may necessary to bring several pumps to the site to feed core spray pumps at capacity. Another avenue for water pumping capacity is the diesel driven site fire system pump which can take suction from various water sources. The site ERO would have been working on using this pump to inject water soon after power was lost.

The site ERO, supported by utility ERO and NRC ERO, would be considering other measures in case core spray proved to be unavailable. These personnel know the plant well and may identify innovative solutions. Use of the containment vent was considered in this analysis. The vent exits the reactor building and has shielded manual isolation valves. This system could be cut open and quickly modified by the site staff of experienced machinists and welders to accept fire truck hose or other pump connections. This may affect pumping capacity dependant on the manner of ganging portable pumps and the fire system diesel driven pump. The size of the line is 16 inches and would not limit capacity; however, the structural supports for containment venting pipe are not structurally designed for piping filled with water. The ERO would work these efforts in parallel and could be ready for operation in about the same 12 hours as other methods. while doing other stuff?.

Really ?

So the line would be cut and rewelded with some sort of fixture to accept fire truck hose (which would already be on site) and figured out how to pump in water.

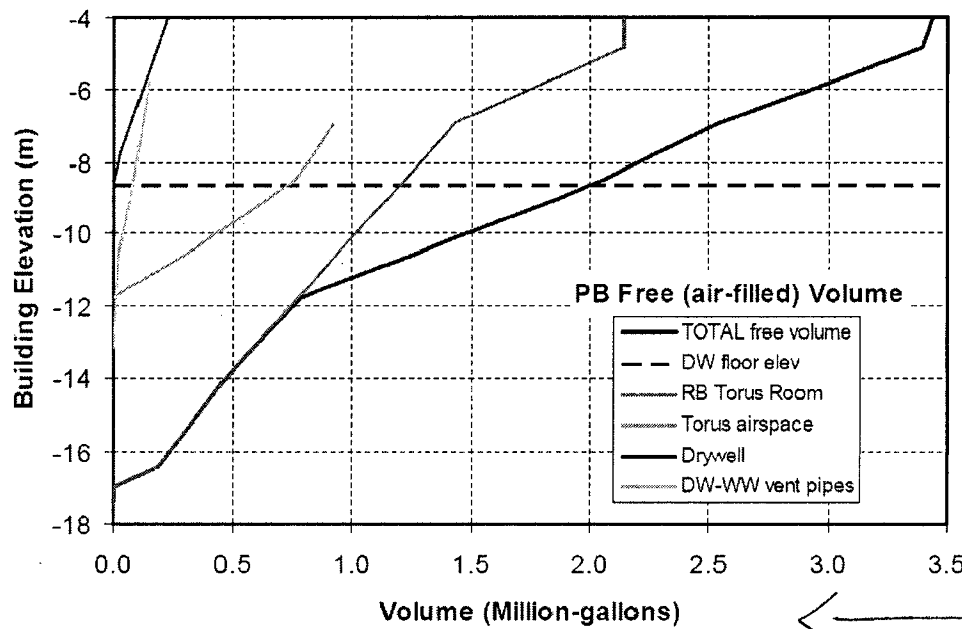
As indicated in Figure 78, about 2,200,000 gallons would be necessary to fill the building sufficiently to cover the molten core in the Peach Bottom reactor building shown in Figure 9

I would not want to rely on doing the correct thing in limited time!

fattening the structural supports - in 12 hours

Is the procedure already thought out?

(page 30). Based on the Peach Bottom pumping capacity curve shown in Figure 79



approximately 12 hours would be required to supply this volume of water at 3000 gpm. Based on these data, it is estimated that recovery operations could start within about 12 hours. This is before the radiological release would begin for the unmitigated LTSBO where core damage starts at 10 hours. However, this contingency is analyzed as though core melt and vessel failure occur. If pumping capacity is 3000 gpm the core would be under about a meter of water at T = 24 hours. If core spray is used, the radiological release from the molten core would be additionally scrubbed by the water even before the reactor building is flooded; however, noble gas would be released in this scenario.

Figure 78 Volume Needed to Fill the Peach Bottom Reactor Building

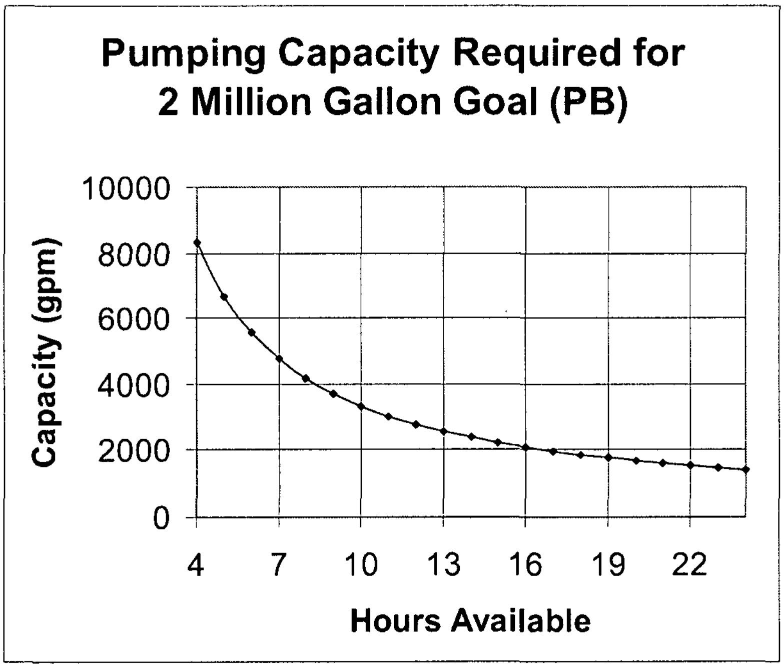


Figure 79 Peach Bottom Pumping Capacity and Time

6.6.3 Truncation Summary

The ~~NRC believes the~~ SOARCA analyses have shown that successful onsite mitigative actions would prevent core damage. This analysis is not definitive. Some of the actions identified are described within emergency response plans and some are ad hoc. The availability of the equipment is likely but not certain. If core damage is not prevented ~~from~~ the onsite mitigative measures, the building could be flooded by about T = 20 hours or longer if reaction times are slower. If this assessment is doubled, it would provide a bound for the length of time it would take to cover the molten core and mitigate the release. This estimate aligns approximately with truncating the release about 24 hours (T = ~44) after the release begins providing a basis for truncation of major radiological releases. Based on the approach provided, which considers in detail the timing of many activities underway during an event, provides a reasonable basis to bound the truncation of the accidents at 48 hours.

As noted below, the authors of NUREG-1150 came to a similar conclusion as indicated on pages E-25 and E-26 [11]:

> "Comment: A time cutoff of 24 hours after the onset of core degradation for the release of radionuclides was used throughout NUREG-1150, although no mention of this fact is contained in the report."

> "Response: A time cutoff of 24 hours after the onset of core degradation was only used when considering the issue of late revolatilization from the reactor coolant system. Some of the members of the source term expert panel were concerned that the majority of the releases were going to occur extremely late in the accident (much later than 24 hours

after the beginning of core damage). The project staff instructed the panel to consider later releases only up to 24 hours after core degradation. The reason for this was that some operator action to cool the reactor coolant system would be expected by that time (e.g., using external cooling by the containment sprays). The time cutoff was not an issue for the other source term processes that were considered because the majority of radionuclides were released well before 24 hours.

6.7 Emergency Preparedness Summary and Conclusions

Advancements in consequence modeling provide an opportunity to integrate realism in the implementation of protective action decisions applied for discrete population segments. To best utilize these advancements, detailed information was developed from area information and obtained from offsite response officials (OROs). Through a user interface added to the model, this detailed information was input to reflect differences in the implementation of protective actions by various population segments. These advancements ~~are significant because they now~~ allow the modeling of response activities, timing of decisions, and implementation of protective actions across different population segments.

the advancements are not really significant The Sandia Siting Study evacuation model is only a 10-20% effort compared with these wonderful advances!

Licensees develop ETEs to support emergency planning and help assure the most appropriate protective actions are implemented in an emergency. These ETEs provide detailed information regarding the evacuation of the general public, schools, special facilities and the evacuation tail. The improvements to consequence modeling and improved understanding of implementation of protective actions now allows use of this detailed information when modeling potential consequences of reactor accidents. For the first time, consequence modeling can represent the actions of OROs and the timing of public response to an emergency with a defensible basis provided for the timing of these actions.

In this analysis, 6 cohorts were modeled for each of the accident scenarios and a seventh cohort was added for the seismic analysis. Protective action factors were applied to each specific cohort.

- For the general public, shielding factors appropriate for the region were applied during normal, sheltering, and evacuation times and speeds were derived from the Peach Bottom ETE.
- Schools are notified directly in accordance with offsite emergency response plans and buses are mobilized to support expedited evacuation of schoolchildren. Mobilizing school resources early allows the evacuation of schools to occur first, prior to roadways becoming congested from evacuation of the general public. Therefore, the speed of the school cohort was established based on relatively little traffic on the roadways at the time.
- Special facilities are also notified early, but respond quite differently than schools. Transportation resources for special facilities are quite specialized, can be limited, and typically take extra time to mobilize. Evacuation of these facilities starts later than schools and continues longer than the evacuation of the general public. This is because transportation resources take longer to mobilize and make return trips to evacuate each facility independently. A benefit of special facilities is the robust nature of the structures of these nursing homes, hospitals, etc. The shielding protection values are increased for

these facilities. For this analysis, this cohort is sheltered until the point at which evacuation begins which for calculation purposes was set at the same time as the evacuation tail begins.

- The evacuation tail has always existed but is a new concept in consequence modeling. The evacuation tail includes those members of the public who take longer to evacuate and are the last to leave the area. Indoor shielding values were applied to this and they were evacuated late in the emergency moving at faster speeds because of the lower volume of traffic on the roadways at this time. The timing of the evacuation tail was derived from the ETE as the time at which the last 10 percent of the public begin to evacuate.
- Recent data published by the NRC [34] provides a quantitative value of the shadow evacuation. The shadow evacuation was modeled representative of their occurrence in previous large scale evacuation. This also is a new concept in consequence modeling!
- For the seismic analysis, it may be expected that a shadow evacuation of residents from within the EPZ may occur prior to the issuance of an evacuation order. This additional shadow evacuation was included in the analysis.
- A non-evacuation cohort was also included in the analysis assuming that a very few members of the public may refuse to evacuate. Normal shielding values were applied to this cohort.

The Peach Bottom EALs were obtained for each of the accident scenarios modeled to best reflect the timing of the declaration of SAE and GE. Because the STSBO is the initiator for 3 of the scenarios, the timing of these declarations was identical.

Which ones in the list below? The reader has no way to tell which of the 6 STSBO initiators

Four accident scenarios were modeled including:

1. LTSBO
2. STSBO with RCIC Blackstart
3. STSBO without RCIC Blackstart
4. STSBO without RCIC Blackstart with evacuation to 16 miles - Sensitivity 1
5. STSBO without RCIC Blackstart with evacuation to 20 miles - Sensitivity 2
6. STSBO without RCIC Blackstart with additional delay in implementation of protective actions - Sensitivity 3
7. Seismic STSBO without RCIC Blackstart

For each of these accident scenarios, the specific EAL information and cohort movement was applied ~~and the WinMACCS files were complied~~ for the consequence analysis.

Sensitivity analyses were also performed to identify differences when varying selected parameters. This included expanding the limits of the evacuation and adjusting the timing of implementation of protective actions. In the first sensitivity analysis, the limits of the evacuation were extended to 16 miles. In order to evaluate such a protective action, an ETE was developed using OREMS. Each cohort was adjusted to reflect the appropriate distance from the plant. A second sensitivity analysis was conducted assuming an evacuation of 20 miles from the plant. The ETE was developed using OREMS, and for this case, there was no shadow evacuation assumed due to the extreme distance from the point of the accident.

All of the initiating events for these accidents was loss of power and the resulting EALs were similar. An additional sensitivity analysis was conducted to assess the sensitivity of the timing of ORO decisions to consequences. This required increasing the delay times for cohorts to take action.

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7.0 OFF-SITE CONSEQUENCES

7.1 Introduction

The MACCS2 consequence model was used to calculate the effects of offsite doses to members of the public. MACCS2 was developed at Sandia National Laboratories for the NRC for use in probabilistic risk assessments for commercial nuclear reactors to simulate the impact of accidental atmospheric releases of radiological materials on humans and on the surrounding environment. The principal phenomena considered in MACCS2 are atmospheric transport using a Gaussian plume model, short-term and long-term dose accumulation through several pathways including cloudshine, groundshine, inhalation, deposition onto the skin, and food and water ingestion. The ingestion pathway was not treated in the analyses reported here because uncontaminated food and water are in adequate supply within the US so that people would not need to consume contaminated food or water. Also, the risk metrics reported here, average individual risk for acute and latent cancer fatalities, do not include doses to decontamination workers. The doses that are included in the reported risk metrics are as follows:

- Cloudshine during plume passage
- Groundshine during the emergency and long-term phases from deposited aerosols

Inhalation during plume passage and following plume passage from resuspension of deposited aerosols. Resuspension is treated during both the emergency and long-term phases.

The SOARCA project employs the most recent version of the MACCS2 analysis codes [28], and additional enhancements have also been undertaken as an element of the SOARCA project. In general, these enhancements reflect recommendations obtained during the SOARCA external review and also reflect needs identified by the broader consequence analysis community. The code enhancements that were done for SOARCA are primarily to simplify user input, improve code performance, and enhance existing functionality. They do not represent a major phenomenological model development effort. Nevertheless, these enhancements are anticipated to have a significant effect on the fidelity of the analyses performed under the SOARCA project.

MACCS2 previously allowed up to three emergency-phase cohorts in the EARLY module plus a long-term cohort in the CHRONC module. Each emergency-phase cohort represents a uniform fraction of the population who behave in a similar manner, although response times can be a function of radius. For example, a cohort might represent a fraction of the population who rapidly evacuate after officials instruct them to do so. To create a high-fidelity model for SOARCA, the number of emergency-phase cohorts was increased as described in the previous chapter on emergency response. This allowed significantly more variations in emergency response, e.g., variations in preparation time prior to evacuation and more accurately reflects the movement of the public during an emergency. In a similar way, modeling evacuation routes using the network-evacuation model adds a greater degree of realism than in previous analyses that used the simpler, radial-evacuation model.

7.2 Peach Bottom Source Terms

Brief descriptions of the source terms for the Peach Bottom accident sequences are provided in Table 21. For comparison, the largest source term from the Sandia Siting Study (SST1) [29] is also shown. Of the Peach Bottom source terms shown in the table, the unmitigated STSBO is the largest in terms of release fractions and the release begins at the earliest time; the LTSBO is the smallest in terms of release fractions and the release begins at the latest time; the mitigated STSBO (with RCIC blackstart) is intermediate both in terms of release magnitude and timing, exceptt in one regard. The Ce release fraction is the largest of the three SOARCA source terms.

The STSBO source terms have unique features that distinguish them from the Peach Bottom LTSBO sequence and also from the Surry sequences reported in Appendix B of this report. The features are related to the relative importance of the Cs release fraction compared with those for the other chemical groups, primarily Ba, I, Te, and Ce. Normally, release fractions for Cs are comparable or greater than those for most of the other groups except for the noble gases and sometimes I. For the unmitigated STSBO, the Cs release fraction is significantly smaller than for Ba, I, and Te. Furthermore, the Ce release fraction is relatively large as well. The STSBO with RCIC blackstart sequences has the same unique features, but to a lesser degree. These unique features of the two STSBO sequences appear to influence some of the consequence trends reported below.

By comparison, the SST1 source term is significantly larger in magnitude, especially for the cesium group, than any of the Peach Bottom source terms. Moreover, it begins only 1.5 hours after accident initiation. The earliest Peach Bottom source term, the unmitigated STSBO, has a very small leakage release (i.e., design basis leakage) that begins 1.1 hours after accident initiation, but significant release only begins 8.1 hours after accident initiation. Thus, it is clear that the current understanding of accident progression has lead to a very different characterization of release signatures than was current at the time of the Sandia Siting Study.

Table 21 Brief Source-Term Description for Peach Bottom Accident Sequences and the SST1 Source Term from the Sandia Siting Study

	Integral Release Fractions by Chemical Group									Release Timing	
Sequence	**Xe**	**Cs**	**Ba**	**I**	**Te**	**Ru**	**Mo**	**Ce**	**La**	**Start (hr)**	**End (hr)**
PB LTSBO	0.833	0.017	0.014	0.036	0.023	0.000	0.004	0.001	0.000	19.5	48.0
PB STSBO	0.985	0.023	0.083	0.103	0.117	0.000	0.006	0.005	0.000	8.1	48.0
PB STSBO w/ BS	0.962	0.021	0.058	0.074	0.033	0.000	0.004	0.006	0.000	13.3	48.0
SST1	1.000	0.670	0.070	0.450	0.640	0.050	0.050	0.009	0.009	1.5	3.5

For comparison purposes, a consequence analysis using the old SST1 source term is presented in this chapter. This allows a direct comparison, using the same modeling options and result metrics, between the outdated SST1 source term and the current, best-estimate source terms, But, because of significant off-site model changes, not with the results of the SSS itself.

7.3 Consequence Analyses

The results of the consequence analyses are presented in terms of increased risk to the public for each of the three accident sequences that were identified for Peach Bottom. Both absolute and conditional risks are tabulated. The conditional risks assume that the accident occurs and show the risks to individuals as a result of the accident. The absolute risks are the product of the core damage frequency and the conditional risks. The absolute risks are the likelihood of receiving a fatal cancer or early fatality to an average individual living within a specified radius of the plant per year of plant operation.

The risk metrics are latent-cancer-fatality and early-fatality risks to residents in circular regions surrounding the plant. These risk values are averaged over weather data for the year 2006. They are also averaged over the entire residential population within the circular region. The risk values represent the predicted number of fatalities divided by the population for four choices of dose-truncation level. These risk metrics account for the distribution of the population within the circular region and for the interplay between the population distribution and the wind rose probabilities. The risk metrics do not account for typical commuting patterns; rather, they are based on the locations where people reside.

In addition to the baseline accident sequences, three additional analyses are reported in this chapter. A sensitivity analysis for the unmitigated STSBO sequence shows the influence of the size of the evacuation zone on predicted risk. Another sensitivity analysis considers the effect of seismic activity on emergency response. A separate analysis of the SST1 source term [29] (summarized in Table 21) allows the older source term assumptions to be compared with the current state-of-the-art methods for source term evaluation using otherwise equivalent assumptions and models. This analysis ~~does not try to reproduce the~~ Sandia Siting Study results; it merely overlays the older source term onto what are otherwise SOARCA assumptions for dose-response modeling, emergency response, etc.

Cannot be compared with

7.3.1 Unmitigated Long-Term Station Blackout Sequence

Table 22 displays the conditional, mean, latent-cancer-fatality risks to residents within a set of concentric circular areas centered at the Peach Bottom site for the unmitigated long-term station blackout (LTSBO) sequence. Four values of dose-truncation level are shown in the table: linear, no threshold (LNT), i.e., a dose-truncation level of zero; 10 mrem/yr; the average, annual, US-background radiation (including average medical radiation) of 620 mrem/yr; and the Health Physics Society (HPS) recommended dose truncation of 5 rem/yr, with a lifetime limit of 10 rem.

The HPS dose-truncation level is more complex that the others because it involves both annual and lifetime limits. According to the recommendation, annual doses below the 5-rem truncation level do not need to be counted toward health effects; however, if the lifetime dose exceeds 10 rem, all annual doses, no matter how small, count toward health effects.

Table 23 is analogous to Table 22, but displays absolute rather than the conditional risks. In the case of the Peach Bottom long-term station blackout, the mean core damage frequency is $3 \cdot 10^{-6}$/yr. This frequency is used to scale the results in Table 23, as described above.

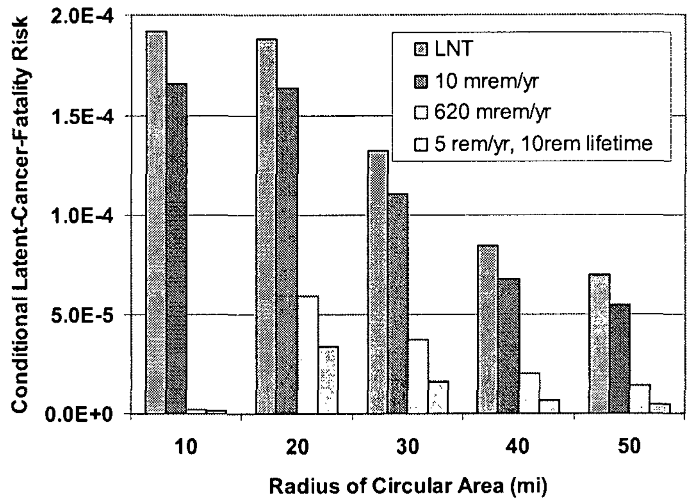
Table 22 Conditional, i.e., assuming accident occurs, Mean, Latent-Cancer-Fatality Risks for Residents within the Specified Radii of the Peach Bottom Site. Risks Are for the Unmitigated LTSBO Sequence, which Has a Mean Core Damage Frequency of $3 \cdot 10^{-6}$/yr.

Radius of Circular Area (mi)	LNT	10 mrem/yr	620 mrem/yr	5 rem/yr; 10 rem lifetime
10	$1.9 \cdot 10^{-4}$	$1.7 \cdot 10^{-4}$	$1.8 \cdot 10^{-6}$	$1.6 \cdot 10^{-6}$
20	$1.9 \cdot 10^{-4}$	$1.6 \cdot 10^{-4}$	$5.9 \cdot 10^{-5}$	$3.4 \cdot 10^{-5}$
30	$1.3 \cdot 10^{-4}$	$1.1 \cdot 10^{-4}$	$3.7 \cdot 10^{-5}$	$1.6 \cdot 10^{-5}$
40	$8.5 \cdot 10^{-5}$	$6.8 \cdot 10^{-5}$	$2.0 \cdot 10^{-5}$	$6.9 \cdot 10^{-6}$
50	$7.0 \cdot 10^{-5}$	$5.4 \cdot 10^{-5}$	$1.4 \cdot 10^{-5}$	$4.5 \cdot 10^{-6}$

Table 23 Absolute, Mean, Latent-Cancer-Fatality Risks for Adult Residents within the Specified Radii of the Peach Bottom Site. Risks Are for the unmitigated LTSBO Sequence, which has a mean core damage frequency of $3 \cdot 10^{-6}$/yr.

Radius of Circular Area (mi)	LNT	10 mrem/yr	620 mrem/yr	5 rem/yr; 10 rem lifetime
10	$5.8 \cdot 10^{-10}$	$5.0 \cdot 10^{-10}$	$5.5 \cdot 10^{-12}$	$4.7 \cdot 10^{-12}$
20	$5.6 \cdot 10^{-10}$	$4.9 \cdot 10^{-10}$	$1.8 \cdot 10^{-10}$	$1.0 \cdot 10^{-10}$
30	$4.0 \cdot 10^{-10}$	$3.3 \cdot 10^{-10}$	$1.1 \cdot 10^{-10}$	$4.9 \cdot 10^{-11}$
40	$2.5 \cdot 10^{-10}$	$2.0 \cdot 10^{-10}$	$6.0 \cdot 10^{-11}$	$2.1 \cdot 10^{-11}$
50	$2.1 \cdot 10^{-10}$	$1.6 \cdot 10^{-10}$	$4.3 \cdot 10^{-11}$	$1.3 \cdot 10^{-11}$

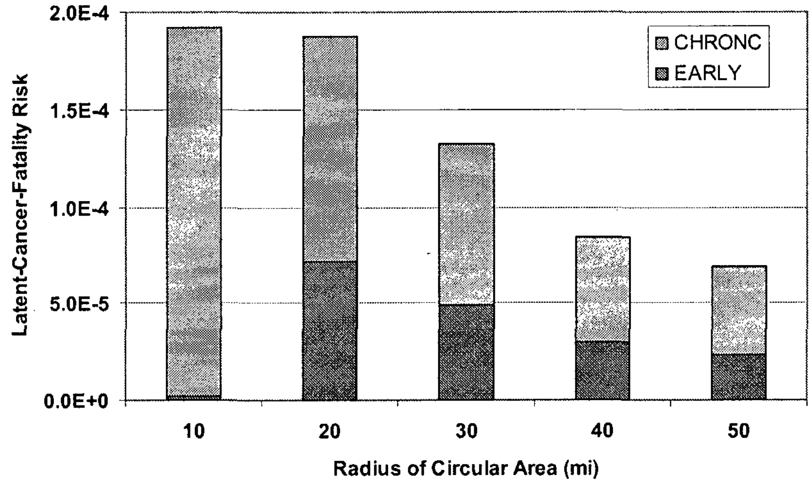
The values in Table 22 are shown in Figure 80. The figure shows that for LNT and for a small truncation dose of 10 mrem, the risk is greatest for those closest to the plant and diminishes monotonically as distance increases. On the other hand, for a large value of the truncation dose, the risk reaches a maximum outside the 10-mile evacuation zone. The explanation for this counterintuitive trend is provided in the following discussion of the risks incurred during the emergency versus the long-term phases.



the CDF for this sequence is 3x10^-6/Ry

Figure 80 **Conditional, i.e., assuming accident occurs, mean, latent-cancer-fatality risks from the Peach Bottom unmitigated LTSBO sequence for residents within a circular area of specified radius from the plant. The curves represent four values of dose-truncation level.**

Figure 81 shows the conditional LNT risks for the Peach Bottom unmitigated LTSBO for the emergency (EARLY) and long-term (CHRONC) phases. The entire height of each column shows the combined (Total) risk for the two phases. The emergency response is very effective within the evacuation zone (10 mi) during the early phase, so those risks are very small and entirely represent the 0.5% of the population that does not evacuate. The peak in the EARLY risk curve is at 20 miles, which is the first location in the plot outside of the evacuation zone.



The CDF for this papers is 3x10-4/Ry

Figure 81 Conditional, i.e., assuming accident occurs, mean, LNT, latent-cancer-fatality risks from the Peach Bottom unmitigated LTSBO sequence for residents within a circular area of specified radius from the plant. The columns show the risks from the emergency phase (EARLY), long-term phase (CHRONC), and the two phases combined (Total).

The CHRONC risks dominate the total risks for the accident sequence when the LNT dose-response assumption is made. These long-term risks are controlled by the habitability (return) criterion, which is the dose level at which residents are allowed to return to their homes following the emergency phase. For Peach Bottom, the habitability criterion is an annual dose limit of 500 mrem. However, this dose rate is below the truncation levels for the background (620 mrem/yr) and HPS dose-truncation criteria; therefore, most of the doses received during the long-term phase are not counted toward health effects when using these criteria. Thus, most of the risks associated with the 620 mrem/yr and HPS dose truncation criteria are from doses received during the first year. Doses received during the first year include all of the EARLY doses plus a fraction of the CHRONC doses. This explains why the risk profiles for these dose-truncation criteria in Figure 80 are similar to the EARLY profile in Figure 81.

The prompt-fatality risks are identically zero for this accident sequence. This is because the release fractions (shown in Table 21) are too low to produce doses large enough to exceed the dose thresholds for early fatalities, even for the 0.5% of the population that does not evacuate.

7.3.2 Short-Term Station Blackout with RCIC Blackstart

Table 24 displays the conditional, mean, latent-cancer-fatality risks to residents within a set of concentric circular areas centered at the Peach Bottom site for the short-term station blackout (STSBO) sequence with successful RCIC blackstart. Four values of dose-truncation level are shown in the table: linear, no threshold (LNT), i.e., a dose-truncation level of zero; 10 mrem/yr; annual, average, US-background radiation (including average medical radiation) of 620 mrem/yr; and the Health Physics Society (HPS) recommended dose truncation of 5 rem/yr, with a lifetime limit of 10 rem. The RCIC blackstart delays the beginning of release and provides more time for evacuation prior to release than in the subsequent sequence, in which RCIC blackstart is not attempted or fails. Table 25 is analogous to Table 24, but shows absolute rather than conditional risks.

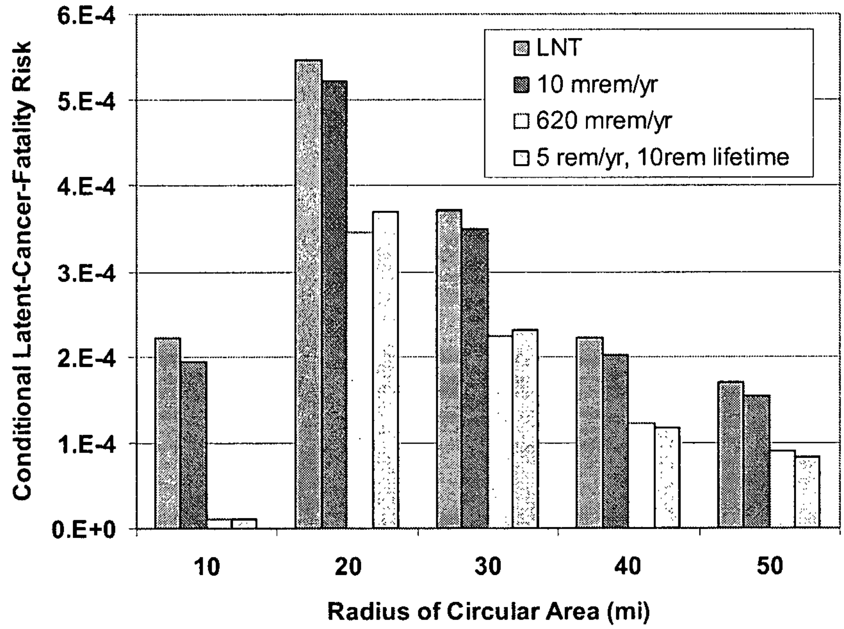
Table 24 Conditional, i.e., assuming accident occurs, Mean, Latent-Cancer-Fatality Risks for Adult Residents within the Specified Radii of the Peach Bottom Site. Risks are for the STSBO Sequence with RCIC blackstart, which has a mean core damage frequency of $3 \cdot 10^{-7}$/yr.

Radius of Circular Area (mi)	LNT	10 mrem/yr	620 mrem/yr	5 rem/yr; 10 rem lifetime
10	$2.2 \cdot 10^{-4}$	$1.9 \cdot 10^{-4}$	$1.0 \cdot 10^{-5}$	$1.1 \cdot 10^{-5}$
20	$5.5 \cdot 10^{-4}$	$5.2 \cdot 10^{-4}$	$3.5 \cdot 10^{-4}$	$3.7 \cdot 10^{-4}$
30	$3.7 \cdot 10^{-4}$	$3.5 \cdot 10^{-4}$	$2.2 \cdot 10^{-4}$	$2.3 \cdot 10^{-4}$
40	$2.2 \cdot 10^{-4}$	$2.0 \cdot 10^{-4}$	$1.28 \cdot 10^{-4}$	$1.2 \cdot 10^{-4}$
50	$1.7 \cdot 10^{-4}$	1.610^{-4}	$9.0 \cdot 10^{-5}$	$8.2 \cdot 10^{-5}$

Table 25 Absolute, Mean, Latent-Cancer-Fatality Risks for Adult Residents within the Specified Radii of the Peach Bottom Site. Risks are for the STSBO Sequence with RCIC blackstart, which has a mean core damage frequency of $3 \cdot 10^{-7}$/yr.

Radius of Circular Area (mi)	LNT	10 mrem/yr	620 mrem/yr	5 rem/yr; 10 rem lifetime
10	$6.6 \cdot 10^{-11}$	$5.8 \cdot 10^{-11}$	$3.1 \cdot 10^{-12}$	$3.2 \cdot 10^{-12}$
20	$1.6 \cdot 10^{-10}$	$1.6 \cdot 10^{-10}$	$1.0 \cdot 10^{-10}$	$1.1 \cdot 10^{-10}$
30	$1.1 \cdot 10^{-10}$	$1.1 \cdot 10^{-10}$	$6.7 \cdot 10^{-11}$	$6.9 \cdot 10^{-11}$
40	$6.6 \cdot 10^{-11}$	$6.1 \cdot 10^{-11}$	$3.7 \cdot 10^{-11}$	$3.5 \cdot 10^{-11}$
50	$5.2 \cdot 10^{-11}$	$4.7 \cdot 10^{-11}$	$2.7 \cdot 10^{-11}$	$2.5 \cdot 10^{-11}$

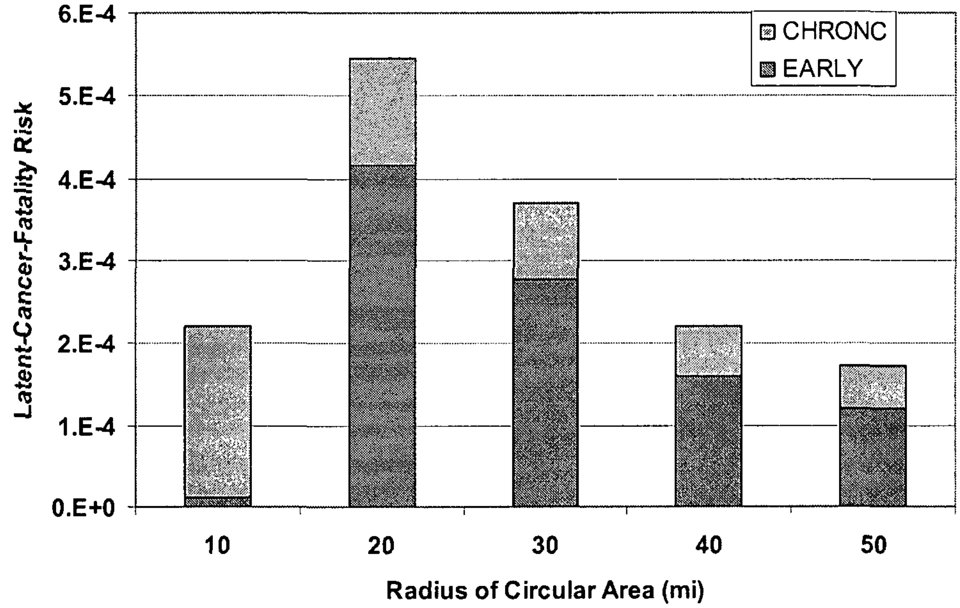
The values in Table 24 are shown in Figure 82. The figure shows that predicted risks reach a maximum beyond the EPZ (10 mi) for all choices of dose truncation level. Risks are higher for this sequence than for the LTSBO described in the previous subsection because the releases are larger.



The CDF for this sequence is 3X10-7/RY

Figure 82 **Conditional, i.e., assuming accident occurs, mean, latent-cancer-fatality risks from the Peach Bottom STSBO sequence with RCIC blackstart for residents within a circular area of specified radius from the plant. The curves represent four choices of dose-truncation level.**

Figure 83 shows the LNT latent-cancer-fatality risks for the Peach Bottom short-term station blackout with RCIC blackstart for the emergency (EARLY) and long-term (CHRONC) phases. The height of each column indicates the combined (Total) risk for the two phases. The emergency response is very effective within the evacuation zone (10 mi) during the early phase, so those risks are very small and entirely represent the 0.5% of the population that does not evacuate. The peak in the EARLY risk curve is at 20 miles, which is the first location in the plot outside of the evacuation zone.



The CDF for this scenario is 3×10^{-7}/Ry

Figure 83 Conditional, i.e., assuming accident occurs, mean, LNT, latent-cancer-fatality risks from the Peach Bottom STSBO sequence with RCIC blackstart for residents within a circular area of specified radius from the plant. The columns show the risks from the emergency phase (EARLY), long-term phase (CHRONC), and the two phases combined (Total).

Unlike the unmitigated LTSBO sequence described in the previous subsection, the long-term-phase risks for this sequence are significantly lower than the emergency-phase risks except within the evacuation zone (10 mi) where the emergency-phase risks are small. The long-term risks are controlled by the habitability or return criterion, which is an annual dose limit of 500 mrem. Since the overall risks are controlled by the emergency-phase risks, the overall risk profile has a peak at 20 miles, reflecting the low risks to those who evacuate.

Since the annual dose limit of the habitability criterion (500 mrem/yr) is lower than the dose truncation levels for the 620 mrem/yr and HPS criteria, those two risk profiles (shown in Figure 82) are similar to the emergency-phase profile shown in Figure 83. In other words, the long-term doses are largely excluded by the 620 mrem/yr and HPS criteria, so the health effects are dominated by doses received during the emergency phase. As a result, those risk profiles are bounded above by the emergency-phase profile in Figure 83.

A unique characteristic of the risks displayed in Figure 83 is the relative importance of the emergency phase. The contribution of the emergency phase to the overall risk is much less for the Peach Bottom unmitigated LTSBO sequence discussed above and for all of the Surry sequences presented in Chapter 7 of Appendix B of this report. The uniqueness of this sequence appears to be related to the unusually small release fraction for Cs compared with those for the other chemical groups (cf., Table 21). In particular, Cs-134 and Cs-137 are responsible for most of the long-term consequences because of their relatively long half-lives, 2 and 30 yr, respectively. Most of the other important isotopes have much shorter half-lives and contribute primarily to the emergency phase.

The prompt-fatality risks are identically zero for this accident sequence. This is because the release fractions are too low to produce doses large enough to exceed the dose thresholds for early fatalities, even for the 0.5% of the population that does not evacuate.

7.3.3 Unmitigated Short-Term Station Blackout

Table 26 displays the conditional, mean, latent-cancer-fatality risks to residents within a set of concentric circular areas centered at the Peach Bottom site for the unmitigated short-term station blackout (STSBO) sequence, i.e., without RCIC blackstart. Four values of dose-truncation level are shown in the table: linear, no threshold (LNT), i.e., a dose-truncation level of zero; 10 mrem/yr; annual, average, US-background radiation (including average medical radiation) of 620 mrem/yr; and the Health Physics Society (HPS) recommended dose truncation level of 5 rem/yr, with a lifetime limit of 10 rem. The releases for this sequence are very similar to those for the previous one, except they are slightly larger and occur earlier in time.

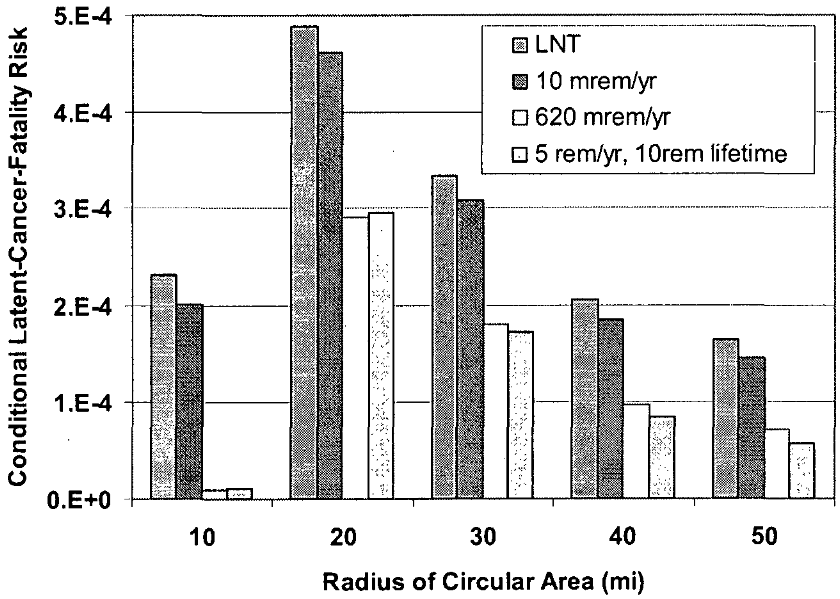
Comparing Table 24 and Table 26, it can be seen that the risks are slightly larger for the unmitigated STSBO sequence, i.e., when RCIC blackstart is not attempted or does not succeed. Table 27 is analogous to Table 26, but shows absolute rather than conditional risks. The values in Table 26 are plotted in Figure 84. The plot shows that predicted risks reach a maximum beyond the EPZ (10 mi) for all choices of dose truncation level.

Table 26 Conditional, i.e., assuming accident occurs, Mean, Latent-Cancer-Fatality Risks for Residents within the Specified Radii of the Peach Bottom Site. Risks are for the unmitigated STSBO Sequence, which has a mean core damage frequency of $3 \cdot 10^{-7}$/yr.

Radius of Circular Area (mi)	LNT	10 mrem/yr	620 mrem/yr	5 rem/yr; 10 rem lifetime
10	$2.3 \cdot 10^{-4}$	$2.0 \cdot 10^{-4}$	$9.9 \cdot 10^{-6}$	$1.0 \cdot 10^{-5}$
20	$4.9 \cdot 10^{-4}$	$4.6 \cdot 10^{-4}$	$2.9 \cdot 10^{-4}$	$3.0 \cdot 10^{-4}$
30	$3.3 \cdot 10^{-4}$	$3.1 \cdot 10^{-4}$	$1.8 \cdot 10^{-4}$	$1.7 \cdot 10^{-4}$
40	$2.1 \cdot 10^{-4}$	$1.9 \cdot 10^{-4}$	$9.8 \cdot 10^{-5}$	$8.4 \cdot 10^{-5}$
50	$1.6 \cdot 10^{-4}$	$1.5 \cdot 10^{-4}$	$7.1 \cdot 10^{-5}$	$5.7 \cdot 10^{-5}$

Table 27 **Absolute, Mean, Latent-Cancer-Fatality Risks for Residents within the Specified Radii of the Peach Bottom Site. Risks are for the unmitigated STSBO Sequence, which has a mean core damage frequency of $3 \cdot 10^{-7}$/yr.**

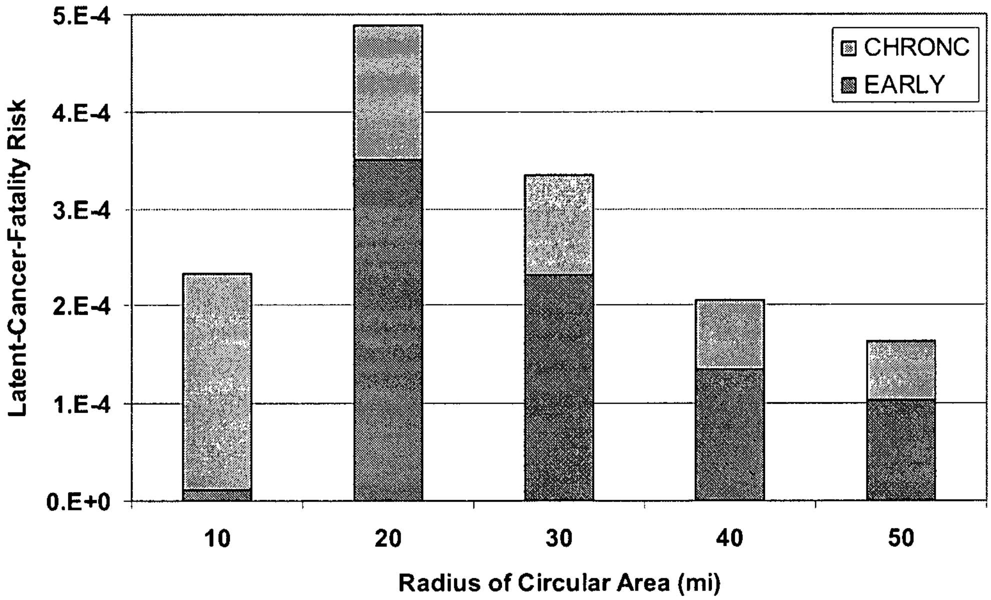
Radius of Circular Area (mi)	LNT	10 mrem/yr	620 mrem/yr	5 rem/yr; 10 rem lifetime
10	$7.0 \cdot 10^{-11}$	$6.0 \cdot 10^{-11}$	$3.0 \cdot 10^{-12}$	$3.1 \cdot 10^{-12}$
20	$1.5 \cdot 10^{-10}$	$1.4 \cdot 10^{-10}$	$8.7 \cdot 10^{-11}$	$8.9 \cdot 10^{-11}$
30	$1.0 \cdot 10^{-10}$	$9.3 \cdot 10^{-11}$	$5.4 \cdot 10^{-11}$	$5.2 \cdot 10^{-11}$
40	$6.2 \cdot 10^{-11}$	$5.6 \cdot 10^{-11}$	$2.9 \cdot 10^{-11}$	$2.5 \cdot 10^{-11}$
50	$4.9 \cdot 10^{-11}$	$4.4 \cdot 10^{-11}$	$2.1 \cdot 10^{-11}$	$1.7 \cdot 10^{-11}$



The CDF for this sequence is 3×10^{-7}/ry

Figure 84 **Conditional, i.e., assuming accident occurs, mean, latent-cancer-fatality risks from the Peach Bottom unmitigated STSBO sequence for residents within a circular area of specified radius from the plant. The curves represent four choices of dose-truncation level.**

Figure 85 shows the LNT latent-cancer fatality risks for the Peach Bottom unmitigated STSBO sequence for the emergency (EARLY) and long-term (CHRONC) phases. The height of each of the columns shows the combined (Total) risk for the two phases. The emergency response is very effective within the evacuation zone (10 mi) during the early phase, so those risks are very small and mostly represent the 0.5% of the population that does not evacuate. The peak in the EARLY risk profile is at 20 miles, which is the first location in the plot outside of the evacuation zone.



The CDF for this sequence is $3X10^{-7}$/y

Figure 85 Conditional, i.e., assuming accident occurs, mean, LNT, latent-cancer-fatality risks from the Peach Bottom unmitigated STSBO sequence for residents within a circular area of specified radius from the plant. The columns show the risks from the emergency phase (EARLY), long-term phase (CHRONC), and the two phases combined (Total).

Similar to the STSBO sequence with RCIC blackstart described in the previous subsection, the long-term-phase risks for this sequence are significantly smaller than the emergency-phase risks except within the evacuation zone (10 mi), where emergency-phase risks are very small. The long-term risks are controlled by the habitability or return criterion, which is an annual dose limit of 500 mrem. Since the overall risks are dominated by the emergency-phase risks, the overall risk profile has a peak at 20 miles.

Because the annual dose limit of the habitability criterion is lower than the dose truncation levels of the 620 mrem/yr and HPS criteria, those two risk profiles (shown in Figure 84) are mainly influenced by risks during the emergency-phase, shown in Figure 85.

The risk trends displayed in Figure 85 are similar to those in Figure 83 in terms of the relative importance of the emergency phase. The contribution of the emergency phase to the overall risk is much less for the Peach Bottom unmitigated LTSBO sequence discussed above and for all of the Surry sequences presented in Chapter 7 of Vol. IV of this report. Like the Peach Bottom STSBO sequence with RCIC blackstart, the uniqueness of this sequence appears to be related to the unusually small release fraction for Cs compared with those for the other chemical groups (cf., Table 21).

The prompt-fatality risks are identically zero for this accident sequence. This is because the release fractions are too low to produce doses large enough to exceed the dose thresholds for early fatalities, even for the 0.5% of the population that does not evacuate.

7.3.3.1 Sensitivity Analyses of the Size of the Evacuation Zone

The baseline analysis included evacuation of the 10-mile EPZ, a partial shadow evacuation between 10 and 20 miles, and sheltering of the remaining members of the public between 10 and 20 miles for a period of 24 hours after plume arrival, at which point this group also evacuates. For the unmitigated STSBO sequence, two additional calculations were performed to assess variations in the protective actions.

Sensitivity #1 - Evacuation of a 16-Mile Circular Area

In this calculation, the evacuation zone is expanded to 16 miles. Shadow evacuation occurs from within the 16- to 20-mile area and the remaining members of the public in this area are assumed to shelter for a period of 24 hours after plume arrival, at which point this group also evacuates.

Sensitivity #2 – Evacuation of a 20-Mile Circular Area

In this calculation, the evacuation zone is expanded to 20 miles. No shadow evacuation is considered.

Sensitivity #3 – Delayed Evacuation of a 10-Mile Circular Area

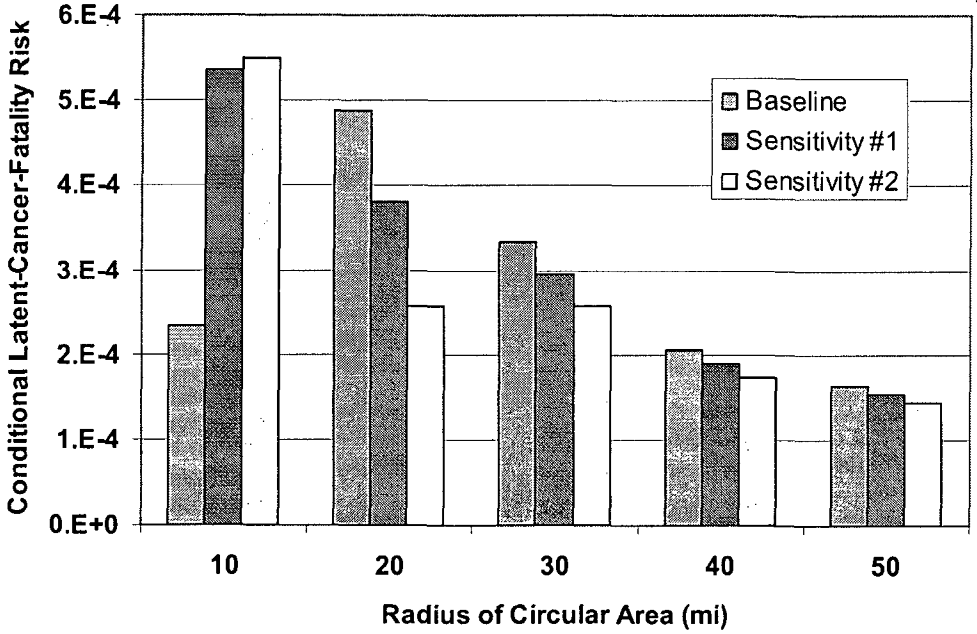
This calculation is identical to the baseline case described above, with the exception that implementation of protective action is delayed by 30 minutes.

The results of all three sensitivity analyses are presented in Table 28; the results of the first two sensitivity analyses are also shown in Figure 86. Because the results for the baseline case and sensitivity #3 are identical, results for sensitivity #3 are not presented in Figure 86.

Table 28 Effect of Size of Evacuation Zone on Conditional, Mean, LNT, Latent-Cancer-Fatality Risks for Residents within the Specified Radii of the Peach Bottom Site. Risks Are for the Unmitigated Short-Term Station Blackout Sequence.

The CDF for this scenario is 3×10^{-7}/Ry

Radius of Circular Area (mi)	Baseline 10-Mile Evacuation	Sensitivity #1 16-Mile Evacuation	Sensitivity #2 20-Mile Evacuation	Sensitivity #3 10-Mile Delayed Protective Action
10	$2.3 \cdot 10^{-4}$	$5.4 \cdot 10^{-4}$	$5.5 \cdot 10^{-4}$	$2.3 \cdot 10^{-4}$
20	$4.9 \cdot 10^{-4}$	$3.8 \cdot 10^{-4}$	$2.6 \cdot 10^{-4}$	$4.9 \cdot 10^{-4}$
30	$3.3 \cdot 10^{-4}$	$3.0 \cdot 10^{-4}$	$2.6 \cdot 10^{-4}$	$3.3 \cdot 10^{-4}$
40	$2.1 \cdot 10^{-4}$	$1.9 \cdot 10^{-4}$	$1.7 \cdot 10^{-4}$	$2.1 \cdot 10^{-4}$
50	$1.6 \cdot 10^{-4}$	$1.5 \cdot 10^{-4}$	$1.4 \cdot 10^{-4}$	$1.6 \cdot 10^{-4}$



The CDF for this sequence is 3×10^{-7}/Ry

Figure 86 Conditional, i.e., assuming accident occurs, mean, LNT, latent-cancer-fatality risks from the Peach Bottom unmitigated STSBO sequence for residents within a circular area of specified radius from the plant. The columns show the dependence of risk on the size of the evacuation zone.

For the unmitigated STSBO source term, there is clearly some benefit for expanding the size of the evacuation zone. There is no effect of delaying by 30 minutes the time at which sheltering and evacuation begins.

7.3.3.2 Evaluation of the Effect of the Seismic Activity on Emergency Response

The effect of seismic activity on emergency response is evaluated in this subsection for the unmitigated STSBO sequence. Several impacts of the seismic activity are evaluated. One of these is the effect of collapsed bridges and impassible roadways on the evacuation itself, which is expected to increase risk. Another effect is on the size of the shadow evacuation, which is expected to decrease risk. Thus, some impacts are expected to enhance emergency response; others are expected to diminish emergency response. The overall impact of the effect of seismic activity on emergency response turns out to be very small, as shown in Table 29. Prompt-fatality risk remains zero for this sequence.

Table 29 Conditional, i.e., assuming accident occurs, Mean, LNT, Latent-Cancer-Fatality Risks for Residents within the Specified Radii of the Peach Bottom Site. Risks Are for the Unmitigated STSBO Sequence and Compare the Unmodified Emergency Response (ER) and ER Adjusted to Account for the Effect of Seismic Activity on Evacuation Routes and Human Response.

Radius of Circular Area (mi)	Unmodified ER	ER Adjusted for Seismic Effects
10	$2.3 \cdot 10^{-4}$	$2.3 \cdot 10^{-4}$
20	$4.9 \cdot 10^{-4}$	$4.5 \cdot 10^{-4}$
30	$3.3 \cdot 10^{-4}$	$3.2 \cdot 10^{-4}$
40	$2.1 \cdot 10^{-4}$	$2.0 \cdot 10^{-4}$
50	$1.6 \cdot 10^{-4}$	$1.6 \cdot 10^{-4}$

The CDF for this sequence is 3×10^{-7}/Ry

7.3.4 Evaluation of SST1 Source Term

to explore adding a source term change in this calculation to compare with the SST1 source

NO!!

An ~~additional set of calculations was performed to enable~~ the current~~,~~ state-of-the-art results to be ~~compared with the older Sandia~~ Siting ~~Study~~ results [29]. ~~In particular~~, the largest source term from the Sandia Siting Study, the SST1 source term, was selected ~~for comparison~~. This set of calculations is based on the Peach Bottom unmitigated LTSBO sequence, but with the source term replaced by the SST1 source term. No other modeling or parameter changes were made.

take out this whole section It serves no useful purpose. This is a mix of situation where some values are best estimate and others are NOT.

The SST1 source term is described in the Sandia Siting Study report as follows:

- Severe core damage
- Essentially involves loss of all installed safety features
- Severe direct breach of containment

An exact sequence and containment failure mechanism, e.g., hydrogen detonation, direct containment heating, or alpha-mode failure, are not specified.

Notification time, i.e., sounding a siren to notify the public that a general emergency has been declared, for the Peach Bottom unmitigated LTSBO occurs at 1.5 hr. Declaration of a general emergency occurs at 45 min. and it takes an additional 45 min. to notify the public. Notification of the public is thus coincident with the beginning of release for the SST1 source term (cf., Table 21), which occurs 1.5 hr after accident initiation. The general public begins to evacuate 30 minutes later, which is 2 hr after accident initiation. The start of evacuation for the general public for this sequence occurs at the same time as the start of evacuation of the first cohort in the Sandia Siting Study. The largest segment of the population in the Sandia Siting Study began to evacuate 2 hr later, 4 hr after accident initiation. Thus, the evacuation used in this sensitivity study is earlier, on the whole, than that used at the time of the Sandia Siting Study. On the other hand the road speeds are significantly less, resulting in less shielding for the whole evacuation sequence.

There are a number of other differences between this sensitivity study and the original Sandia Siting Study that preclude direct comparisons. The purpose of this sensitivity study is simply to show the impact of the improvements made in the source term analysis methods and practices on the consequence results.

While the Sandia Siting Study treated emergency response very simplistically, a major emphasis of the SOARCA project is to treat all aspects of the consequence analysis as realistically as possible. It is not the intention here to modify all of the other emergency response parameters to be like those used during the Sandia Siting Study. Furthermore, without knowing the specific accident sequence and containment failure mode that corresponds to the SST1 source term, it is not possible to know what notification time would now be considered realistic for Peach Bottom. Thus, in the end it was decided to keep the emergency response parameters the same as in the unmitigated LTSBO sequence.

Table 30 shows the latent-cancer-fatality risks for a release corresponding to the SST1 source term occurring at Peach Bottom. Table 31 compares the LNT risks for the SST1 source term with those for the largest source term calculated for Peach Bottom in this study, the unmitigated STSBO. The LNT risk within 10 miles for the SST1 source term is about a factor of 25 higher than for the unmitigated STSBO; the 10-mile risk using a 620 mrem/yr dose-truncation criterion is a factor of 500 higher. At larger distances, the risks are less disparate. The ratio is a factor of 3 within 50 miles. The ratio is about 7 for the risk within 50 miles when the 620 mrem/yr dose-truncation criterion is applied.

Table 30 Conditional, i.e., assuming accident occurs, Mean, Latent-Cancer-Fatality Risks for Adult Residents within the Specified Radii of the Peach Bottom Site. Risks Are Based on the SST1 Source Term from the Sandia Siting Study and the SOARCA off-site model

Radius of Circular Area (mi)	LNT	620 mrem/yr	5 rem/yr; 10 rem lifetime
10	$6.0 \cdot 10^{-3}$	$5.8 \cdot 10^{-3}$	$5.9 \cdot 10^{-3}$
20	$2.0 \cdot 10^{-3}$	$1.8 \cdot 10^{-3}$	$1.9 \cdot 10^{-3}$
50	$4.7 \cdot 10^{-4}$	$3.7 \cdot 10^{-4}$	$3.8 \cdot 10^{-4}$

Table 31 Conditional, i.e., assuming accident occurs, Mean, LNT, Latent-Cancer-Fatality Risks for Residents within the Specified Radii of the Peach Bottom Site. Risks Are for the SST1 Source Term from the Sandia Siting Study and the unmitigated STSBO sequence.

Radius of Circular Area (mi)	SST1	Unmitigated STSBO
10	$6.0 \cdot 10^{-3}$	$2.3 \cdot 10^{-4}$
20	$2.0 \cdot 10^{-3}$	$4.0 \cdot 10^{-4}$
50	$4.7 \cdot 10^{-4}$	$1.6 \cdot 10^{-4}$

The maximum risk is within 10 miles for the SST1 source term, which is partially due to the fact that emergency response is not rapid enough to prevent exposures within the EPZ during the emergency phase. This is expected since release begins at the same time as notification of the public and, therefore, before evacuation begins.

A notable feature of the risks presented in Table 30 is that the choice of dose truncation criterion has a minor influence on risk. This is very different than the SOARCA accident sequences discussed in preceding subsections. Figure 87 provides some insights into this behavior. For the SST1 source term, nearly all of the risk, especially at short distances from the plant, is from exposures that occur during the emergency phase (EARLY). Because a significant fraction of these doses are received over a short period of time and the doses are large due to the large source term, the values for the dose truncation criterion have little influence on predicted risks. Again, this is a very different trend than is observed for the current, state-of-the-art source terms.

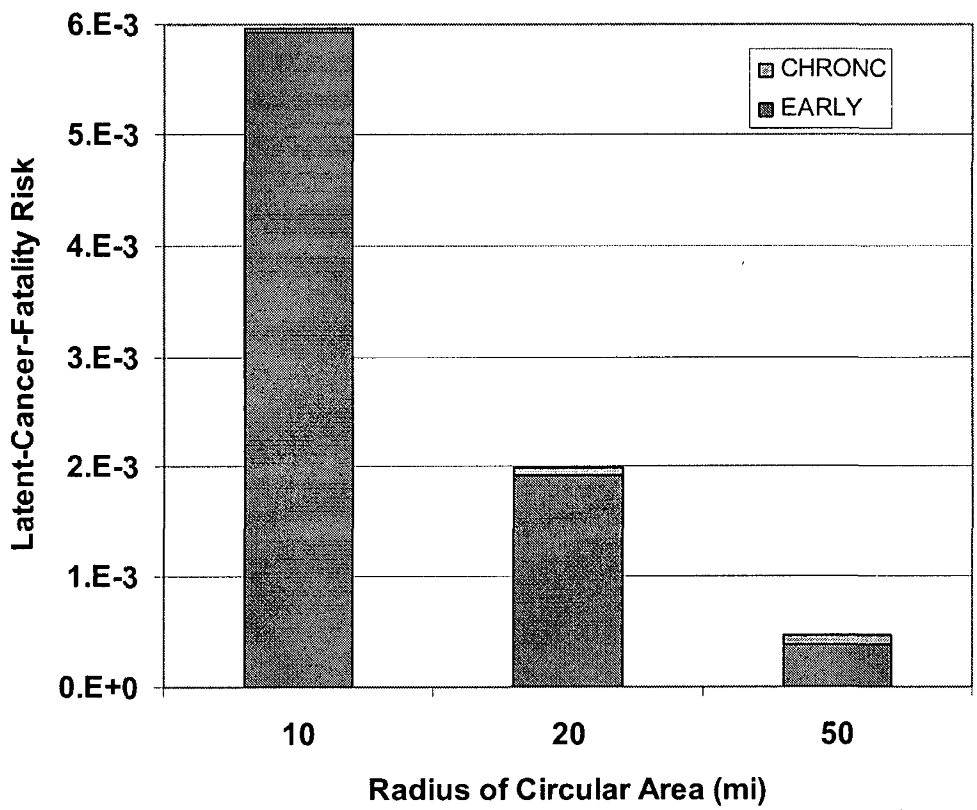


Figure 87 Conditional, i.e., assuming accident occurs, mean, LNT, latent-cancer-fatality risks from the SST1 source term for residents within a circular area of specified radius from the Peach Bottom plant. The columns show the risks from the emergency phase (EARLY), long-term phase (CHRONC), and the two phases combined (Total).

Table 32 shows the risk of prompt fatalities for several circular areas of specified radii centered at the plant. Unlike the source terms presented above, the predicted prompt-fatality risks are greater than zero. The SST1 release fractions are more than large enough to induce prompt fatalities for members of the public who live close to the plant.

The NRC quantitative health object (QHO) for prompt fatalities is generally interpreted as the absolute risk within 1 mile of the exclusion area boundary. For Peach Bottom, the exclusion area boundary is 0.5 miles from the reactor building from which release occurs, so the outer boundary of this 1-mile zone is at 1.5 miles. The closest MACCS2 grid boundary to 1.5 miles used in this set of calculations is at 1.3 miles. Using the risk within 1.3 miles should reasonably approximate the risk within 1 mile of the exclusion area boundary. The frequency stated for the SST1 source term in the Sandia Siting Study [29] is 10^{-5}, so the absolute risk of a prompt fatality for this source term is approximately $5.8 \cdot 10^{-8}$. Even for this very large source term, this risk is well below the QHO. The actual risk of a prompt fatality, using current best estimate practices for calculating source terms, is not quantified here but is at least two orders of magnitude lower (because the frequency would be less that 10^{-7}, the cutoff frequency used in SOARCA) than this analysis using the SST1 source term would imply.

What does this have to do with any thing?

~~If you loosen er you should discuss differences in the FP ... threshold now lower, LD50~~

Table 32 Conditional, i.e., assuming accident occurs, Mean, Prompt-Fatality Risks for Residents within the Specified Radii of the Peach Bottom Site. Risks Are for the SST1 Source Term from the Sandia Siting Study.

Radius of Circular Area (mi)	Prompt Fatality Risk
1.0	$5.7 \cdot 10^{-3}$
1.3	$5.8 \cdot 10^{-3}$
2.0	$2.8 \cdot 10^{-3}$
2.5	$1.9 \cdot 10^{-3}$
3.0	$1.3 \cdot 10^{-3}$
3.5	$7.1 \cdot 10^{-4}$
5.0	$2.0 \cdot 10^{-4}$
7.0	$9.0 \cdot 10^{-5}$
10.0	$3.9 \cdot 10^{-5}$

I see it below

The acute-fatality risks presented in Table 32 are lower than risks that would have been calculated in the Sandia Siting Study. There are two primary reasons for this difference. One is that 30% of the population within the EPZ is assumed to evacuate a full 6 hr after accident initiation in the Sandia Siting Study; here, 98.5% of the population within the EPZ begins to evacuate at least by 2 hr after accident initiation. A second reason is that the coefficients in the equations for acute health effects have been updated since the Sandia Siting Study based on more recent expert data [30]. The updated coefficients result in lower predicted acute fatalities across most of the dose range for which these health effects can occur. So dont think so - threshold now lower but LD50 now higher - The curves crossover PZ.!

For the types of releases that would be encountered in a severe nuclear accident of sufficient severity, the hematopoietic syndrome would be responsible for most of the acute fatalities. Figure 88 shows the evolution of dose-response curves used at the time of the Sandia Siting Study, the NUREG-1150 PRA study, and now being used for SOARCA. The dose-response curve used in NUREG-1150 predicts the largest number of fatalities over most of the range; the one used at the time of the Sandia Siting Study is intermediate over most of the range; the one used here is the lowest over most of the dose range. However, the current model predicts a higher risk of prompt fatalities at the low end of the dose range than does the Sandia Siting Study model. Mean (over weather) peak (around the compass) acute doses to the red marrow, assuming no evacuation, for this case using the SST1 source term range from 37 Gy to the members of the population closest to the site to 0.69 Gy at 10 miles. These doses span the entire range of the curves shown in Figure 88. The maximum radius at which acute health effects occur is slightly less than 10 miles using the SST1 source term at Peach Bottom.

Clearly, the SST1 source term and its assumed frequency of occurrence are large compared with the source terms obtained using current, best-estimate practices. This reflects improvements in understanding and modeling capabilities that have been developed since the Sandia Siting Study was conducted.

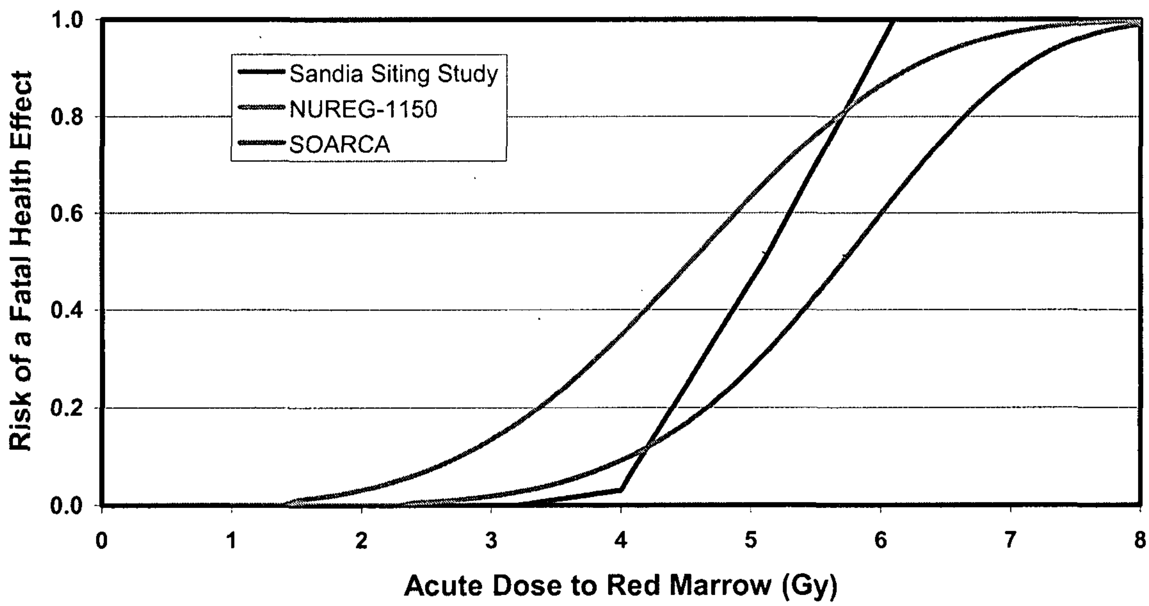


Figure 88: Risk of a fatal occurrence of the hematopoietic syndrome due to an acute dose to the red marrow. The three curves are for the models used at the time of the Sandia Siting Study, NUREG-1150, and in SOARCA.

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